MULTIFAMILY RETROFIT DEMONSTRATION PROJECTS DATA ANALYSIS REPORT

Florida Department of Agriculture and Consumer Services
Adam H. Putnam, Commissioner

Table of Contents

Sections	Page No.
1. Executive Summary	**1**
2. Background	**4**
3. Data Analysis Methodology	**6**
3.1 Electricity Consumption Data	
3.2 Treatment Data	
3.3 Statistical Analysis	
4. Pinellas County Housing Authority Retrofit Demonstration Project	**8**
4.1 PCHA Walk-through Energy Audits	
4.2 Five Retrofit Levels	
4.3 Crystal Lakes Manor Findings	
4.4 Crystal Lake Manor Observations	
5. West Palm Beach Housing Authority Retrofit Demonstration Project	**12**
5.1 WPBHA Walk-through Energy Audits	
5.2 Three Retrofit Levels	
5.3 Robinson Village Findings	
5.4 Robinson Village Observations	
6. Recommendations	**16**
7. Appendices	
Appendix A. Sample Unit Inspection Checklist from Crystal Lakes Manor	**18**
Appendix B. Sample Unit Inspection Checklist from Robinson Village	**20**
Appendix C. Data Analysis of Crystal Lakes Manor Building-Level Use	**22**
Appendix D. Data Analysis of Robinson Village Building-Level Use	**24**

1. Executive Summary

In 2015, the Florida Department of Agriculture and Consumer Services Office of Energy (FDACS OOE) created the Multifamily Energy Efficiency Retrofit Demonstration Project (Retrofit Demonstration Project) based on recommendations from *The Florida Multifamily Efficiency Opportunities Study* (Multifamily Study).[1] The Retrofit Demonstration Project documented steps to make energy-efficient improvements in multifamily properties, then tracked and analyzed tenant electricity usage to determine how different levels of retrofit treatments affected energy savings over time. The objective was to better understand energy retrofit needs in the multifamily sector and better understand efforts needed by multifamily property owners to undertake energy retrofits.

FDACS OOE provided grants to Pinellas County Housing Authority (PCHA) and West Palm Beach Housing Authority (WBPHA). Each public housing authority (PHA) received $500,000 to conduct walk-through energy audits and upgrade appliances where needed. The PHA applied a series of energy efficiency retrofit treatment options to replace older, inefficient equipment. Unit-level electricity consumption data was collected for one year prior and following the retrofits to quantify resulting energy savings.

This report documents the steps taken to make energy efficiency improvements and analyzes variances in unit-level electricity use by comparing the collected energy consumption data.

The Retrofit Demonstration Project allowed the PHAs to implement a range of energy efficiency treatment options appropriate to their properties, based upon walk-though energy audits. Lower-level energy efficiency retrofit treatment options included, but were not limited to: energy efficient lighting, ceiling fans and water heaters, as well as increased attic insulation. Higher level retrofit treatment options addressed whole-house efficiency, adding ductwork leakage repairs or replacement, and installation of new heating and air conditioning/ ventilation (HVAC) systems. PCHA used their award to install lower-level retrofits across all 236 units and used the remaining funds to install 66 new HVAC systems to increase efficiency in units with the most need. WPBHA used their award to install retrofits to all of their 84 units, including 69 that received new HVAC systems. A total of 320 units received walk-through energy audits and some level of retrofits.

In April 2015, both PHAs conducted walk-through energy audits to evaluate the condition of existing equipment to determine the level of retrofits needed:

- Older incandescent hall or bathroom lights were upgraded to light emitting diodes (LEDs) or compact fluorescents (CFLs);
- Old ceiling fans were replaced with new ENERGY STAR® ceiling fans;
- Old water heaters were upgraded to energy efficient ENERGY STAR® electric water heaters or natural gas tankless water heaters;
- Attic insulation was added to reach a thermal resistance (R-value) level of at least R38;
- Old ductwork was examined for leaks and repaired or completely replaced, as needed; and

[1] The Florida Multifamily Efficiency Opportunities Study, January, 2015, online at http://freshfromflorida-2072238849.us-east-1.elb.amazonaws.com/content/download/60388/1263496/Florida_Multifamily_Efficiency_Opportunities_Study_January_2015.pdf, (last visited on November 7, 2017).

- Old HVAC systems with 12 or 13 Seasonal Energy Efficiency Ratio (SEER) ratings were replaced with 15 or 18 SEER rated systems.

The PCHA property, Crystal Lakes Manor, constructed in 1999, consisted of 48 buildings that housed 236 units. All buildings were one-story, and most were one-bedroom units, except for 10 two-bedroom units. Crystal Lakes Manor was a senior living (55 and older) affordable housing complex that generally housed only one person per unit. Prior to retrofits, PCHA residents' average electricity use was 16.15 kilowatt hours (kWh) per day. After retrofits, this fell to an average 13.99 kWh per day. PCHA residents realized an average 13.34-percent decrease in electricity use in the year following the retrofits.

The WPBHA property, Robinson Village, constructed in 1986, consisted of 15 buildings at three locations that housed 84 units. Of these, 78 units had identical two-story, three-bedroom floor plans. For handicapped individuals, there were six accessible one-story units with two bedrooms each. WPBHA housed low-income families. Most units averaged adults and three school-aged children per unit. Prior to retrofit, the residents used on average 36.25 kWh per day. After retrofits, this fell to 25.23 kWh per day. Residents of Robinson Village realized an average 30.4-percent decrease in electricity use.

Table 1: PHA Average Unit-Level Changes in Daily kWh Use, Before and After Retrofits

Demonstration Project	12 Months Before Retrofit	12 Months After Retrofit	Percent Reduction in kWh/d After Retrofit
Crystal Lake Manor across 236 units*	16.15 kWh/d	14 kWh/d	**-13.34%**
Robinson Village across 84 units*	36.25 kWh/d	25.24 kWh/d	**-30.4%**

** Based on reported unit-level energy consumption data: 69% of PCHA units; 87% of WPBHA units.*

These findings demonstrate that tangible energy savings can be found in Florida's aging multifamily sector through targeted efficiency upgrades (Table 1). Although the same types of retrofits were undertaken in both projects, energy savings differ substantially between the two PHAs. Several factors contributed to this, including: building age, the number of tenants per unit, different residential use patterns, unit size, and PHA methodologies used to determine which treatments to apply at individual units.

