

Applying Best Practices to Florida Local Government Retrofit Programs

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*Building America Partnership for Improved Residential
Construction (BA-PIRC)*

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Definitions

ACCA	Air Conditioning Contractors of America
ACH50	Air changes per hour at a standard test pressure difference of 50 Pascals
AHU	Air handling unit
BA-PIRC	Building America Partnership for Improved Residential Construction
BEopt	Building Energy Optimization software
CFL	Compact fluorescent lamp
COP	Coefficient of performance
DOE	U.S. Department of Energy
EF	Energy factor
FSEC	Florida Solar Energy Center
HERS	Home Energy Rating System
HSPF	Heating seasonal performance factor
HVAC	Heating, ventilation, and air conditioning
JCHS	Joint Center for Housing Studies
kWh	Kilowatt hour
NFRC	National Fenestration Rating Council
NSP	Neighborhood Stabilization Program
QA	Quality assured
SEER	Seasonal energy efficiency ratio
SHGC	Solar heat gain coefficient

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Executive Summary

Approximately 70% of America’s 132 million existing homes were constructed prior to the 1990s (U.S. Census Bureau 2011), when states began adopting residential energy codes. Improving the energy efficiency of even a portion of these homes could generate substantial energy savings. Many local government and nonprofit entities have funds to renovate distressed, foreclosed homes in this vintage for the affordable housing market. They have numerous opportunities to improve whole-house energy efficiency because of neglect and deterioration of both the envelope and major equipment. While motivation to capitalize on these opportunities is high, conflicting information in the marketplace and variations in house condition complicate decision-making.

During 2009, 2010, and 2011, researchers of DOE’s Building America Partnership for Improved Residential Construction (BA-PIRC) provided analysis and recommendations to eight affordable housing entities conducting comprehensive renovations in 70 distressed, foreclosed homes in central Florida (Phase 1). Partners achieved a mutually agreed upon goal of 30% improvement in Home Energy Rating System (HERS) Index score in 46 renovations.

The study found that moderately more efficient replacement components and additional efficiency enhancements can be combined to cost-effectively achieve projected annual whole-house energy savings of 15%–30% and higher in typical existing homes in central Florida. Improvement levels correlated more closely with pre-retrofit HERS Index scores, an indicator of whole-house efficiency, than with age of the home, which might be thought of as an indicator of relative inefficiency.

At the end of Phase 1, researchers identified the most prevalent strategies in the deep retrofits and compiled a set of best practices appropriate to the current labor pool and market conditions in central Florida (McIlvaine et al. 2013a).¹ The strategies apply variably to homes depending on existing conditions, simplifying decision-making for retrofit program managers and staff.

In Phase 2, the best practices were refined based on feedback from new partners: the City of Melbourne and the City of Fort Myers (Appendix A; McIlvaine et al. 2013b). Both partners incorporated the best practices into master specifications for community-scale renovation programs. The City of Fort Myers subsequently shifted activity to redevelopment. The Melbourne program included 10 renovations; seven were completed at the time of this report.

Researchers posed four research questions in Phase 2 in preparation for broader deployment of the best practices:

- Research question #1: What range of energy efficiency cost savings can be expected from implementation of the current best practices in a variety of implementation scenarios?

The answer varies with the pre-retrofit whole-house efficiency and condition of major energy-related characteristics. Fewer of the best practices are relevant to homes that do not need energy-

¹ All subsequent reference to “best practices” refers to the current best practices reported by McIlvaine et al. (2013a). The best practices were refined and revised at the end of Phase 2 and published as a working document (McIlvaine et al. 2013b). The revised, Version 2, best practices are included in Appendix A.

related replacements or that have relatively high whole-house efficiency. Researchers found typical specifications drawn from the best practices result in 19%–28% projected annual energy cost savings compared to minimum efficiency retrofit options when applied to an average distressed home (HERS Index ~130). This was reflected in both field work and simulation.

- Research question #2: To what extent are partners willing and able to adopt the best practices?

Program managers and staff were willing to adopt improvements if there was compelling evidence that the benefit to the occupants justified the investment, and that implementation would be practical given program boundaries and existing market conditions (labor, availability, code compliance, etc.). The decision-making process included input from multiple program stakeholders including top management, field work management, and contractors. In some cases, staff found that the cost and availability of higher performance options had changed since they last reviewed the market. Additionally, implementation of the best practices was easier to manage in stages. Achieving new goals was aided by developing clear, standardized language for bid documents and work write-ups.

- Research question #3: What steps (training, test houses, presentations to decision-makers, provision of research results, etc.) help to engage partners in implementation?

Group discussions with administrators, financial, and field staff that encompassed building science, practical applications, and financial considerations clearly helped to build momentum, confidence, and interest. True engagement seemed to arise coincident with conducting simulation analysis to answer a partner’s specific questions (e.g. seasonal energy efficiency ratio [SEER] 13 versus SEER 15) and to compare their standard approach to the best practices in one of their real projects. The former contributed to confident decision-making. An important step in implementation of unfamiliar details, such as sealing return plenums, required prototyping in test homes to give staff and contractors guided, first-hand experience.

In Phase 2, it was intended that this support would come from a certified home energy rater or other qualified consultant rather from researchers. In the case of the City of Melbourne, there were no funds available for such support. This will likely be a barrier to wider adoption of the best practices.

- Research question #4: Which elements, if any, required technical assistance from BA-PIRC? Can the language of the best practices be adjusted to overcome this need?

The City of Melbourne implemented the majority of best practices applicable to its homes. For elements involving unfamiliar building science concepts, there was a need to provide training on heat, air, and moisture flow dynamics to allay concerns. This could constitute a barrier to implementation in the absence of a qualified professional with a building science background. If the reasoning behind a practice is not well understood, there is a risk that it will be a lower priority practice. It is unlikely that this can be resolved in the context of a document focused on best practices; however, Building America publications available through the website, online training through programs such as ENERGY STAR[®] for Homes, and the emerging Building

America Solution Center provide excellent resources to serve program staff who are motivated to learn building science principles and applications.

Eight “lessons learned” presented in the conclusions provide recommendations for local governments and nonprofit affordable housing providers on incorporating the best practices into master specifications for community-scale deep retrofits.

These lessons, combined with the refined best practices documented in Appendix A, provide guidance for program managers striving to achieve deep retrofit goals in the context of a foreclosed home renovation in pre-energy code era homes.

1 Introduction

Approximately 70% of America’s 132 million existing homes were constructed prior to the 1990s (US Census Bureau 2011), when states began adopting residential energy codes. Improving the energy efficiency of even a portion of these homes could generate substantial energy savings.

In many communities, local government and nonprofit entities have funds to purchase and renovate distressed, foreclosed homes for resale in the affordable housing market. Numerous opportunities to improve whole-house energy efficiency are inherent in these comprehensive renovations. In 2009, researchers of the Building America Partnership for Improved Residential Construction (BA-PIRC) began talking to affordable housing providers in Florida about capitalizing on these opportunities. While motivation to capitalize on these opportunities is high, conflicting information in the marketplace and variations in house condition complicate decision-making. Program managers requested recommendations that could be applied unilaterally across all homes in their programs.

Researchers worked with about a dozen programs in a multiyear field study, making recommendations in individual homes, meanwhile compiling improvement costs, projected energy savings, practical challenges, and labor force factors surrounding common energy-related renovation measures. The field study, Phase 1 of this research, resulted in a set of current best practices appropriate to the current labor pool and market conditions in central Florida (McIlvaine et al. 2013a).² We found that moderately more efficient replacement components and additional efficiency enhancements can be combined to cost-effectively achieve projected annual whole-house energy savings of 15%–30% and higher.

In Phase 2, researchers conducted a simulation study and worked with a local government partner to implement and refine the “current best practices.” Our new local government partner, the City of Melbourne, implemented the best practices in a community-scale renovation program that included 10 homes in 2012. Additionally, a simulation study was conducted to characterize savings potential in the same home under three sets of as-found conditions (Scenarios 1, 2, and 3). These represent varying two levels of renovation expenditure and three levels of replacement needs that apply readily to the general remodeling industry as well as renovation of distressed, foreclosed homes for the affordable housing market.

1.1 Remodeling Industry Trends and Spending

The downturn in construction activity affected new construction far more than remodeling, which dropped to slightly above 2003 levels (Figure 1). Since 2005, the remodeling industry’s share of total residential construction investment has steadily risen (JCHS 2011a). In fact, the value of private remodeling activity exceeded that of private single-family new construction by 1% in 2009 and 2010 (Figure 1).

² All subsequent reference to “best practices” refers to the current best practices reported by McIlvaine et al. (2013a). The best practices were refined and revised at the end of Phase 2 and published as a working document (McIlvaine et al. 2013b). The revised, Version 2, best practices are included in Appendix A.

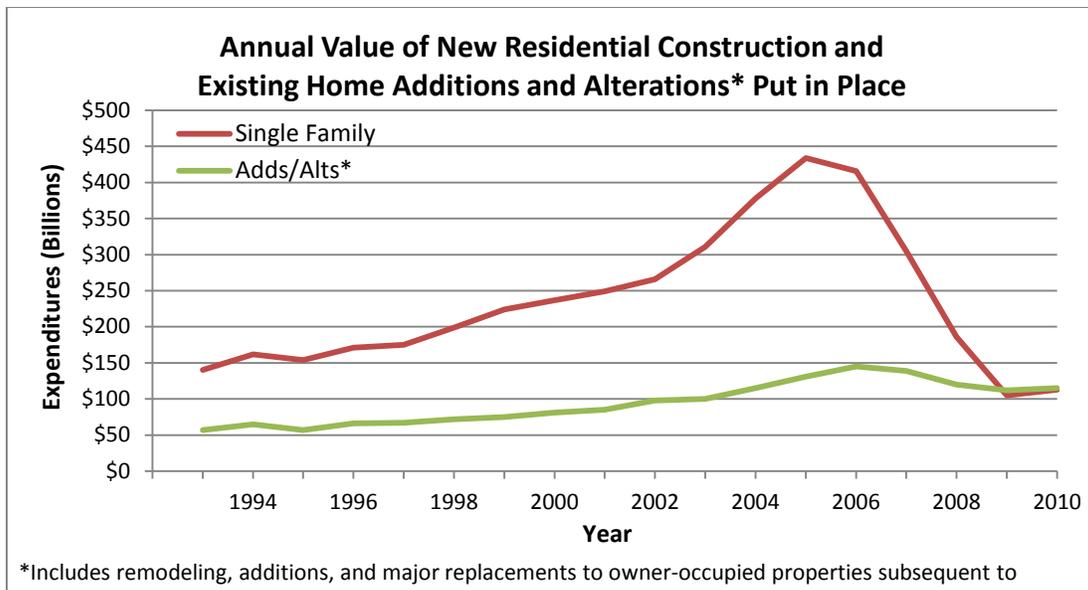


Figure 1. The value of private remodeling activity exceeded that of private single-family new construction by 1% in 2009 and 2010

(U.S. Census Bureau 2012)

The Joint Center for Housing Studies (JCHS) at Harvard University and the Home Improvement Research Institute collect and analyze data relating to household remodeling spending. Based on 2009 data presented by JCHS (2011b), owners spent just over \$6,000 annually during the first 2 years of ownership (\$12,000 combined). This figure was more than double the usual amount, which averages \$2,500 (JCHS 2011b). This suggests a renovation effort that includes replacement of one or more major components or equipment.