Based on analysis of these Retrofit Demonstration Projects, the following two considerations are significant when planning this type of large-scale multifamily retrofit project: the construction age of the facility and the HVAC system replacement savings, and the type of upgrades and peripheral installation costs.

Construction age of a multifamily property is a primary consideration due to ongoing improvements of energy efficiency standards, and the implementation of statewide building codes in 2002. Crystal Lake Manor was 16 years old at the time of the retrofit project, and most units were single occupants over 55 years of age. Robinson Village was nearly 30 years old when retrofitted, and tenants were required to maintain occupancy levels of three to four residents per unit minimum.

The type of upgrades is also a primary consideration. If the option exists to choose between replacing multiple HVAC systems or installing a series of lower-level treatments, statistical analysis suggest HVAC system upgrades result in more energy savings than any other single treatment upgrade (Table 2). This analysis found that a new ENERGY STAR® HVAC system, along with repairs to leaks in ductwork, provided the greatest energy efficiency per investment and significantly reduced maintenance work hours for these property owners.

Table 2: PHA Changes in Daily kWh Following Retrofits; Differentiated by HVAC Replacement

Demonstration Project	Units with No HVAC Replaced		Units with New HVAC Installed	
	Average kWh/d	Reduction	Average kWh/d	Reduction
Crystal Lake Manor	-1.4	**-8.9%**	-4.6	**-25.6%**
Robinson Village	1.6	**4.2%**	-13.7	**-38.1%**

In conclusion, large-scale multifamily retrofits result in energy savings. While these two PHAs experienced different energy savings, analysis suggests this was directly related to the age of construction and tenant occupancy levels. Robinson Village, which were older units with four or more tenants per unit, showed more energy savings than in Crystal Lake Manor where units were newer and had fewer tenants. Different retrofits resulted in different energy savings. HVAC replacement resulted in larger efficiency gains. When considering a multifamily retrofit project, measuring energy consumption data will demonstrate that targeting unit-level energy efficiency needs through walk-through energy audits leads to overall savings and decreased maintenance costs.

2. Background

In 2014, FDACS OOE contracted with the University of Florida's Public Utilities Research Center and Program for Resource Efficient Communities and the University of Central Florida's Florida Solar Energy Center to examine energy efficiency opportunities in Florida's multifamily housing market. This collaborative research group prepared the January 2015 report, *The Florida Multifamily Efficiency Opportunities Study* (*Multifamily Study).*

The *Multifamily Study* stated that the bulk of Florida's energy and water savings potential can be found within the state's existing housing stock. Multifamily housing comprises 16 percent of all Florida residential units. Approximately 45 percent of Florida's multifamily housing was built prior to 1980, before Florida instituted statewide energy efficiency codes. The multifamily sector offers a large potential for cost-effective efficiency improvements.[2]

Based on these observations, the *Multifamily Study* set two objectives. The first was to document, using respected modeling programs, the potential amount of energy and water savings that could be achieved from improvements to Florida's multifamily rental housing market, and to identify methods to capture those potential savings. The second objective was to identify policy and program options Florida should consider for adoption and implementation to encourage property owners to make energy and water efficiency improvements.

The *Multifamily Study* findings stated that while potential energy and water savings exist in Florida's multifamily housing market, retrofit projects in older construction are stagnant. The *Multifamily Study* concluded that it is "not possible to understand, quantify, and communicate the full benefits and costs of potential energy and water efficiency investments without [energy and water efficiency] tracking and analytic data."[3] Moreover, the *Multifamily Study* recommended Florida should "generate and leverage the data to build the case … property owners to invest in efficiency."[4]

The Retrofit Demonstration Project was developed from a combination of two recommendations made in the *Multifamily Study*: [5]

- Implement a pilot program/demonstration project that ***targets efficiency retrofit measures to specific multifamily market segments*** (using benchmarking best practices). Such a program or project would benchmark current energy and water efficiency/performance and target specific owners, properties, buildings, and/or units with retrofit opportunities to capture deep, cost-effective and scalable savings.

- Provide funding for pilot programs that ***include as part of walk-through audits the installation of efficiency measures with short payback periods*** (i.e., "shallow" measures or "rapid return" retrofit packages).

[2] Ibid, P. 28.
[3] Ibid, P. 1.
[4] Ibid, P. 1.
[5] Ibid, P. 5-6.

The Retrofit Demonstration Project was designed to use results from walk-through audits to make targeted energy efficiency technology retrofits in multifamily buildings. The project included benchmarking (tracking and analyzing) utility data on tenant electricity use before and after retrofits to determine what impact these retrofits had on overall electricity consumption.

FDACS OOE contacted the U.S. Department of Housing and Urban Development (HUD) for assistance in identifying older multifamily housing communities within Florida who could benefit from energy efficiency retrofits.

In March 2015, two communities, Pinellas County Housing Authority and West Palm Beach Housing Authority, were chosen for the *Retrofit Demonstration Project* based on the quality of their proposals. These two public housing authorities had unique qualifications to perform the retrofits, such as location, property ownership and in-house staff with the technical expertise to perform some of the work required. Each PHA received $500,000 from American Recovery and Reinvestment Act (ARRA) funds to make energy efficiency improvements throughout their multifamily properties.

PCHA chose to retrofit 236 units at Crystal Lakes Manor in Pinellas Park, Florida. WPBHA selected 84 units across three sections of Robinson Village in West Palm Beach, Florida. The two projects were similar in scope, but differences in building age, unit types, tenant demographics and project management style made each project unique in implementation and results.

The two PHAs voluntarily collaborated on designing a uniform unit inspection checklist for their energy efficiency audits (Appendix A). Unit inspection checklists were used to identify the initial condition of older electrical equipment, indicate the work to be done and note the replacement efforts at each unit. These checklists enabled inspectors to conduct walk-through energy audits quickly and efficiently throughout any unit type. Data from the checklists later proved invaluable in understanding the level of retrofitted treatments that were applied in each unit.

In April 2015, both PHAs conducted walk-through energy audits to determine what treatments were needed in each unit. Information was tracked on the unit inspection checklists, including: the existing condition or age of older incandescent hall or bathroom lights, old ceiling fans, old water heaters, attic insulation, ventilation ductwork leaks and old, inefficient HVAC systems.

Based on results of the walk-though energy audits, the PHAs developed their scope of work and submitted it to contractors for bidding. The retrofits required work orders for electrical, plumbing, air-conditioning, permitting, and in the case of WPCHA, the installation of natural gas lines. Once bids were approved by FDACS OOE, the retrofit installations began. The PHAs completed all energy efficiency treatment installations by the end of July 2015.

3. Data Analysis Methodology

The analysis in this report was based on a review of data provided by each housing authority and their respective utilities. Data was comprised of energy consumption reports compiled by the utility company that showed two years of tenant electricity use in kilowatt hours (kWh) and treatment data compiled using unit inspection checklists, work orders, invoices and quarterly reports.

The two utilities serving the PHAs, Florida Power & Light and Duke Energy, require written authorization from tenants before releasing individual customer data. To obtain this, the PHAs informed their residents about the retrofit projects and ensured their privacy would be maintained. The majority of residents signed on to allow collection of their electricity use data. Only units where tenants signed waivers authorizing collection of their electricity use data were included in this report.

- PCHA analysis was based on 69 percent, or 163 out of 236 units, reporting consumption data.
- WPBHA analysis was based on 87 percent, or 73 out of 84 units, reporting consumption data.

These percentages are statistically sufficient for analysis. To ensure tenant privacy, FDACS OOE established unique identifiers in the data analysis for all units and buildings. Building and unit numbers referenced within this report are based on these identifiers and do not correspond to actual physical locations.

3.1 Electricity Consumption Reports

In September 2016, the PHAs submitted unit-level electricity consumption reports to FDACS OOE from July 2014 through July 2016. Reports included data collection dates, quantity of days billed and total kWh billed per month. These data points were analyzed to reflect the average kWh per day per unit usage for each multifamily unit.

In some instances, electricity consumption data was not available for the entire 25 months of an individual unit for several reasons. First, no data exists during periods of unit vacancy. Second, tenant authorization was not always provided. Third, initial tenant authorization was provided for a unit who later moved out, and no further data was collected for that unit because the utility did not have a waiver from the new tenant. Finally, an error of omission occurred in second year WPBHA data.[6] While most of this data was recovered, some data points were not available for comparison.

Incomplete or unclear data was removed from the analysis to garner precise, comprehensive savings results. The entire unit data was removed when fewer than six consecutive months of data were available to compare from both years. Data from the corresponding period was removed

[6] Kilowatt-hour data was missing from the initial second WPBHA energy consumption report. The former utility staff person tasked with sending reports had left, and data had to be reconstructed. Both WPBHA and FPL were helpful in recovering the missing data.

when kWh data was not available for a period in one year. The final analysis compared the same billing periods from the year before the retrofits against the year after retrofits.

3.2 Treatment Data

Using the unit inspection checklists, work orders and invoices, FDACS OOE developed an Excel spreadsheet of treatment data that profiled each unit by the treatments it received. Comparing electricity consumption data to the treatment data helped FDACS OOE formulate questions for this analysis pertaining to long term reductions in use, such as:

- Do retrofits result in energy savings?
- Will both housing developments experience similar energy savings?
- Do different retrofits result in different energy savings?

The first step in the analysis was to define the average electricity use in kWh within a single day by comparing electricity use before and after retrofits. This average kWh per day electricity use was then analyzed in relation to unit profiles. The next analysis observed how individual treatments affect individual unit performance. This helped FDACS OOE identify sets of retrofit levels within each PHA. Finally, where treatments were uniformly applied, analysis was conducted to understand how those retrofit levels performed compared to their neighbors.

3.3 Statistical Analysis

The electricity use reports and retrofit level treatment data was analyzed using Stata SE 13.1 (http://www.stata.com/). The analysis of each PHA's project summarizes the evaluation findings, using a scale of average kWh per day.

4. Pinellas County Housing Authority (PCHA) Retrofit Demonstration Project

PCHA identified 236 units at Crystal Lakes Manor for their project site:

- This was an affordable multifamily property reserved for senior citizens and disabled individuals 55 years of age or older. Section 8 vouchers were accepted.
- The property is a one-story community of multifamily building constructed in 1999, and is comprised of 48 single-story buildings across 19 acres.
- There were 10 two-bedroom/one-bath 685 sq. ft. units accessible to persons with disabilities, and 221 one-bedroom/one-bathroom 565 sq. ft. units.
- Rental rates were $490 per month for a one-bedroom unit and $535 per month for a two-bedroom unit (effective January 1, 2016).
- Crystal Lake Manor units were serviced by Duke Energy.

4.1 PCHA Walk-through Energy Audits

In April 2015, walk-through energy audits were conducted using the Crystal Lake Manor unit inspection checklists (Appendix A). Based on the evaluation of the information obtained in each unit during the targeted audit, PCHA was able to identify treatment types in most need of replacement (Table 3).

Table 3: Crystal Lake Manor Energy Efficient Treatment Upgrades

Treatment Type	Replacement Details
Lighting	Incandescent and fluorescent lights were replaced with energy efficient LED and/or CFL lights throughout all units.
Ceiling Fans	Older ceiling fans in poor condition were replaced with ENERGY STAR® ceiling fans that house LED lightbulbs.
Attic Insulation	R30 or less insulation was covered with additional blown-in insulation, increasing attic insulation value to R41.
Water Heaters	Original electric water heaters from 1999, in poor condition, were replaced with 2015 ENERGY STAR® electric water heaters installed in all units.
Attic Ventilation Ductwork	Walk-through energy audits revealed intake air leaks were present and flex connections to air conditioning registers were in bad condition. Inspections were performed on all HVAC systems and attic ductwork. In total, 11 attic ventilation ductworks were repaired.
HVAC Systems	HVAC systems rated 7 to 12 SEER. Approximately 190 HVAC systems, rated 10 SEER, were found in poor condition. Other systems were found to be in Fair to Good condition. In total, 66 units received new 15 SEER ENERGY STAR® HVAC systems with smart thermostats.