According to the Home Improvement Research Institute, buyers of distressed homes, such as the ones involved in this study, spend an average of 14% more on improvements within the first year of ownership than buyers of nondistressed homes (JCHS 2011b). This is attributed to the lack of maintenance undertaken while homes have been in foreclosure or vacant (JCHS 2011b). As exhibited by projects in Phases 1 and 2 of this research, energy-related improvements are often included in these major renovations of distressed homes to replace worn-out equipment and components or bring homes up to market standards. Distressed homes were identified as those bought from financial institutions, purchased as short sales, or with loans that were either delinquent or in the foreclosure process in the JCHS report (2011b). The data are not disaggregated by buyer type, such as primary residence, investor, or publicly funded programs.

Additionally, the amount spent repairing distressed homes at time of sale appears to be trending upward. Baker (2012) shows that Fannie Mae spending on foreclosed home repairs rose from \$5,600 in 2010 to \$6,100 in 2011.

This research (Phases 1 and 2) focuses on publicly funded programs that rehabilitate and renovate foreclosed homes; however, the previously described findings suggest that the research may be relevant to buyers and owners, in general, undertaking the improvement of distressed properties. Partners in Phase 1 were mostly recipients of Neighborhood Stabilization Program

(NSP) funding awarded by the U.S. Department of Housing and Urban Development for the purchase and renovation of foreclosed homes for resale as affordable housing. Proceeds from sales are reinvested to continue the work.

Phase 1 of this research was a field study of 70 comprehensive Florida (hot-humid climate) renovations conducted from mid-2009 through the end of 2011 by 10 nonprofit and local government housing entities, mostly NSP recipients. Findings are detailed by McIlvaine et al. (2013a). Key findings underpinning and relevant to Phase 2 are presented here for convenience.

1.2 Phase 1 Summary

The partnership goal was a 30% improvement in Home Energy Rating System (HERS) Index score between pre-retrofit and post-retrofit conditions while preserving or enhancing occupant safety, indoor air quality, building durability, and comfort at a cost-neutral price point. This is roughly equivalent to the program goal of 30% reduction in projected energy cost set forth in the Building America House Simulation Protocols (Hendron and Engebrecht 2010). Such renovations are referred to as “deep energy retrofits.” The goal criterion was modified slightly in Phase 2 to improve consistency with other Building America research.

No utility data were available for these unoccupied homes. Improvement was assessed by comparing the HERS Index score and the projected annual energy cost of pre- and post-retrofit conditions of each house as assessed during pre- and post-retrofit audits.

Nearly all the distressed homes in Phase 1 needed multiple energy-related improvements. The average HERS Index score improvement (pre- versus post-retrofit) among the 70 houses was 34%, with average projected annual energy cost savings of 25%. The deep retrofit goal was met in 46 homes with an average HERS Index score improvement of 41%, ranging from 30% to 60%.

The study found that moderately more efficient replacement components and additional efficiency enhancements can be combined to cost-effectively achieve projected annual energy savings of 15%–30% and higher in typical existing homes in central Florida. Improvement levels correlated more closely with pre-retrofit HERS Index scores, which reflect home improvements and replacements, than with vintage.

The most prevalent improvements among the deep retrofits were coalesced into a set of current best practices reported by McIlvaine et al. (2013a).

1.2.1 Development of the Current Best Practices

The current best practices were distilled from the choices made by partners for 70 homes in the current marketplace. In addition to projected energy savings, *current marketplace conditions* influenced decisions including cost and availability, buyer expectations, skills and preferences of trade contractors, and program expectations, policies, and limitations. This methodology differs from a simulation optimization study, such as that conducted for “pre-code” homes by Fairey and Parker (2012) that examined a set of retrofit opportunities for the hot-humid climate similar to those found in the Phase 1 field study. The distilled “current best practices” represent what is currently accepted as practical and feasible to contractors, funding agencies, and trades in the affordable housing sector, which is traditionally risk averse and very cost conscious.

Another factor influencing energy improvement choices was that the overall scope of renovation in each house was set prior to purchase based on the condition of major components (e.g., structure, finishes, fixtures, windows) and equipment so that investment needed to restore the home to market acceptance could be weighed against the anticipated sale price. Unless a component or piece of equipment was at or near the end of its useful life (herein referred to as “replacement at wear out”) or below market expectations, it was not slated or even considered for replacement. Analysis provided to partners included moderately higher performance specifications for replacements and efficiency enhancements (excluding replacements at wear out) such as compact fluorescent lamps (CFLs) and ceiling insulation. Researchers developed an improvement package that collectively generated a positive first-year cash flow with a 30% improvement of HERS Index score between pre-retrofit and post-retrofit conditions.

The current best practices reflect partner choices in the existing marketplace and labor force. Researchers found 13 key strategies that were evident in the field study (Table 1). Those formed the basis of the best practices. To that, we added some known missed opportunities and building science measures not thoroughly implemented but deemed necessary for high performance housing. In particular, a passive outside air ventilation system was recommended for all 70 houses; however, only one included this. Reasoning is discussed in the field study report (McIlvaine et al. 2013a).

Table 1. Prevalence of 13 Key Efficiency Strategies Implemented

13 Key Efficiency Strategies	Deep Retrofits (n = 46)	Non-Deep Retrofits (n = 24)	All Houses (n = 70)
1. Higher cooling and/or heating efficiency at replacement	96%	71%	87%
2. Additional ceiling insulation	93%	63%	83%
3. Better whole-house airtightness (ACH50^a)	92%	77%	88%
4. Better measured³ air distribution (duct) tightness (Q_{n,out})	86%	68%	80%
5. Lower solar heat gain coefficient (SHGC) window film or windows at replacement windows	80%	46%	67%
6. ENERGY STAR® refrigerator at replacement	76%	71%	74%
7. Slightly higher efficiency water heater at replacement (electric EF=0.92)	70%	38%	59%
8. 30% more fluorescent fixtures/bulbs	52%	42%	49%
9. Programmable thermostat	48%	42%	46%
10. Replaced duct system	39%	13%	30%
11. Higher reflectivity exterior wall color at replacement	30%	8%	23%
12. Higher reflectivity roof shingles at replacement	30%	13%	24%
13. Higher efficiency ceiling fan(s) at replacement	15%	13%	14%

a. Air changes per hour at a standard test pressure difference of 50 Pascals.

³ Duct leakage to the outside measured under depressurization conditions according to ASTM test results normalized for conditioned square footage (ASTM International 2013).

These practices, too, relate to readily available, off-the-shelf technology and current labor and market conditions in the affordable housing sector. Higher performance specifications than those most evidenced in the field study may be cost effective; however, they were passed over for various reasons. This is explored in the field study report (McIlvaine et al. 2013a).

Phase 1 key finding: The deep retrofit improvement packages (30% improvement in HERS Index score) were very similar but produced varying degrees of improvement because of varying degrees of pre-retrofit whole-house efficiency. The non-deep retrofits included many of the same best practices, but fewer in each home.

1.2.2 Cost Effectiveness

In both Phase 1 and Phase 2, cost effectiveness compared projected annual energy cost savings and the annual increase in mortgage cost for the improvement package. First cost estimates came from partners' previous projects or cost data in the Building America Building Energy Optimization (BEopt) software. Cost effectiveness is considered achieved if 1 year of projected savings exceeds 1 year of increased mortgage burden from financing the first cost. In the case of improvements made strictly for efficiency enhancement, such as ceiling insulation, the increased mortgage burden was calculated using the full first cost of the improvement which was then compared to full projected annual savings. However, for replacement equipment, which was selected by partners only when it was needed from a functionality standpoint, analysis considered only the cost and benefit of making a higher efficiency choice. For example, when partners determined that an air conditioner would be replaced, it was often a seasonal energy efficiency ratio (SEER) 10 unit, which is no longer available on the market. Even a minimum efficiency replacement under U.S. Department of Energy (DOE) appliance standards (a SEER 13 unit) would generate significant savings. Analysis was done to project the additional or incremental savings generated by choosing a SEER 15 air conditioner instead of the minimum efficiency SEER 13 replacement, ignoring the savings gained between the SEER 10 and SEER 13 systems. That incremental savings was then compared to the incremental cost of the higher efficiency replacement over the minimum efficiency replacement.

In Phase 1 of the study, only mechanical equipment replacements were treated in this manner. But in Phase 2, researchers adopted several other minimum replacement specifications for windows, water heaters, and refrigerators related to Building America program standards for benchmarking rather than market availability. This change makes the analysis more consistent with other Building America existing homes analysis, specifically analysis done with BEopt's existing home reference building.

The cost effectiveness goal for this study was cost-neutral, first-year cash flow, which compares the increase in annual mortgage cost to the projected annual energy cost savings. When annual savings exceed increased annual mortgage cost, a positive cash flow results from the first year of occupancy onward. This method of assessing cost effectiveness is applicable to programs such as NSP that sell homes after renovation. However, it does not factor in the expected lives of items that will need replacement during the loan period. The mortgage terms of 30 years at 7% interest used in the analysis are consistent with other Building America projects. Cash flows would be higher under mortgage rates typical of the current market. The post-retrofit sales price was not a part of the evaluation.

Partners reported costs for 42 of the 46 deep retrofits. *Incremental* (premiums for higher performance options combined full cost for efficiency-only improvements) ranged from \$780 to \$8,382 with an average of \$3,854. There was a positive cash flow in 36 of the retrofits, ranging from a few dollars to \$626. The average first-year annual cash flow for the 46 deep retrofits was positive (\$169).

Phase 1 key finding: The deep retrofit improvement packages generated positive first-year cash flow of varying degrees with reasonable incremental cost within the context of a major renovation.

1.2.3 Phase 1 Gaps and Barriers Addressed in the Best Practices

Several gaps and barriers identified in Phase 1 are addressed in the best practices included in Appendix A of this report. Key findings include:

- A home energy rater or similar professional can provide skills and knowledge to the implementation planning, training, and analysis process to help fill the building science knowledge gap.
- A home energy rater or similar professional can provide post-retrofit testing to ensure targets have been met that cannot be assessed visually.
- Lists of common leakage points for whole-house and duct air sealing can increase the likelihood that airtightness targets are met without a contractor recall.
- The Florida residential mechanical code includes requirements for system and equipment sizing, equipment and duct installation, and construction detailing for new construction that can be applicable, though not required, in existing homes.

1.3 Phase 2 Goals and Research Questions

In Phase 2 of this study, researchers investigated three implementation scenarios for the current best practices and a community-scale implementation by the City of Melbourne. A second partner, the City of Fort Myers, completed the first segment of partnership but subsequently shifted activity to redevelopment. The following research questions are addressed:

- What range of energy efficiency improvement can be expected from implementation of the current best practices in the three implementation scenarios?
- To what extent are partners willing and able to adopt the best practices?
- What steps (training, test houses, presentations to decision-makers, provision of research results, etc.) help to engage partners in implementation?
- Which elements, if any, required technical assistance from BA-PIRC? Can the language of the best practices be adjusted to overcome this need?

2 Expected Improvement Results From Implementation of the Best Practices

The best practices reflect the varying degree of efficiency in the existing housing stock. There is no one-size-fits-all improvement package for deep retrofits. For example, almost all of the deep retrofits in Phase 1 included replacement of worn-out or missing mechanical equipment. However, making mechanical system replacement part of a standardized deep retrofit improvement package, regardless of need, would be imprudent. The *incremental* cost of a higher efficiency replacement can be justified based on first-year cash flow; however, the *full* cost of a system replacement cannot. For each category of energy-related renovation activity, the language of the best practices differentiates those that apply to replacement choices at “wear out” from those that apply when no replacement is needed. This means that the best practices are differentially applicable to houses in varying conditions. In a community-scale program, a range of efficiency improvement will be achieved from application of the best practices to the extent that the homes vary in as-found, whole-house efficiency and remaining service life of key equipment and components.

To assess what range of energy efficiency improvement might result from application of the current best practices at community scale, researchers produced a simulation analysis for three scenarios likely to manifest in any given community. A HERS Index score for a pre-energy code home of 1970s vintage was derived by selecting the most typical or approximate average characteristics of the 70-home dataset. Airtightness levels are representative of similar-aged homes from the field study. The resulting 131 HERS Index score is just slightly higher than the 70-home dataset average of 129. This was also deemed to be an appropriate base model because homes with this level of whole-house efficiency or worse have a very good chance of achieving 30% improvement over the pre-retrofit HERS Index score by implementing a combination of the best practices. This is evidenced by the linear regression line in Figure 2 that shows the fit between the pre- and post-retrofit HERS Index for the whole 70-house dataset ($R^2 = 0.4994$). Only two homes (red diamonds) with pre-retrofit HERS Index score above 124 failed to achieve a 30% improvement when comparing pre-retrofit to post-retrofit HERS Index.

For reference, although the Florida energy code and the HERS Index calculation methodology do not have one-to-one correlation, researchers find that code compliant new homes in Florida generally score in the mid to upper 80s on the HERS Index.

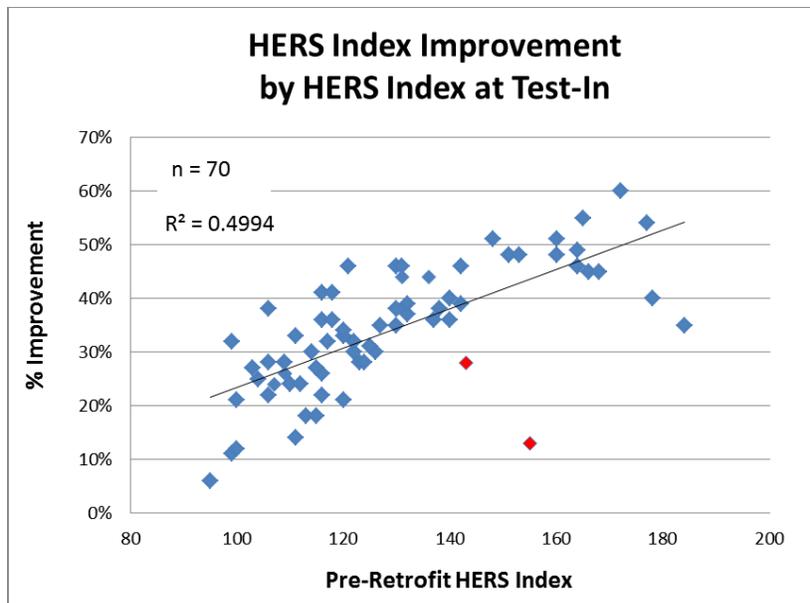


Figure 2. HERS Index improvement compared to the pre-retrofit HERS Index for the whole 70-house dataset

Table 2 lists key energy-related characteristics and projected annual energy source energy generated with BEopt and site energy use, energy cost, and the HERS Index score generated with EnergyGauge USA.⁴

Table 2. Energy-Related Characteristics of Base Home

Characteristic	As-Found Base Home Specification
Location, Climate Zone	Orlando, Florida, climate zone 2
General	1,422 ft ² , typical for 1960s construction in 70-home field study, 3 bed, 2 bath
Utility rate	\$0.12/kWh (typical Florida)
Roof Finish	Medium colored asphalt shingles; solar absorptance = 0.85; vented
Ceiling Insulation	R-15 ceiling insulation, vented attic
Exterior Walls	R-4.7 concrete masonry units, solar absorptance = 0.6
Windows	Single, clear, metal (U = 1.16; SHGC = 0.76)
Floors	60% tile
Whole-House Infiltration	ACH50 = 14
Heating and Cooling System	10 SEER; 2.5 ton; electric resistance heat; COP ^a = 1
Air Distribution System	Leakage 18% @ supply leak (Qn,out = 0.19); R-6

⁴ Projections generated by EnergyGauge USA, an hourly energy use simulation software, were used for analysis during partnership development and tracking. BEopt analysis was conducted for Building America program reporting and project tracking, but BEopt simulation results were not used for partnership activity or final analysis because of modeling challenges related to existing house reference home characteristics.

Characteristic	As-Found Base Home Specification
Supply/Return/Air Handler Locations	Attic/interior/interior
Water Heating System	40 gal, electric; EF ^b = 0.88
Refrigerator	18 in. ³ ; 540 kWh ^c /year
Lighting	20% CFLs (1474 kWh/year)
Fans	Standard default
Projected Annual Source Energy Use (MBtu) (BEopt)	195
Projected Annual Source Energy Use (kWh) (Energy Gauge USA)	21,132
Annual Energy Cost (Energy Gauge USA)	\$2,535
HERS Index	131

^a Coefficient of performance

^b Energy factor

^c Kilowatt-hour

The three scenarios modeled to assess the potential range of savings represent varying conditions in the as-found home that do not affect the HERS Index. Specifically, the useful lives left in the items delineated in Table 2 above have implications for the cost effectiveness of making efficiency improvements. If a refrigerator needs to be replaced, a very small incremental investment (i.e., cost premium) can render savings. On the other hand, if the refrigerator is just as inefficient, but only 3 years old, it does not need to be replaced. The full cost of a new refrigerator cannot be justified on the basis of energy savings alone. The three scenarios portray the same house with varying degrees of needed renovation. They also portray varying degrees of budget availability. All three evaluations focus only on energy-related, current best practices measures. Additional health, safety, durability, and indoor air quality measures that either have no impact on energy use, or their impact is not represented in modeling software, are not part of this analysis.

Throughout the three scenarios, when a replacement is needed for functionality, the cost-effectiveness calculations consider only the incremental cost premium of a higher performance choice compared to the incremental energy cost savings. Whenever the minimum allowable or market-accepted replacement specifications exceed the as-found specifications, *savings and costs are calculated with respect to the minimum replacement, not the as-found condition*. The minimal efficiency air conditioner replacement described previously in Section 1.1.2 is an example. Full and incremental costs were drawn from a variety of sources. BEopt 2.0 was referenced where costs reflected researchers' field experience. Where BEopt was out of range for this market, costs from partners or other Florida Solar Energy Center (FSEC) studies were used. Table 3 provides references for all costs used in this Phase 2 analysis.

Table 3. Cost References

Measure	Full Cost References	Incremental Cost References
Asphalt Shingles	BEopt	\$0
Ceiling Insulation	City of Melbourne	City of Melbourne
Exterior Paint	Phase 1	\$0
Windows	City of Melbourne	City of Melbourne/sliding glass door projected
Window Film	Phase 1	Phase 1
ACH50 = 7		Phase 1
Runtime Ventilation	City of Melbourne	City of Melbourne
Air Conditioner	BEopt	Internal research
Duct Leakage Reduction	BEopt	BEopt
Electric Water Heater	BEopt	\$0
Refrigerator	BEopt	Internal research
Lighting Energy Reduction	BEopt	BEopt
Fans	City of Melbourne	BEopt

2.1 Retrofit Scenario 1

Retrofit Scenario 1 assumes that none of the energy-related components or equipment in the as-found home warrant replacement for functionality. The package of improvements consists of those key strategies that can be implemented in the absence of need for replacements. These improvements are strictly for efficiency gains, though dissatisfaction with comfort and moisture control may be other motivators.

A home with a HERS Index score of 131 that does not need any replacements could have the following hypothetical but realistic characteristics:

- Original single-pane awning or single-hung metal frame windows, well maintained
- Medium color exterior paint (solar absorptance of 0.6) and medium colored shingles (solar absorptance 0.85), less than 5 years old
- Ceiling insulation upgraded in the 1990s from R-11 to R-19, average of R-15 due to compression, poor coverage, or displacement
- Central SEER 10 air conditioning with electric resistance heating, 9 years old (installed shortly before the 2006 federal minimum air conditioning efficiency shifted to SEER 13). Air infiltration consistent with pre-energy code home of 1970s vintage, airflow bypasses at poorly sealed windows and doors, recessed lighting, plumbing penetrations, air handler unit (AHU) closet, and attic hatch cover.
- Duct leakage consistent with pre-energy code home of 1970s vintage with return air plenum formed in the lower part of the AHU closet by open framing and the AHU support platform
- Standard efficiency refrigerator, 5–7 years remaining life

- Standard electric tank water heater, 7 years old
- Three ceiling fans, good condition.

This scenario represents the whole-house efficiency that would be possible in the field study houses if they had not been moderately or severely distressed, which are commonly available on the Florida housing market.