4.2 Five Retrofit Levels

PCHA installed five levels of treatments (Table 4). Level I, II and III retrofits focused on lighting, insulation, ceiling fans and water heater replacements. Level IV and V retrofits these treatments, plus HVAC system replacements, and in some cases, repairs to ductwork.

Table 4: Crystal Lakes Manor Types of Energy Efficiency Treatments Installed Over the 236 Units

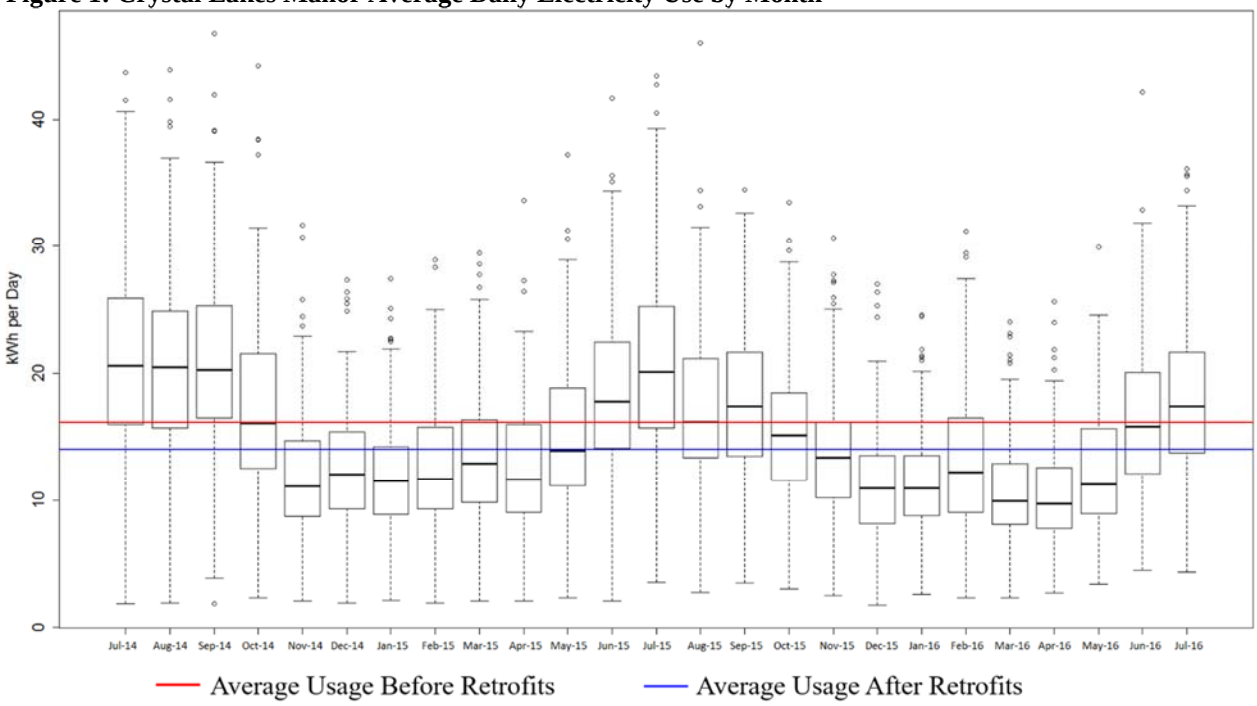
Retrofit Level	Units	Treatment types installed
Level I	3	Due to tenant health concerns, only ENERGY STAR® ceiling fans, lighting upgrades, electric water heaters, but NO blown-in attic insulation.
Level II	160	ENERGY STAR® ceiling fans, lighting upgrades, electric water heaters and additional attic insulation, but NO HVAC systems or ductwork.
Level III	7	Ductwork repair but NO HVAC systems, as well as ENERGY STAR® ceiling fans, lighting upgrades, electric water heaters and additional attic insulation.
Level IV	62	Installed HVAC systems but NO ductwork repair, as well as ENERGY STAR® ceiling fans, lighting upgrades, electric water heaters and additional attic insulation.
Level V	4	Installed HVACs and ductwork repair, as well as ENERGY STAR® ceiling fans, lighting upgrades, electric water heaters and additional attic insulation.

All units in Crystal Lake Manor received some type of energy-efficient upgrade, though not every unit received all types of upgrades. Many units only needed a few treatment replacements to achieve improved energy efficiency, while other units required a full set of treatment upgrades for the retrofits to have a positive influence on living conditions.

4.3 Crystal Lake Manor Findings

Analysis shows that the retrofits project was successful in lowering the electricity consumption throughout Crystal Lakes Manor. Prior to retrofits, average electricity consumption throughout Crystal Lake Manor was 16.15 kWh per day per unit. This fell in the year after retrofits to an average of 13.99 kWh per day per unit. This change shows overall daily electricity use throughout Crystal Lake Manor decreased 13.34 percent from the year before to the year after retrofits (Figure 1)**.**

Figure 1: Crystal Lakes Manor Average Daily Electricity Use by Month[7]



Findings show units with higher level retrofits typically experienced greater energy savings in the year after retrofits when compared to units with lower-level retrofits (Table 5).