Retrofit Scenario 1 consists of five improvements (Table 4) that target the cooling load and specifically airflow control, which is essential for all high performance homes.

Table 4. Scenario 1 Efficiency Enhancement Package and Full Costs

Component	Improvement Specification	Estimated Full Cost (\$)	Estimated Cost Premium (\$)
Ceiling Insulation	Insulated to R-38	1,063	1,063
Windows	Tint windows (SHGC = 0.35)	696	696
Air Distribution System	Reduce duct leakage to 9% of rated AHU flow, supply side (roughly equivalent to $Q_{n,out} = 0.06$)	233	233
Lighting	Increased efficient lighting. (approximately 950 kWh/year)	139	139
Whole-house Infiltration	Reduced to ACH50 = 7	749	749
Efficiency Enhancement Package Estimated Cost		2,880	2,880

None of the Scenario 1 improvements involve replacements at wear out. All are implemented as an energy efficiency retrofit; therefore, the estimated full cost of the improvement, \$2,880, is a cost premium (compared to doing nothing) and is considered in the cost effectiveness calculations. This level of spending could easily be accommodated in the initial investment of about \$12,000 over the first 2 years of ownership and is very close to the average annual renovation spending of \$2,500 cited in the JCHS report (2011b), refer to Section 1.1 above. Table 5 shows the savings for Scenario 1 compared to the as-found condition of the house.

Table 5. Scenario 1 Improvement Summary

	As Found	Scenario 1	Savings	Savings (%)
Projected Annual Energy Use (kWh)	21,132	16,905	4,227	20%
Projected Annual Energy Cost (\$)	\$2,535	\$2,030	\$505	20%
HERS Index	131	94	37	28%

Projected annual energy use and energy cost for Retrofit Scenario 1 are approximately 20%. The improvement package reduced the HERS Index 28% to 94, which is similar to new construction homes in Florida.

Elements of the Scenario 1 improvement package would be applicable to homes with better as-found whole-house efficiency that resulted from, for example, a previous mechanical system change out. The savings produced would be consequently lower because the annual heating and cooling costs would be low in the as-found house; however, there would still be improved airflow control and enhanced comfort benefits. Likewise, for homes in worse condition, like those in the field study, savings would be consequently higher. The economic implications of implementing the five items in Retrofit Scenario 1 are shown in Table 6.

Table 6. Scenario 1 First Year Cash Flow Analysis

Estimated Full Costs	\$2,800
Annual Mortgage Increase (7% @ 30 years)	\$232
Projected Annual Energy Cost Savings	\$505
First Year Cash Flow	+\$273
Simple Payback (Years)	5.7

The estimated full cost of \$2,880 is used to calculate the additional annual mortgage burden of \$232 associated with Scenario 1 improvements. The affordable housing entities participating in the field study and this community-scale phase were making improvements at the time of resale. This package would also apply, in general, to a home sale transaction. Projected annual energy cost savings of \$505 translate into a positive first-year cash flow of \$273. Under finance terms more consistent with current market rates, first-year cash flow would be higher for all three scenarios considered. At the same time, the expected useful lives of some measures are shorter than the 30-year mortgage period, which is a known bias in the cost effectiveness calculations.

2.2 Retrofit Scenario 2

Retrofit Scenario 2 represents a moderately distressed home with specifications similar to those of Scenario 1, but with several energy-related components with no service life left. Scenario 2 includes measures that carry a low or no-cost premium for better replacements and efficiency enhancements that have a low full cost.

Hypothetical characteristics for Scenario 2 would resemble Scenario 1, except that the following items will be replaced because of function or market appropriateness:

- Medium color exterior walls
- Medium color shingles
- Refrigerator
- Standard efficiency, electric tank water heater
- Three ceiling fans.

Ceiling insulation was not included here because the existing as-found condition of R-15 is acceptable in the current marketplace. Addition of this measure would add about \$900 of full first cost, a key decision factor in this scenario. Analysis showed that the combination of lighting and whole-house air sealing saved slightly more than the ceiling insulation for about the same estimated cost.

Scenario 2 assumes this level of renovation would cost about \$10,000 in the central Florida market. Many of the replacement measures in this package would likely be included in an initial renovation after purchase. The scenario assumes a budget increase of about 16%, or \$1,900, for additional efficiency enhancements and higher performance replacement choices, raising the total to about \$12,000. This amount of spending is reasonable given it is consistent with the reported average investment level in the first 2 years of homeownership reported by JCHS (2011b). Refer to Section 1.1 above.

The improvement package consists of four efficiency enhancements (Table 7) and five higher performance replacement improvements (Table 8). The package targets the cooling load, airflow control, appliances, lighting, and water heating (very small improvement). As in Scenario 1, the full cost of the efficiency enhancements is compared to the full savings from those measures. The cost premium is the difference in cost for a standard or minimum replacement and a higher performance replacement. This difference is compared to the savings generated only by the higher performance specification.

Table 7. Scenario 2 Efficiency Enhancements and Costs

Components	Improvement Specification	Estimated Full Cost (\$)	Estimated Cost Premium (\$)
Windows	Tint windows (SHGC = 0.35)	696	696
Air Distribution System	Reduce duct leakage to 9% of rated AHU flow, supply side (roughly equal to $Q_{n,out} = 0.06$)	233	233
Lighting	Increased efficient lighting. (approximately 950 kWh/year)	139	139
Whole-House Infiltration	Reduced to ACH50 = 7	749	749
Efficiency Enhancements Estimated Cost		1,817	1,817

Table 8. Scenario 2 Replacement Improvements, Costs, and Cost Premiums

Component Replaced at Wear Out	Minimum Replacement Specification	Higher Performance Replacement Specification	Estimated Full Cost of Higher Performance Specification (\$)	Estimated Cost Premium Over Minimum Specification (\$)
3 Ceiling Fans	Like efficiency	ENERGY STAR (130 cfm/W at medium speed)	750	54
Refrigerator	Same size rated at 480 kWh/year ⁵	ENERGY STAR same size (374 kWh/year)	900	50
Medium Shingle Roof	Same color	White shingles (solar absorptance of 0.75)	5,941	0
Medium Exterior Wall Paint	Same color	Light paint (solar absorptance of 0.55)	2,090	0
Water Heater	Like efficiency	Same size electric tank (EF = 0.92)	723	0
Replacement Total			10,404	104
Efficiency Enhancement Total (from above)			1,817	1,817
Total Full Cost and Total Cost Premium for Whole Package			12,221	1,921

⁵ This is the minimum refrigerator replacement specification allowable under the Building America benchmarking protocols.

The estimated full cost total is \$12,221. Efficiency enhancements totaling \$1,817 of that, and the cost premium for higher performance replacement, accounts for \$104 of the total full cost. The estimated efficiency-related outlay is \$1,921. Note that the lighter color paint and shingles and slightly higher efficiency water heater do not carry a cost premium. ENERGY STAR ceiling fans and refrigerators carry a small premium of about \$50 each.

Table 9 shows projected savings. Retrofit Scenario 2, representing a moderately distressed home, generates an estimated 19% annual energy and energy cost savings. The HERS Index score improved 26% to 96, which is similar to new construction homes in Florida.

Table 9. Scenario 2 Improvement Summary

	As Found	As-Found With Minimum Replacement Specifications	Scenario 2	Savings Over Minimum	Savings Over Minimum (%)
Projected Annual Energy Use (kWh)	21,132	20,982	16,904	4,078	19%
Projected Annual Energy Cost (\$)	\$2,535	\$2,518	\$2,028	\$490	19%
HERS Index	131	130	96	34	26%

Cash flow analysis is shown in Table 10. The estimated cost premium for Scenario 2 is \$1,921, representing 16% of the estimated full cost of the package. The additional mortgage burden for the cost premium is \$155. Projected annual energy cost savings of \$490 generate a positive first-year cash flow of \$335.

Table 10. Scenario 2 First-Year Cash Flow Analysis

Estimated Full Costs	\$12,221
Estimated Efficiency Cost Premium Over Minimum Replacement Specifications	\$1,921
Annual Mortgage Increase (7% @ 30 years)	\$155
Projected Annual Energy Cost Savings Over Minimum Specifications	\$490
First Year Cash Flow	\$335
Simple Pay Back (Years)	3.9

Scenario 2 produces a level of improvement similar to Scenario 1, with a cost almost \$1,000 lower. The point here is that significant improvement can be achieved for little incremental cost when key energy-related components reach the end of their service lives and higher performance options cost little to nothing. Cashing in on these choices requires being prepared ahead of the need with knowledge of what to select. The best practices provide this type of advance decision-making that could save decision-makers the time and effort of evaluating specific choices in specific houses.

2.3 Retrofit Scenario 3

Retrofit Scenario 3 represents a significantly distressed home with specifications similar to those of Scenario 2, but also in need of window and complete heating, ventilation, and air conditioning (HVAC) system replacement. This scenario is most similar to the deep retrofits in the field study, and similarly, it includes almost all of the 13 key efficiency strategies highlighted in the field study report (McIlvaine et al. 2013a).

Hypothetical characteristics for Scenario 3 would resemble Scenario 2, except that:

- Original, metal frame windows no longer function adequately.
- Central SEER 10 air conditioning with electric resistance heating shows severe neglect (fouled coils, rust, mold, compromised refrigerant lines, etc.).

Scenario 3 combines Scenarios 1 and 2 with mechanical system and window replacements, which generate large annual savings but also carry high capital costs. This level of renovation could be part of the major renovation within the first 2 years of ownership of distressed properties. The package also includes a passive outside air ventilation system that is part of the best practices. It adds cost as well as possibly reducing savings by introducing about 50 cfm of outside air into the return plenum whenever the AHU is operating. It is incorporated as an indoor air quality and airflow control measure. Efficiency enhancements are shown in Table 11, and higher performance specifications for replacements are shown in Table 12.