Table 5: Crystal Lakes Manor Retrofit Levels Compared by Average Change in Electricity Use

Retrofit Level	Units Retrofitted	Units with Reported Data	Percent Compared	Post-retrofit reduction in kWh/d	Post-retrofit percentage reduction
Level I	3	3*	100%	-3.44	-15.83%
Level II	160	116	73%	-1.4	-8.98%
Level III	7	4*	57%	-0.3	-2.19%
Level IV	62	38	61%	-4.33	-24.40%
Level V	4	2*	50%	-8.92	-44.24%

**Number of units represented in this set were insufficient to draw an overall conclusion.*

Apartment size at Crystal Lake Manor had a minor impact on energy savings. Smaller one-bedroom units saw an average 13.3 percent kWh per day decrease after retrofits compared to the prior year. Larger two-bedroom units performed slightly more efficiently, with an average use decrease of 14.6 percent kWh per day.

Building 8 and 12, two identical six-unit buildings, reported full consumption data for each unit in every month. Comparing their data provides the most statistically complete picture for

[7] In this box-and-whisker plot, each box represents a month of electricity use data, and the line in the middle represents the average. Half of the observations are contained within the box. Flat line 'whiskers' represent the minimum and maximum, while dots outside the whiskers represent outliers.

understanding the impact retrofits had within a whole-building envelop. Here is their post-retrofit performance:

- Building 8: This building, comprised of six units, decreased its average kWh per day electricity consumption by 23.5 percent. Five of six units received lower Level II retrofits. The other was an interior unit that received a higher retrofit Level IV.
- Building 12: This building, comprised of six units, decreased its average kWh per day electricity consumption by 8.1 percent. The two interior units received mid-range Level IV retrofits. The other four units received lower Level II retrofits.

4.4 Crystal Lake Manor Observations

More energy savings were found in Crystal Lake Manor units that received new HVAC systems. Retrofit Levels IV and V units with new HVAC systems, consumed electricity on an average of 25.6 percent less kWh per day after retrofits compared to the prior year, which is an average decrease of 4.58 kWh per day. Retrofit Levels I, II and III units that did not receive new HVAC systems only lowered electricity use an average of 8.9 percent less kWh per day after retrofits compared to the prior year, which is an average decrease of 1.4 kWh per day.

PCHA reported a significant reduction in maintenance work orders following retrofits. In the year prior to retrofits, PCHA reported 759 labor hours on HVAC work orders, totaling $18,671 in annual maintenance costs. In the year after retrofits, labor hours were reduced to only 215 hours, totaling $5,272. This represents a savings of 28.3 percent in HVAC maintenance costs. PCHA also reported a reduction in total annual labor hours for water heater repairs, from 33 labor hours prior to retrofits to 10 labor hours after retrofits.

5. West Palm Beach Housing Authority (WPBHA) Retrofit Demonstration Project

WBPHA chose to retrofit 84 units at Robinson Village across three locations, Village 1, 2 and 3, for their project site:

- Robinson Village was built in 1986 and is comprised of 15 nearly identical buildings.
- Village 1 is the largest of the three, with 60 units across ten buildings. Nine of these were identical, each housing six 1,200 sq. ft., two-story three-bedroom/one-bath units. One building was designed to be accessible to persons with disabilities. It is one-story, with six 700 sq. ft., two-bedroom/one bath units.
- Village 2 has four buildings, with twenty identical 1,200 sq. ft. units.
- Village 3 is a single four-unit building with the same 1,200 sq. ft. floor plan.
- Rental rates were $556 per month for a two-bedroom unit and $785 per month for a three-bedroom unit.
- Robinson Village has a tenant minimum requirement, depending upon unit size. Tenants must keep a minimum occupancy to qualify and maintain eligibility for residency. For example, if a resident is required to have four occupants in a three-bedroom unit, the tenant may forfeit the lease if one child graduates and moves out.
- Robinson Village units were serviced by Florida Power & Light (FPL).

5.1 WPBHA Walk-through Energy Audits

In May 2015, WPBHA conducted walk-through energy audits using the Robinson Village unit inspection checklists (Appendix B). Based on the evaluation of the information obtained during the 84 targeted audits, WPBHA was able to identify for each unit electrical equipment in most need of replacement (Table 6).

Table 6: Robinson Village Energy Efficient Treatment Upgrades

Treatment Type	Replacement Details
Lighting	Incandescent lights were replaced with energy-efficient LED lightbulbs, 14 bulbs per unit.
Attic Insulation	R30 or less insulation was covered with additional blown-in insulation, increasing attic insulation value to R38.
Water Heaters	Original electric water heaters from 1986, in poor condition, were replaced in all units. At Village I, older, inefficient water heaters were replaced with 60 natural gas tankless water heaters following the installation of new gas lines. The other 24 units received 2015 ENERGY STAR® electric water heaters.
Attic Ventilation Ductwork	Walk-through energy audits revealed intake air leaks present and flex connection to air conditioning registers were in bad condition. Attic ductwork was sealed properly to address air leakages into attic space in all units.
HVAC Systems	Older, inefficient HVAC systems were replaced in 69 units with ENERGY STAR® 18 SEER HVAC systems.

5.2 Three Retrofit Levels

WPBHA installed three treatment retrofit levels prioritized by greatest need (Table 7). All levels received new energy efficient LED light bulbs, added attic insulation and repairs to ductwork leakages.

Table 7: Types of Energy Efficiency Treatments Installed Over the 236 Units in Robinson Village

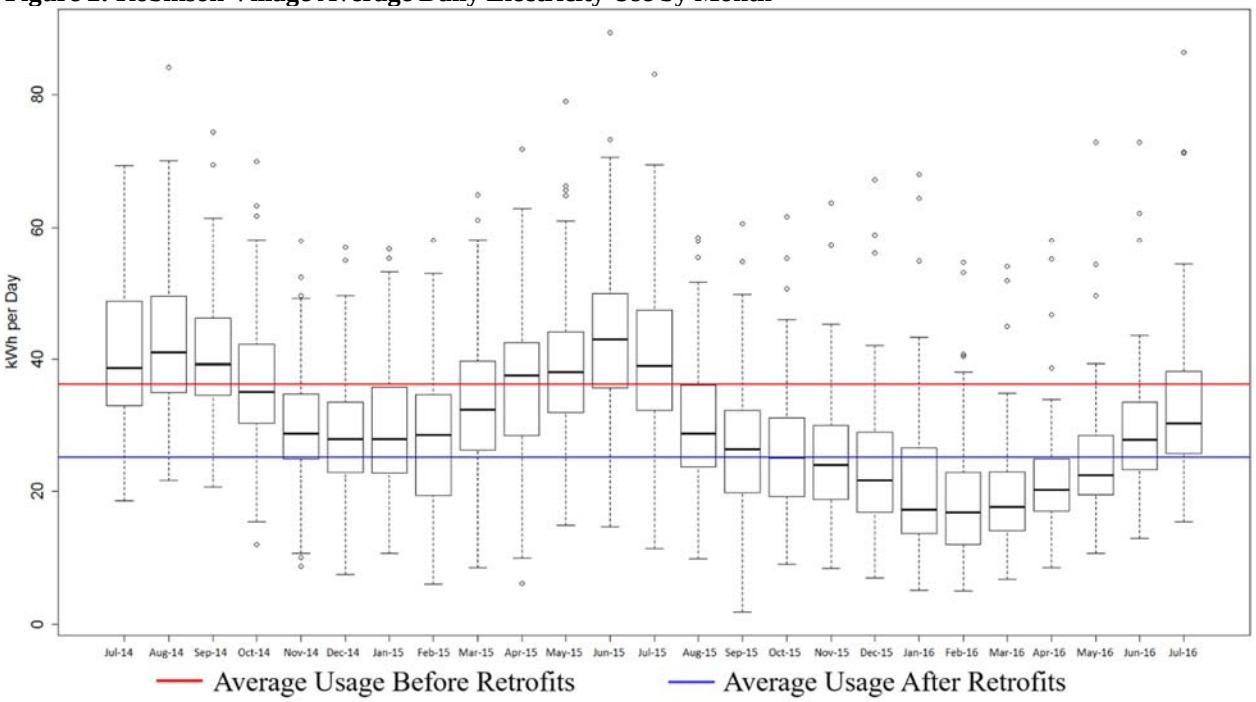
Retrofit Level	Units	Treatment types installed
Level I	15	Installed electric water heater, lighting, attic insulation, and ductwork upgrades. HVAC systems were NOT replaced. Represents four units at Village 3 and eleven units at Village 2.
Level II	9	Installed new HVAC and electric water heater, along with lighting, attic insulation and ductwork upgrades. Represents nine units at Village 2.
Level III	60	Installed new HVAC and natural gas tankless water heater, lighting, attic insulation and ductwork upgrades. Represents all 60 units at Village 1.

Because this was a demonstration project, the PHAs could choose the high efficiency treatment options appropriate to their property. When evaluating their product options, WPBHA chose to install natural gas tankless water heaters in Village 1 as a more energy-efficient option than electric. The local gas utility agreed to install new gas lines at Village 1 at no charge. Units where natural gas tankless water heaters was installed, on average, had three or more children per household. The cost to install a natural gas tankless water heater ($1,928.47) was seven times the cost of installing an energy-efficient electric water heater ($279).

5.3 Robinson Village Findings

The analysis shows that the Retrofit Demonstration Project was successful in lowering the electricity consumption throughout WPBHA. Prior to retrofits, the average electricity consumption throughout Robinson Village was 36.25 kWh per day per unit. This fell to an average of 25.24 kWh per day per unit in the year after retrofits, which is a 30.4 percent decrease of overall daily electricity use throughout all Robinson Village units from the year before to the year after retrofits (Figure 2).

Figure 2: Robinson Village Average Daily Electricity Use by Month[8]



Findings show units that received higher level retrofits experienced greater energy savings in the year after retrofits when compared to units with lower level retrofits (Table 8).

Table 8: Robinson Village Retrofit Levels Compared by Average Change in Electricity Use

Retrofit Level	Units Retrofitted	Units with Reported Data	Percent Compared	Change in kWh/d	Percent change kWh/d
Level I	15	13	87%	+1.55%	+4.16%
Level II	9	8	89%	-6.85%	-20.44%
Level III	60	52	87%	-14.81%	-40.66%

Apartment size at Robinson Village had some impact on energy savings. Smaller two-bedroom, one-story units saw an average 15.7 kWh per day decrease after retrofits compared to the previous year. Larger three-bedroom, two-story units showed an average decrease of 10.8 kWh per day for the same time frame.

Based on available electricity consumption data from Robinson Village, all 15 buildings reported enough information to compare whole-building energy savings (Appendix D).

[8] Ibid.

5.4 Robinson Village Observations

More energy savings were found in Robinson Village units that received new HVAC systems and ductwork. Units with new HVAC systems (Levels II and III) consumed electricity an average of 38.1 percent less kWh per day after retrofits when compared to the prior year, which is an average decrease of 13.7 kWh per day. Units that did not receive new HVAC systems (all of Level I and some of Level II) increased consumption an average of 4.2 percent more kWh per day after retrofits when compared to the prior year, which is an average increase of 1.6 kWh per day. These slight increases may be explained by temperature differences or changes in personal use patterns because of newer equipment.

The three buildings that showed higher electricity use were the three buildings that did not receive any HVAC systems. Two buildings at Village 2 reported an increase of only 1.7 to 2.4 percent. However, Village 3, the third building, reported an 8.8-percent increase after retrofits.

Robinson Village 2 consumption dropped less than 1 percent, from an average 34.2 kWh per day before the retrofits to an average 31.3 kWh per day after retrofits, which is an average decrease of 2.9 kWh per day. This site has 20 units throughout four two-story buildings; only nine of these received new HVAC systems. As previously stated, these slight increases may be explained by temperature differences or changes in personal use patterns because of newer equipment.

6. Recommendations

The following are recommendations for owners planning a multifamily retrofit project.

Project Focus:

1. Complete and evaluate all unit inspections prior to installing any energy efficiency retrofit treatments. Evidence shows well-conducted energy audits and targeted assessments can be effective, even when funding for higher-level retrofits are not available.