Table 11. Scenario 3 Specifications and Costs for Efficiency Enhancements

Components	Improvement Specification	Full Cost (\$)	Efficiency Enhancement Package Cost Premium (\$)
Ceiling Insulation	Insulated to R-38	1,063	1,063
Air Distribution System	Reduce duct leakage to 9% of rated AHU flow, supply side (roughly equal to $Q_{n,out} = 0.06$)	233	233
Lighting	Increased efficient lighting. (approximately 950 kWh/yr)	139	139
Whole-House Infiltration	Reduced to ACH50 = 7	749	749
Outside Air Ventilation	Passive, supply only, ducted, dampered, and filtered outside air duct from soffit register to return plenum	500	500
Efficiency Enhancement Cost (Full Cost)		2,684	2,684

Table 12. Scenario 3 Specifications and Costs for Higher Performance Replacement Choices

Component Replaced at Wear Out	Minimum Replacement Specification	Higher Performance Replacement Specification	Estimated Full Cost of Higher Performance Specification (\$)	Estimated Cost Premium Over Minimum Specification (\$)
Central Heating and Cooling	SEER 13, electric resistance heat; COP = 1	15 SEER, 8.5 heating seasonal performance factor (HSPF) air source heat pump	4,431	1,168
Windows	Double-pane, single-hung, clear, metal-frame windows (U = 0.76, SHGC = 0.67) ⁶	Double-pane, single-hung, low-e, vinyl-frame (U = 0.37; SHGC = 0.30)	5,860	1,582
3 Ceiling Fans		ENERGY STAR (130 cfm/W medium speed)	750	54
Refrigerator	Same size rated at 480 kWh/year	ENERGY STAR same size (374 kWh/year)	900	50
Asphalt Shingle Roof		White shingles (solar absorptance of 0.75)	5,941	\$0
Exterior Wall Paint		Light paint (solar absorptance of 0.55)	2,090	\$0
Water Heater		Same size electric tank (EF = 0.92)	723	0
Replacement Total			20,695	2,854
Efficiency Enhancement Total (from above)			2,684	2,684
Total Full Cost and Total Cost Premium for Whole Package			23,379	5,538

⁶ These are the minimum window and refrigerator replacement specifications allowable under the Building America benchmarking protocols.

Scenario 3 assumes an energy-related renovation cost of approximately \$23,000 in the central Florida market, with about \$5,500 for higher performance replacements and efficiency-only improvements. Table 13 shows an improvement summary for Scenario 3.

Table 13. Scenario 3 Improvement Summary

	As Found	As-Found With Minimum Replacement Specifications	Scenario 3	Savings Over Minimum (\$)	Savings Over Minimum (%)
Projected Annual Energy Use (kWh)	21,132	19,228	13,862	5,366	28%
Projected Annual Energy Cost (\$)	\$2,535	\$2,308	\$1,664	\$644	28%
HERS Index	131	113	69	44	39%

Analysis indicates that Retrofit Scenario 3 generates approximately 28% annual energy savings compared to the minimum replacement case with a comparable savings in projected annual energy cost. The HERS Index score improved 39% to 69.

In this scenario, the specifications for the minimum replacement case are significantly better than the as-found case. Even when high impact replacements such as mechanical equipment and windows are needed, incremental savings do not skyrocket because the minimum replacement specifications are more similar to the higher performance choices than they are to as-found. This erodes incremental improvement. The outside air ventilation system also works against incremental improvement, causing a slight increase in cooling and heating energy use. Table 14 summarizes projected first-year cash flow.

Table 14. Scenario 3 First-Year Cash Flow Analysis

Estimated Full Costs	\$23,379
Estimated Efficiency Cost Premium Over Minimum Replacement Specifications	\$5,538
Annual Mortgage Increase (7% @ 30 years)	\$446
Projected Annual Energy Cost Savings	\$644
First Year Cash Flow	+\$198
Simple Payback (years)	8.6

The estimated cost premium for Scenario 3 is \$5,538, representing about 24% of the estimated full cost of the package. The additional annual mortgage burden for the cost premium is \$446, with a projected annual energy cost savings of \$644. This results in a first-year positive cash flow of \$198.

Two elements in Scenario 3 do not generate positive cash flow on an individual basis: the outside air ventilation system and the low-e windows.

The windows produce a negative first-year cash flow even though they produce incremental annual savings second only to the HVAC equipment replacement. Our partners report that low-e windows cost approximately one-third more than standard double-pane windows in central Florida. However, the vast majority of them chose window replacements that were low-e, not the minimum market-accepted, double-pane clear units. Partners cited the fact that if low-e units are not selected at replacement *now*, it will be perhaps two decades or more before the chance arises again. Therefore, it has been included in the best practices based on merit of avoiding a major “missed opportunity.” Improved comfort may reduce energy consumption in a way not accounted for in modeling by eliminating local “hot spots” near windows that prompt occupants to reduce the cooling set point.

The passive ventilation system delivers a small amount (e.g., 50 cfm) of outside air via ducted path to the return plenum while the mechanical system is running. BA-PIRC and other Building America teams and partners have specified this system in thousands of new Florida homes to provide a small amount of ventilation and simultaneously induce a slight positive pressure in the main body of the home (with respect to outdoors) only while the AHU is operating. Combined with a tight duct system and passive return air pathways from bedrooms, this detail reduces mechanically induced infiltration. Unfamiliarity with the system and space constraints inside AHU closets designed for smaller machines are barriers to wider implementation of this approach.

2.4 Anticipated Level of Savings Summary

Table 15 summarizes the anticipated expense and savings from application of the best practices in three scenarios representing varying conditions of energy-related components and equipment that would be expected in a community-scale retrofit program. The base home has characteristics typical of the 70-home field study. Table 15 compares the three.

The base house for Scenarios 1, 2, and 3 has a HERS Index of 131. Each scenario represents a different level of opportunity for efficiency gains based on what energy-related components and equipment need replacing and available budget. The anticipated level of projected annual energy cost savings in a home of this typical character ranged from 19% to 28%. Cost premiums among the three scenarios ranged from about \$1,900 to about \$5,500.

Table 15. Summary of Scenarios 1, 2, and 3

Description	Scenario 1 Efficiency Enhancement Package (No Replacements)	Scenario 2 Efficiency Enhancements and Higher Performance Replacements	Scenario 3 Scenarios 1 and 2 Plus HVAC and Window Efficiency Upgrades at Replacement
HERS Index Pre-Retrofit	131	131	131
HERS Index With Minimum Replacements (where applicable)	NA	130	113
HERS Index Post-Retrofit	94	96	69
HERS Index Improvement (over minimum, if applicable)	28%	26%	39%
Projected Annual Energy Cost Savings (% over minimum if applicable)	20%	19%	28%
Estimated Full Costs	\$2,880	\$12,221	\$23,379
Estimated Efficiency Cost Premium	\$2,880	\$1,921	\$5,538
Annual Mortgage (7% @ 30 years)	\$232	\$155	\$446
Projected Annual Energy Cost Savings	\$505	\$490	\$644
First Year Cash Flow	\$273	\$355	\$198
Simple Payback (years)	5.7	3.9	8.6

3 Recruitment of Community-Scale Retrofit Partners

The Building America systems-engineering process centers on identifying potential problems and developing standardized methods of resolving them before they occur on the job site. Past Building America experience in both new construction and the 70-home field study has shown that test, or prototype, homes help identify barriers to adoption and gaps in technology or labor that can be resolved prior to ramping up to community-scale implementation. A standardized approach facilitates adoption of a high performance goal at the community scale.

We wanted to see if new partners could and would use the best practices to develop a master specification document that essentially sets “default” specifications and establishes a standardized treatment of predictable as-found conditions. Ideally, if a home needs a refrigerator replacement, there is a specification in the master standard to put in the bid documents; the decision-making process is streamlined. Master specifications result in consistent treatment of the same change in multiple houses, which is an important element in public and nonprofit program accountability (no favorites).

In Phase 2, the objective was to work with a new partner to see if the best practices alone, without the detailed level of researcher support provided in Phase 1, would be sufficient for the organization to set up internal master specifications and standardized bid document language. In essence, we wanted to test the viability of using the best practices as a tool in the general renovation community with emphasis on foreclosed properties and affordable housing.

Partnership invitations were sent directly to Florida recipients of federal funding (e.g., NSP, Community Development Block Grant), state funding (e.g., Florida State Housing Initiatives Partnership, Residential Construction Mitigation Program), and private/nonprofit funding organizations (e.g., Habitat for Humanity) for renovation of multiple houses. Local government housing entities at Brevard County, the City of Melbourne (in Brevard County on the east coast), and the City of Fort Myers (Lee County on the west coast of south Florida) responded with serious intent to adopt the best practices.

Initially, the potential partners were provided with the best practices, renovation standards developed by the Sarasota Office of Housing and Community Development, and analysis examples from projects in the field study similar to the three scenarios described in Section 2. These resources helped potential partners develop a concrete understanding of how the best practices could be developed into retrofit standards and what application of them would look like in their program homes. Seeing activity of peers in other parts of the state added credibility to and emphasized practicality of the best practices.

All three partners agreed to work with researchers on two or three pilot “test” houses to test-drive the best practices. A further commitment to use the best practices to develop or augment existing master specifications, similar to the Sarasota example, was also required.

Researchers recognized the need to be flexible within the standardization process because of variation in organizational readiness, goals, commitment, and familiarity with key high performance concepts. This was evident in the field study from variation among partners.

Each partner was tasked with identifying any “no go” elements of the best practices. Initial discussions with all three housing agencies focused on evaluating the feasibility of unfamiliar specifications, construction details, quality assurance, and mandatory measures in the best practices. These included:

- Outside air ventilation system
- AHU closet detailing
- Duct testing requirement and participation of a home energy rater
- Availability and cost premiums of ENERGY STAR products
- Use of heat pumps instead of central electric resistance heating
- Higher efficiency air conditioning
- Whole-house air sealing points
- Lighting fixtures rated for insulation contact and airtightness
- Passive return air pathways.

During these initial talks, researchers used partner feedback to modify the language and organization of the best practices to improve understanding. The iterative process of selecting which best practices the partners would include in their master specifications revolved largely around cost and practicality. Partner feedback throughout this process was instrumental in developing an improved version of the current best practices to address some of the implementation challenges.

Ultimately, the City of Fort Myers and the City of Melbourne Housing & Community Development created master specifications. Fort Myers met with researchers over multiple conference calls. Though the City of Fort Myers was not involved in prior FSEC retrofit research, it was already committed to many energy-efficient elements as standard practice in its new construction projects, including an independent energy rater’s involvement. As part of the pre-partnership work, the City of Fort Myers developed a flowchart of how researcher and rater involvement would both fit into the work process for retrofits. This was a helpful tool in identifying how best to incorporate recommendations into the retrofits, which will initially involve change orders as decisions on the standard practices detailed in Appendix C are finalized.

Researchers learned that all three of the partners use software designed for development of work write-ups and bid documents. The software uses libraries to hold standard specifications for use in any project. That became the path for integrating the best practices into bid documents.

The City of Fort Myers has a well-developed master specification (Appendix C); however, difficulty acquiring retrofit properties under funding program guidelines directed the focus to new construction just as the master specification was being completed. The City of Melbourne put in an overall implementation effort with 10 homes. Therefore, the partnership with the City of Melbourne is addressed in the next section.

4 Partnership With the City of Melbourne

Preliminary discussions with the City of Melbourne (herein referred to as “the City”) included an overview of the current best practices and discussion of foreseen implementation gaps and barriers. Subsequently, the City committed to a program-wide adoption of a modified version of the best practices.

In the process of deciding which best practices to adopt, The City was interested in analyzing higher performance options for exterior walls, windows, air conditioners, and water heating systems. Researchers provided simulation analysis of projected annual energy costs and savings for higher performance alternatives to typical specifications. This exercise was instrumental in the City’s decision to adopt the HVAC best practice of using ENERGY STAR or higher efficiency heat pumps in central Florida.

BA-PIRC researchers reviewed the work order and cost estimate for a project in the early stages of development and made recommendations. Recommendations were presented in the form of analysis that included projected annual energy cost savings and first-year cash flow calculations using cost estimates that they provided. Similar to the field study, the analysis addressed the planned scope of work and alternate specifications from the best practices.

Through modification of the scope of work, recommendations were incorporated into the renovation. Table 16 describes the as-found condition of the home, partner’s original retrofit package, and final retrofit package with full and incremental costs reported by the partner.

Table 16. City of Melbourne Test House Analysis

Home Components	As Found	Minimum Improvement Scenario	Partner's Original Package	Partner's Actual Final Package	Partner's Reported Full Costs (\$)	Cost Premium (\$)
Ceiling Insulation	1,104 ft ² , R-5			Insulated to R-30	829	829
Doors	1 insulated door; 1 wood door			3 insulated	714	–
Floors	5% vinyl; 25% tile; 70% carpet			65% tile; 35% carpet	2,799	–
Whole-House Infiltration	ACH50 = 15.22		Drywall patch and window pane repair (estimated ACH50 = 8)	ACH50 = 11.92	– (coincident with minor repairs)	–
Outside Air Ventilation	None			Passive “runtime” ventilation	4,313	1,879
Central Heating and Cooling Equipment	Missing; default 10 SEER straight cool Integrated electric resistance heat (COP = 1)	13 SEER straight cool integrated electric resistance heat (COP = 1)	13 SEER; right-sized	15.25 SEER	4,313	1,879
			Heat pump; HSPF = 7.7	Heat pump; HSPF = 8.7	4,313	1,879
Air Distribution System	Q _{n,out} = 0.145; ducts R-5.8		Improved leakage; (estimated Q _{n,out} = 0.07)	Q _{n,out} = 0.037	4,313	1,879
Water Heating System	40 gal, electric; EF = 0.92		40 gal, electric; EF unspecified (no change assumed), thermal wrap (R-7)	No change	774	–
Cost Totals					9,429	2,708

The differences between the original package and the improved package were changes recommended by BA-PIRC except for the insulated doors and tile flooring. Those replacements were made for functional or market appropriateness, not for energy efficiency; however, each carries a small boost to whole-house efficiency with no cost premium. The tile flooring would not be a recommended efficiency improvement based on very small cooling benefit and comparatively high cost.

The final retrofit included a moderately higher efficiency heat pump, R-30 ceiling insulation, improving duct airtightness to $Q_{n,out} < 0.06$, and passive outside air ventilation. The ceiling insulation level in the best practices is R-38. Shallow roof pitch sometimes makes this impractical, especially because supply ducts occupy a portion of the limited head room.

The passive outside air ventilation system adds cost and increases energy use slightly, but is part of the best practices for indoor air quality. In practice, it induces a slight positive pressure in the house that prevents outside air from entering through breaches in the whole house air barrier while the AHU is running (“runtime”). The modeling software is not sophisticated enough to model this effect and as such does not credit infiltration reduction during conditioning.

Regarding infiltration, the achieved whole-house airtightness test result was close to ACH50 of 12, approximately double the best practices target ACH50 of 6. At ACH50 of 12, the industry ventilation standard, ASHRAE 62.2, would not indicate a need for outside air ventilation. It was installed here as part of the best practices implementation trial.

The incremental cost for the final improvement package over the minimum was \$2,708 (Table 16), with an estimated annual energy cost savings of \$231 (Table 17). Projected first year cash flow calculations are shown in Table 18.

Table 17. City of Melbourne Test House 1 Improvement Summary

	As Found	As-Found With Minimum Replacement Specifications	Partner’s Original Package	Partner’s Final Package	Original Package Savings Over Minimum	Final Package Savings Over Minimum
Projected Annual Energy Use (kWh)	12,771	11,887	10,549	9,911	1,338 (11%)	1976 (17%)
Projected Annual Energy Cost (\$)	\$1,488	\$1,385	\$1,229	\$1,154	\$156 (11%)	\$231 (17%)
HERS Index	134	119	108	89	11 (9%)	30 (25%)

Table 18. City of Melbourne Test House First Year Cash Flow Analysis

Estimated Full Costs	\$9,429
Estimated Efficiency Cost Premium Over Minimum Replacement Specifications	\$2,708
Annual Mortgage Increase (7% @ 30 years)	\$218
Projected Annual Energy Cost Savings	\$231
First Year Cash Flow	+\$13

Projected annual costs were reduced from \$1,229 (11% savings over minimum) given the original package to \$1,154 (17% savings over minimum) implementing the added efficiency improvements of the final package. Rolling the incremental cost into the sale price would increase the annual mortgage burden by \$218, which is outweighed by \$231 in projected annual energy cost savings (Table 18).

The analysis presented here was produced after the renovation was completed. Pre-retrofit analysis included a proposed deep retrofit package based on the best practices and included annual energy cost savings projections for each element of the retrofit. City staff were tasked with developing their own cost data rather than using our cost estimates. Decision-makers can decide for themselves whether the incremental cost justifies the incremental savings.

Seeing the positive first-year cash flow (\$13 with the final retrofit package) early in the partnership gave the City's staff a concrete understanding of how a modest investment could benefit their prospective buyers even though it slightly elevated the annual mortgage burden.

This partner and others report that this quantitative exercise, using houses specific to their programs, aids the decision-making process and builds confidence among staff and administrators that funds are spent prudently. In both the field study and this community-scale investigation, researchers found that partners had a more animated response to this type of analysis than to measured field data or analysis examples from other partnerships.

Ideally, this introductory analysis would be provided by an independent home energy rater, which is a guideline in the best practices, so that the evaluation and guidance process could be sustained in absence of research participation. As we conducted this initial evaluation, we simultaneously provided a list of certified home energy raters in the area and advised retaining one.

Immediately, a barrier to adoption of this best practice was proffered. The City's funding for the housing and rehabilitation program includes restrictions that do not allow expenditure outside the context of a specific house. Any home energy rater activity would have to be consigned to the budget for a specific house and, consequently, arranged and paid for by the contractor winning the bid for that house. This may create a perceived or real conflict of interest if general contractors pay for their own rating services. There could be a skewed presentation of analysis data. The HERS rating industry has a nationwide code of ethics as well as quality assurance by HERS providers that could ameliorate this conflict. Two potential alternative ways to get analysis help of this nature are to recruit a volunteer rater who needs to do provisionary ratings for certification or build the internal capacity for conducting the simulation analysis. There are online tools that may serve this purpose more readily than sending an employee through home energy rater training.

After the introductory evaluation, the City selected a set of best practices to incorporate into projects through a master specification (termed *retrofit standards* by this partner) and, separately, into work write-ups and bid documents for individual houses. These two activities proceeded in parallel; otherwise, the opportunity for immediate implementation and partnership would have been missed. Whereas the master specification sets forth the standard treatment of specific

aspects of renovation, work write-ups and bid documents translate those standard treatments into specifications for a given house.

Throughout 2012 and for the first quarter of 2013, the City applied its best practices to a set of 10 additional houses in varying degrees of incorporation; however, only seven of these homes had been completed by the writing of this report. With the last few houses, integration was more thorough and consistent.

The current best practices document was refined based on implementation experiences of the City of Melbourne as it incorporated them into the master specifications (Appendix A; McIlvaine et al. 2013b). For instance, it was found that specifying ENERGY STAR windows was not enough to ensure they were being installed because the National Fenestration Rating Council (NFRC) labels were removed before the program staff conducted the final inspection. A best practice was added that called for the retention of NFRC labels to confirm specifications were being met.

The following analysis (Tables 19–22) shows the end result of the City’s effort to integrate the best practices by examining its revised typical characteristics. The analysis assumes the same base house as shown for Scenarios 1–3 but relocated to Melbourne, which is closer to the coast and has a slightly different climate. Replacement needs shown in Table 20 are similar to those for Scenario 3 in Section 2.3 above, which is a reasonable portrayal of home conditions in the City’s renovation program. The package of improvements includes efficiency enhancements (Table 19) and replacement upgrades (Table 20).

Table 19. City of Melbourne Revised Typical Specifications and Costs for Efficiency Enhancements

Components	Efficiency Enhancement Specification	Full Cost (\$)	Efficiency Enhancement Package Cost Premium (\$)
Ceiling Insulation	R-38 ceiling insulation	1,064	1,064
Whole-House Infiltration	ACH50 = 7	Part of other measures	
Air Distribution System	Leakage 4.5% @ supply leak (Qn,out = 0.03); R-6	Part of HVAC Cost	
Mechanical Ventilation	Runtime ventilation @ 20% A-62.2	500	500
Lighting	Increased efficient lighting. (approximately 950 kWh/year)	139	139
Efficiency Enhancement Full Cost		1,703	1,703

Table 20. City of Melbourne Revised Typical Specifications and Costs for Higher Performance Replacement Choices

Component Replaced at Wear Out	Minimum Replacement Specification	Higher Performance Replacement Specification	Full Cost (\$)	Replacement Improvement Package Cost Premium (\$)
Windows	Replace with double-pane (U = 0.76, SHGC = 0.67)	Double-pane, tinted, vinyl (U = 0.23; SHGC = 0.20)	5,750	1,553
Heating and Cooling System	SEER 13; 2.5 ton electric resistance heat; COP = 1	15 SEER; 2.5 ton heat pump; 8.5 HSPF	5,300	1,168
Water Heating System	Replace with EF = 0.90	Replace with EF = 0.92	450	0
Refrigerator	Replace with 480 kWh/year	18 in. ³ ; 374 kWh/year	780	50
Replacement Cost			12,280	2,771
Efficiency Enhancement Total (from above)			1,703	1,703
Total Full Cost and Total Cost Premium for Whole Package			13,983	4,474

This City of Melbourne typical retrofit scenario results in about \$14,000 in energy-related renovation cost, with a cost premium of about \$4,500 for efficiency-only measures and higher performance replacements. Table 21 shows an improvement summary for Scenario 3 followed by projected cash flow analysis in Table 22.