2. Short timelines should not be a reason to avoid larger retrofit projects. While a retrofit project of this scale can be complex, retrofit treatments addressing whole-building efficiency can be accomplished in a short period of time. PHAs performed most installations within 30 days, installing up to four HVAC systems per day in some cases.

Benchmarking:

3. Before beginning a benchmarking process, take time to consider what questions are being asked. This will inform project managers on which types of data should be collected. Collect more data than seems necessary so that available data can adequately answer those questions.

4. From the start, work with the utilities to identify the data needed for benchmarking, and how it should be collected. It will save time in the analysis phase to have a conversation upfront with the utilities regarding how utility data should be captured. Utilities use proprietary software, and can customize reports to meet benchmarking needs. Document this step so that staffing changes and other unforeseen changes over time do not affect data collection.

5. Unit inspection checklists were useful in understanding the various retrofit levels applied across each project. Make this a part of any project that plans to collect electricity consumption data. Consider providing specific guidelines to help each retrofit project customize its own unit inspection checklists, to be used before, during, and after treatment installation. Make it a priority to fill out each checklist completely and consistently throughout the project. The more detailed the document, the more reliable the data will be for back-end collection and analysis.

Funding:

6. If a choice must be made between installing a new high SEER ENERGY STAR® HVAC system or installing a series of lower-level energy efficiency equipment across multiple units, statistical results suggest replacing old HVAC systems results in more energy savings than any other action. Retrofitted units where the HVAC was not replaced show significantly lower energy savings, even when lower-level energy efficiency equipment was installed. Replacing older, poorly functioning HVACs can also result in lower maintenance repair time and costs.

7. When weighing where best to invest in treatment types, electric water heaters will have less overhead costs and are quicker to install than natural gas tankless water heaters, and the difference in cost leaves more in the budget for other higher priced appliances, including HVAC systems and duct repair.

8. When considering large-scale multifamily retrofit projects, determine first what, if any, additional layer of local government fees will result from the installation of new equipment. For example, some counties and municipalities charge a separate fee for each natural gas line and hookup.

9. The older the complex that is retrofitted, the higher the energy savings result, especially where electricity consuming equipment has outlived its normal life-cycle. Electric water heaters tend to last approximately 10years, while HVAC systems may last between 15 to 20 years. Both will have increased maintenance needs as they age.

Tenant Considerations:

10. Provide tenants with information before, during, and after a retrofit project to encourage participation and promote energy efficiency practices. Retrofits are disruptive, so efforts toward cooperation can prevent unnecessary delays. Informed consumers are more likely to be supportive of the project, willing to sign utility release waivers and be more accommodating when unit access is needed for the retrofits.

APPENDIX A

Sample Crystal Lake Manor Unit Inspection Checklist used to document retrofits.

In the two left columns, an inspector records unit conditions during the walk-through. The third column allows the property owner to assess unit needs. The last column can be used to mark completed retrofits.

Unit Number

Bedroom Size

Crystal Lakes Manor
2015 Energy Grant Inspections
Pinellas County Housing Authority

Inspection completed by:
Time to complete inspection:

	Initial Inspection	Status of Product	For office use only:		Final Inspection
Date of Inspection	/2015	*(Good/ Fair/Poor)*	To be replaced with energy grant		/2015 *Item Replaced/Repaired (Y/N/na)*
Living/Dining					
Incandescent light existing (Y/N)			Needs replaced		
Florescent light (Y/N)			n/a		
Ceiling Fan w/ Light (Y/N)			Needs replaced		
If (Y) - Why is replacement necessary					
Age (Y/N)					
Operational (Y/N)					
Kitchen					
Incandescent light existing (Y/N)			Needs replaced		
Florescent light (Y/N)			n/a		
Ceiling Fan w/ Light (Y/N)			Needs replaced		
If (Y) - Why is replacement necessary					
Age (Y/N)					
Operational (Y/N)					
Bedroom 1					
Incandescent light existing (Y/N)			Needs replaced		
Florescent light (Y/N)			n/a		
Ceiling Fan w/ Light (Y/N)			Needs replaced		
If (Y) - Why is replacement necessary					
Age (Y/N)					
Operational (Y/N)					
Bedroom 2 (if applicable)					
Incandescent light existing (Y/N)			Needs replaced		
Florescent light (Y/N)			n/a		
Ceiling Fan w/ Light (Y/N)			Needs replaced		
If (Y) - Why is replacement necessary					
Age (Y/N)					
Operational (Y/N)					
Bathroom					
Incandescent light existing (Y/N)			Needs replaced		
Florescent light (Y/N)			n/a		
Hallway					
Incandescent light existing (Y/N)			Needs replaced		
Florescent light (Y/N)			n/a		
Hot water heater					
Energy Factor (indicate level, i.e. .88)	.		Needs replaced		.

All incandescent fixtures and existing old ceiling fans needs replacement with energy efficient lights and fans
All hot water heaters with an energy factor of less than .88 should be replaces with a hot water heater with an energy factor of .92 or greater

APPENDIX B

Sample of Robinson Village Unit Inspection Checklist used to document retrofits.

In the two left columns, an inspector records unit conditions during the walk-through. The third column allows the property owner to assess unit needs. The last column can be used to mark completed retrofits.

Unit Number | **Bedrooms**

Robinson Village
2015 Energy Grant Inspections
West Palm Beach Housing Authority

Inspection completed by:
Time to complete inspection:

	Initial Inspection	Status of Product	For office use only:	Final Inspection
Date of Inspection	/2015	*(Good/ Fair/Poor)*	To be replaced with energy grant	/2015 *Item Replaced/*
Living/Dining				
Incandescent light existing (Y/N)			Replace Incandescent bulbs with LED bulbs	
Florescent light (Y/N)			n/a	
Ceiling Fan w/ Light (Y/N)			Replace Incandescent bulbs with LED bulbs	
If (Y) - Why is replacement necessary				
Age (Y/N)				
Operational (Y/N)				
Kitchen				
Incandescent light existing (Y/N)			Replace Incandescent bulbs with LED bulbs	
Florescent light (Y/N)			n/a	
Ceiling Fan w/ Light (Y/N)			Replace Incandescent bulbs with LED bulbs	
If (Y) - Why is replacement necessary				
Age (Y/N)				
Operational (Y/N)				
Bedroom				
Incandescent light existing (Y/N)				
Bedroom				
Incandescent light existing (Y/N)				
Bedroom				
Incandescent light existing (Y/N)				
Closet				
Incandescent light existing (Y/N)			Replace Incandescent bulbs with LED bulbs	
Closet				
Incandescent light existing (Y/N)			Replace Incandescent bulbs with LED bulbs	
Closet				
Incandescent light existing (Y/N)			Replace Incandescent bulbs with LED bulbs	
Bathroom				
Incandescent light existing (Y/N)			Replace Incandescent bulbs with LED bulbs	
Florescent light (Y/N)			n/a	
Hallway				
Incandescent light existing (Y/N)			Replace Incandescent bulbs with LED bulbs	
Florescent light (Y/N)			n/a	
Insulation				
R level (indicate level i.e. R30)			Needs additional	
Hot water heater				
Energy Factor under .92			Needs replaced	
HVAC Duct Repair				
In need of repair (Y/N)			Needs repair	
If (Y) - Why are repairs necessary				
Air leakage (Y/N)				
Loose tape (Y/N)				
Tears (Y/N)				
Indicate other reason				
HVAC Replacement				
Air Handler (Year, SEER #, other)			Needs replaced	
Condensing Unit (Year, SEER #, other)			Needs replaced	

All incadescent lighting will have new LED bulbs installed
All hot water heaters with an energy factor of less than .88 should be replaces with a hot water heater with an energy factor of .92 or greater
All HVAC ducts that are leaking, torn, loose, or in disrepair should be replaced or repaired
All HVAC equipment with a 13 SEER unit or under needs replacement with a 16 SEER unit or greater.
All insulation under R38 needs additional insulation added up to an R38 or greater

APPENDIX C

Data analysis results of PCHA electricity consumption at the building level (Page 11).

Crystal Lake Manor Building ID	Building Level Average Usage (kWh/d) Year Before Retrofits	Building Level Average Usage (kWh/d) Year After Retrofits	Usage Change (kWh/d) After Retrofits	Percentage Usage Change After Retrofits
1	16.23	14.81	-1.42	-8.8%
2	17.30	14.30	-3.00	-17.3%
3	13.48	10.72	-2.76	-20.5%
4	18.30	12.82	-5.49	-30.0%
5	17.42	15.01	-2.41	-13.8%
6	10.02	9.42	-0.60	-6.0%
7	14.08	13.24	-0.84	-6.0%
8	16.07	12.28	-3.78	-23.5%
9	21.74	18.30	-3.44	-15.8%
10	17.51	15.00	-2.51	-14.3%
11	16.82	17.07	0.25	1.5%
12	16.03	14.73	-1.30	-8.1%
13	20.43	17.62	-2.80	-13.7%
14	16.76	14.56	-2.21	-13.2%
15	16.95	13.30	-3.65	-21.5%
16	13.56	13.68	0.12	0.9%
17	17.89	15.06	-2.83	-15.8%
18	20.85	18.76	-2.09	-10.0%
19	14.91	12.43	-2.48	-16.7%
20	21.43	21.56	0.13	0.6%
21	18.06	11.96	-6.10	-33.8%
22	19.23	13.69	-5.55	-28.8%
23	11.64	10.35	-1.29	-11.1%
24	14.64	15.02	0.39	2.7%
25	17.94	15.88	-2.06	-11.5%
26	12.70	11.38	-1.32	-10.4%
27	15.15	13.37	-1.78	-11.7%
28	20.81	18.80	-2.01	-9.7%
29	17.94	11.75	-6.19	-34.5%
30	19.94	14.90	-5.03	-25.2%
31	21.09	15.34	-5.75	-27.3%
32	15.96	13.38	-2.58	-16.2%
33	16.25	15.10	-1.14	-7.0%
34	17.10	11.29	-5.81	-34.0%
35	14.95	14.48	-0.47	-3.2%
36	12.90	13.92	1.03	7.9%
37	13.15	13.54	0.40	3.0%
38	16.32	14.88	-1.44	-8.8%
39	14.11	8.55	-5.56	-39.4%
40	13.27	11.68	-1.59	-12.0%
insert41	12.16	10.78	-1.39	-11.4%
42	0.00	0.00	0.00	No Data

43	20.75	18.84	-1.91	-9.2%
Crystal Lake Manor Building ID	Building Level Average Usage (kWh/d) Year Before Retrofits	Building Level Average Usage (kWh/d) Year After Retrofits	Usage Change (kWh/d) After Retrofits	Percentage Usage Change After Retrofits
44	13.01	11.38	-1.62	-12.5%
45	12.37	11.24	-1.13	-9.1%
46	16.23	16.71	0.47	2.9%
47	15.81	16.68	0.87	5.5%
48	23.53	19.22	-4.31	-18.3%

APPENDIX D

Data analysis results of WPBHA electricity consumption at the building level (Page 15).

Robinson Village Building ID	Building Level Average Usage (kWh/d) Year Before Retrofits	Building Level Average Usage (kWh/d) Year After Retrofits	Usage Change (kWh/d) After Retrofits	Percentage Usage Change After Retrofits
1	39.34	22.28	-17.07	-43.38%
2	34.60	20.81	-13.79	-39.85%
3	28.98	20.61	-8.36	-28.86%
4	32.46	21.36	-11.10	-34.21%
5	42.62	24.72	-17.90	-42.00%
6	39.56	24.93	-14.63	-36.99%
7	33.25	21.83	-11.42	-34.34%
8	42.87	24.20	-18.67	-43.56%
9	33.49	17.24	-16.25	-48.52%
10	32.65	16.96	-15.68	-48.04%
11	43.57	47.39	3.82	8.77%
12	35.24	28.94	-6.30	-17.88%
13	32.50	26.32	-6.17	-19.00%
14	32.30	32.83	0.53	1.65%
15	36.83	37.73	0.89	2.43%