Table 21. City of Melbourne Revised Specifications Improvement Summary

	As Found	As-Found With Minimum Replacements	City of Melbourne Revised	Savings Over Minimum (\$)	Savings Over Minimum (%)
Projected Annual Energy Use (kWh)	21,140	19,150	14,283	4,867	25
Projected Annual Energy Cost (\$)	2,536	2,297	1,714	583	25
HERS Index	129	111	70	41	37

Table 22. City of Melbourne Revised Specifications Projected First-Year Cash Flow Analysis

Final Full Costs	\$13,983
Estimated Efficiency Cost Premium	\$4,474
Annual Mortgage (7% @ 30 years)	\$361
Projected Annual Energy Cost Savings	\$583
First-Year Cash Flow	\$222
Simple Payback (years)	7.7

The City of Melbourne staff have worked diligently to refine their standardized approach and integrated it more smoothly into bid documents and work write-ups. Their bottom line benefits from exceeding the best practices in three areas: mechanical system efficiency, duct airtightness, and window specifications. The package of efficiency and replacement enhancements produces a projected annual energy use and cost savings of 25%, with a projected positive cash flow of \$222.

5 Key Concepts

The City of Melbourne staff integrated the best practices and specifications into the work order development process over the course of several months. This is better done slowly and surely than all at once because there are legal and contractual implications inherent in bid documents.

The bid documents and work write-ups are developed with software that uses libraries arranged by standard trade/location divisions. The City’s field manager was able to quickly add language for new specifications that amounted to changing a few words or numbers. Affected trade divisions included Trade 16 (Conservation), Trade 21 (HVAC), Trade 23 (Electric), and Trade 29 (Windows).

Some of the best practices, though, require rethinking conventional methods of construction. Key concepts discussed here related to the some of the best practices that require deviation from common practices and the related gaps, barriers, and lessons learned.

5.1 Mechanical Equipment Efficiency, Air Distribution System, and Passive Outside Air Ventilation

From the preliminary analysis, we learned that the City of Melbourne was already specifying minimum efficiency heat pumps (rather than straight cool with integrated electric resistance heating). The shift to ENERGY STAR or better heat pumps initially drew skepticism because of perceived higher cost. However, staff agreed to revisit the issue with HVAC contractors and suppliers and found that the situation had changed since it was last investigated and was now at an acceptable price point to justify investment.

The partner’s specification below (from bid documents) shows their decision to make SEER 15 heat pumps standard practice and encompassing best practices for system-sizing, equipment matching, duct sealing at supply registers, return plenum air barrier and sealing was written (Figure 3).

Trade: 21 HVAC		Quantity	Units	Unit Price	Total Price
Spec Number	Specification				
5932	CENTRAL HVAC SYSTEM -15 SEER Remove existing heating and/or cooling equipment. Install new central A/C heat pump system with a minimum SEER of 15.0, Goodman or equal. Unit to have heat strips for emergency heating. Indoor/ outdoor coil match- up must be ARI listed. Install new foil covered ducts to all rooms with white supply/return air grills and apply mastic where box penetrates through the ceiling to prevent leakage. Include new thermostat, compressor pad & all necessary connections including properly sized circuit breakers for each unit. Unit shall be sized to efficiently heat and cool residence. Include GFI outlet as required by code. Line inside of return air box with new duct board. Seal all gaps and penetrations with mastic to insure that intake air flow goes through the air filter as designed. 8 - Hall	1.00	EA	_____	_____
Total for 21 - HVAC:					_____

Figure 3. Excerpt from bid document for Trade 21: HVAC incorporating some of the best practices for HVAC equipment

By specifically asking for matched indoor and outdoor equipment, equipment right sizing, and return plenum and duct sealing, programs put themselves in a better position to ensure investments are paying for high performance installation as well as the high efficiency equipment.

A fundamental tenet of high performance housing is airflow control. The mechanical section of the best practices addresses air distribution system construction, assembly, and airtightness as well as reduction of household pressure differentials. Cummings et al. (2012) cited all of these factors in uncontrolled airflow. The Florida residential mechanical code includes provisions addressing these details; however, these elements of the code apply to new construction only, not replacement equipment or systems. For residential mechanical systems undergoing “repair” or “alteration,” the Florida building code requires replacement or repair of materials and components to “preserve the original approval or listing” (ICC 2011a; ICC 2011b; ICC 2011c). In 2012, the Florida residential energy code added a requirement that replacement conditioning equipment must be sized using an approved method (e.g., ACCA Manual J) and that contractors must seal all accessible duct joints that have 30 in. of clearance (ICC 2011d).

In the Phase 1 field study, researchers often observed scopes of work and bid documents written by local government partners that stated “all work shall be executed in accordance with prevailing codes.” We see here that this language is not sufficient to ensure that the mechanical system is brought up to new construction code requirements in existing homes. One of the refinements in Phase 2 was to add specific language modeled after individual provisions of the code requirements for new construction addressing flex duct installation, AHU closet and return plenum construction, air distribution system sealing, and passive return air pathways.

The specification shown in Figure 3 (above) includes several of these. The new construction requirements also address passive return air pathways in homes with central returns. The City later integrated that language into bid documents (Figure 4).

Trade: 21 HVAC				
Spec Number	Specification	Quantity	Units	Unit Price Total Price
5932	<p>CENTRAL HVAC SYSTEM</p> <p>Remove existing heating equipment. Install new central A/C heat pump system with a minimum SEER of 15.0, Goodman or equal. Unit to have heat strips for emergency heating. Indoor/ outdoor coil match- up must be ARI listed. Install new foil covered ducts to all rooms with white supply/return air grills and apply mastic where box penetrates through the ceiling to prevent leakage. Include new thermostat, compressor pad & all necessary connections including properly sized circuit breakers for each unit. Unit shall be sized to efficiently heat and cool residence. Include GFI outlet as required by code. Line inside of return air box with new duct board. Seal all gaps and penetrations with mastic to insure that intake air flow goes through the air filter as designed.</p> <p>5 - Hall</p> <p>(1) Install a duct and register in the Family Room and also the Office if possible. Can build a soffit to hide duct in Kitchen like the one above the existing cabinets.</p> <p>(2) Using duct board build a return plenum out flush with the wall or door for ease of filter change out. Seal with mastic.</p> <p>(3) Install a 3" or 4" fresh air duct with run time damper into the return plenum.</p> <p>(4) At each bed room and bath room door cut above the header and install 4"x14.5" air return ducts with registers on each side. Install duct board inside each one and seal with aluminum tape.</p> <p>(5) Pressure test the duct work and plenum and submit acceptable findings to Housing & Community Development Dept.</p>	1.00	EA	_____
		Total for 21 - HVAC:		_____

Figure 4. Excerpt from City of Melbourne bid document for Trade 21: HVAC incorporating all the best practices for HVAC equipment

Passive return air pathways have been required in Florida new construction for many years. It was a surprise to hear that one of the City’s homes had failed an inspection because passive vents had been installed between the bedrooms and the main body of the house, as was called for in the City’s scope of work. The inspector cited fire safety concerns. We believe this might have been resolvable by discussion of the applicable code; however, we did not learn of the issue until corrective action had already been taken. The incident reinforces that unfamiliar details should be discussed with the building inspector’s office in advance of field implementation. While passive return air pathways are mandatory for new construction, the inspectors for existing homes likely do not encounter them often.

The excerpt shown in Figure 4 (above) also includes language to eliminate air distribution via building cavities calling instead for retrofitting and sealing an air barrier into such spaces. Building cavities forming return air plenums were widely evident in the field study and a major source of return air bypass and pressure imbalances. Figure 5 illustrates a common pre-retrofit condition with City of Melbourne post-retrofit solution.



Figure 5. Pre-retrofit metal AHU stand with no dedicated return air path (left); post-retrofit platform AHU support with dedicated, mastic sealed return air path (right)

In addition to the mechanical system criteria modeled after new construction code requirements, the best practices include two items that exceed that code, both shown in the City of Melbourne’s specification in Figures 4 (above): a passive outside ventilation system (described in Section 2) and a duct airtightness performance target.

5.2 Air Handling Unit Closet

AHU closets inside the conditioned space with door- or wall-mounted return air grilles were very common in the field study. Researchers observed AHU closets that were variously connected to attics through open framing of closet walls and/or absence of closet ceiling.

At the onset of Phase 2 research, the best practices included reconfiguration of the air handler closet whenever the air handler was being replaced. Under the City of Melbourne partnership, the best practices were modified to read:⁷

“Air Handler (AHU) Closet at AHU Replacement: Modify AHU closets to create a dedicated, sealed return plenum with a correctly-sized wall or ceiling-mounted return air grille.”

“AHU Closet – All homes regardless of replacement: Eliminate louvered doors that serve as returns. Eliminate metal AHU stands. Where the return plenum is formed by open framing and a plywood platform supporting the air handler, install and seal an air barrier (drywall or duct board) to separate return plenum from adjacent wall cavities and the closet space above. Provide partial door above return air grille (or solid door on side wall) for AHU access. If necessary, extend support platform to form door sill.”

⁷ All quotes in this section are from unpublished work write-ups produced by the City of Melbourne provided to researchers through direct correspondence or from the best practices included in the Phase 1 report (McIlvaine et al. 2013) and in Appendix A.

The Florida residential mechanical code recognizes drywall as an acceptable air barrier for return plenums in new construction. All drywall seams must be taped and finished. Additional sealant must be applied at all intersections of drywall and other materials such as concrete slab floors, wood framing, and plywood. Figure 5 (above) includes elements of these practices. Later in the partnership, the specification language was expanded to include more direction on AHU closet framing, passive return air pathways, and duct testing (Figure 6 below). Examples of pre- and post-retrofit AHU closets are shown in Figures 7 and 8.

Trade:	21	HVAC			
Spec Number	Specification	Quantity	Units	Unit Price	Total Price
5932A	<p>CENTRAL HVAC SYSTEM - 15 SEER Heat Pump Remove existing heating and/or cooling equipment. Install new central A/C heat pump system with a minimum SEER of 15.0, Goodman or equal. Unit to have heat strips for emergency heating. Indoor/ outdoor coil match- up must be ARI listed. Install new foil covered ducts to all rooms with white supply/return air grills and apply mastic where box penetrates through the ceiling to prevent leakage. Ensure flex duct collars are fully insulated. Include new thermostat, compressor pad & all necessary connections including properly sized circuit breakers for each unit. Unit shall be sized to efficiently heat and cool residence. Include GFI outlet as required by code. Line inside of return air box with new duct board. Seal all gaps and penetrations with mastic to insure that intake air flow goes through the air filter as designed.</p> <p>Build a stand for the air handler to sit on and line it with duct board, mastic and tape. Set a return register in the wall into the main hall with the duct board seal up to it. Install at each bedroom a 4"X14.5" return air vent above door, if possible. Place 1.2" duct board in the wall cavity. Ducts insulated to R-6 or higher. Have a duct leakage test done and a passing report (not more than 6% sent to Melbourne Housing & Community Dev. Dept before the subcontractor receives the final payment.</p>				
	<p>9 - Utility Room The existing system has a metal duct ran in the ceiling chase of the hallway. This should be abandoned even if the drywall ceiling must be opened to remove and new ducting installed.</p>	1.00	EA		

Figure 6. City of Melbourne HVAC specification

The excerpt shown in Figure 6 (above), includes language to eliminate air distribution via building cavities calling instead for retrofitting and sealing an air barrier into such as a space as it is written in the best practices. Figures 7 and 8 illustrate common pre-retrofit conditions with post-retrofit City of Melbourne solutions.

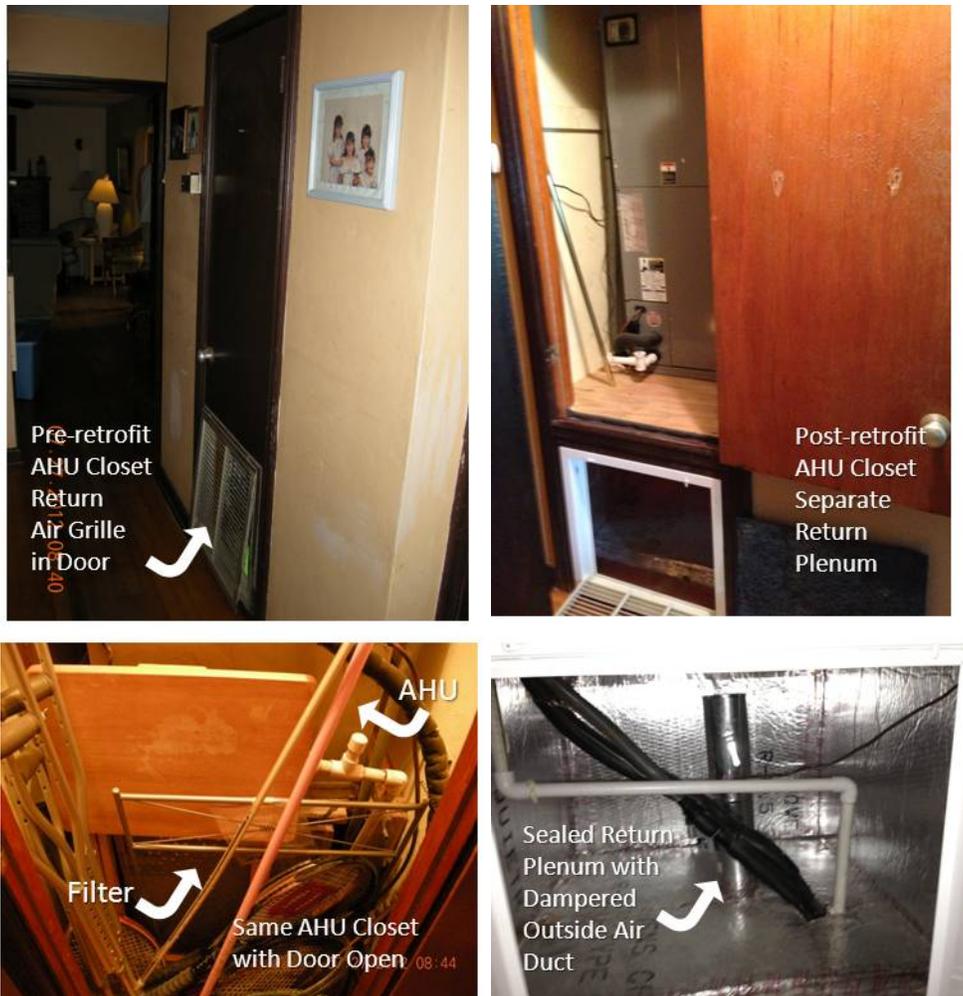


Figure 7. Pre-retrofit AHU closet with no dedicated return (left); post-retrofit with dedicated return and outside air ventilation (right)

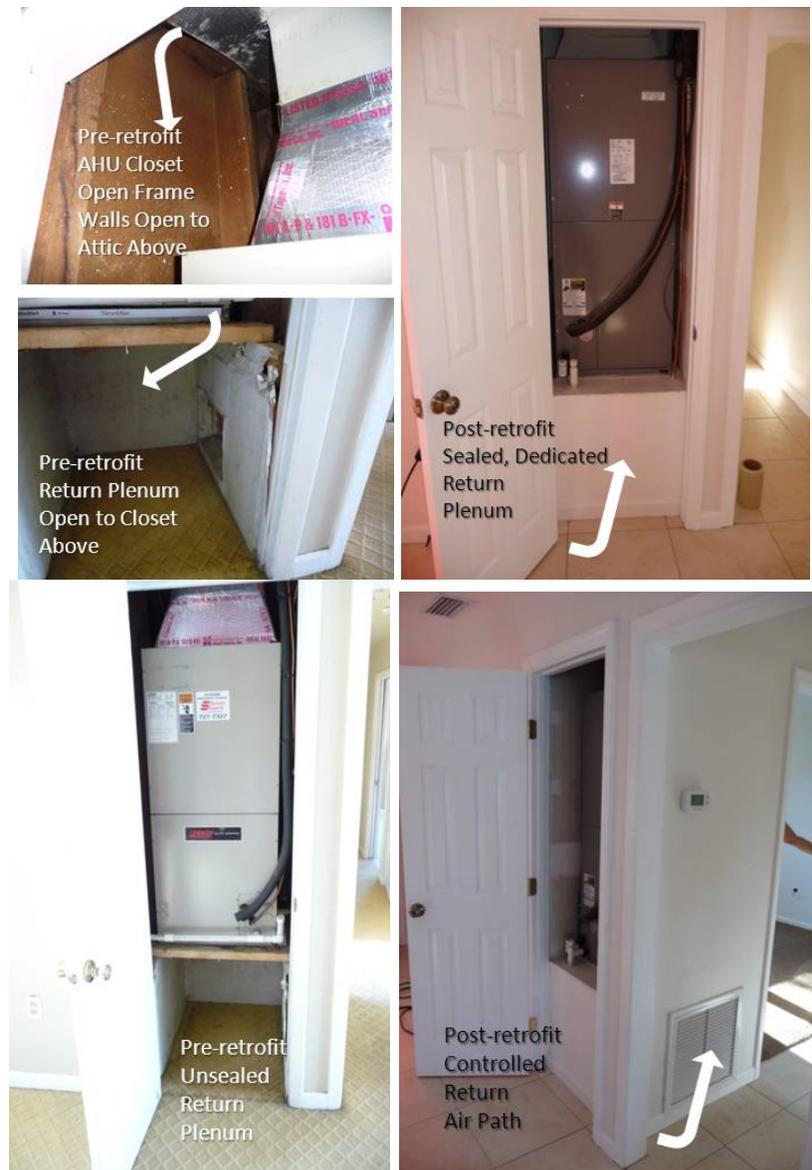


Figure 8. AHU closet with side wall return grille: pre-retrofit (left) and post-retrofit (right)

AHU closet configuration is among the more complex elements of best practices. Developing a standardized approach is challenging because of the diversity in as-found conditions. Whereas specifications for equipment and major components such as windows can be applied without deviation across all homes, the AHU closet involves physical limitations of the existing space as well as the intended size of the replacement AHU. This is reflected in the City’s work write-ups. The language for heat pump specifications is consistent from one scope of work to the next, but the AHU closet renovation is tailored for each house. This takes time in addition to being an unfamiliar goal. This area warrants training at the onset of program development for both the decision-makers writing the work orders and the contractors implementing the improvements.

5.3 Air Distribution System Testing

The duct testing specification in the best practices calls for test-out only:

“Duct testing - Maximum acceptable test result is six cubic feet of air per minute (cfm) per 100 square feet of conditioned area at the test pressure of 25 pascals ($Q_{n,out} \leq 0.06$). Contractor will revisit site to conduct additional sealing for all duct systems (new and existing) that do not pass the post-renovation leakage test.”

This approach was vetted by the Sarasota Office of Housing & Community Development under its NSP2 standards in dozens of homes. The municipality found the approach workable with the labor force in its communities, which includes many home energy raters. The rationale for not including a pre-retrofit duct test is that if the duct system is being replaced, testing the existing one produces no useful information. If the duct system is not being replaced, the best practices call on the mechanical contractor to inspect and seal common points of leakage. This activity, in addition to the AHU closet and return plenum detailing, represents the main extent of what should be done regardless of pre-retrofit test results. A visual inspection is not going to quantify duct airtightness, but it can be used to locate gross leakage points such as disconnects.

Note in Figure 6 (above) that the City is calling for a duct testing report showing compliance to be submitted to their office prior to payment of mechanical contractor. This quality control measure grew in importance to program staff after a contractor made a field decision that the duct testing was not necessary. In the absence of home energy raters to conduct this test, programs could take a prescriptive approach with a detailed duct sealing checklist.

For reference, the target level of normalized duct airtightness is consistent with typical new construction in Florida and slightly less stringent than the level required in the ENERGY STAR for Homes program. Even though the City did not incorporate this specification immediately, results show that the participating HVAC contractors met the goal in five of the seven houses tested (Table 23). This may not be replicable in all markets. The active involvement of the mechanical contractor is paramount to meeting airflow and whole-house efficiency goals. As such, lack of a trained workforce or training availability is a major gap in the market. Training and certification for high performance mechanical systems installation and service are available through the Air Conditioning Contractors of America (ACCA), although feedback from contractors indicates that the cost is high compared to demand at present. As participation grows, energy retrofit programs may be able to specify installation in accordance with ACCA’s Quality Installation Standard (ACCA 2010). Currently there are 55 such contractors in Florida recognized as Quality Assured (QA) New Homes contractors. In March of 2013, ACCA launched the QA Residential Service & Installation program, which will apply the same QI Standard to existing homes.

Table 23. Post-Retrofit Duct Testing Results

Post-Retrofit Testing Required in Bid Document?	$Q_{n,out}$ Target	$Q_{n,out}$ Test Result	Target Met?
Yes	≤ 0.06	0.02 ✓	Yes
Yes	≤ 0.06	0.03 ✓	Yes
No	≤ 0.06	0.04 ✓	Yes
No	≤ 0.06	0.05 ✓	Yes
No	≤ 0.06	0.06 ✓	Yes
No	≤ 0.06	0.07 ×	No
No	≤ 0.06	0.09 ×	No

From Table 23, duct tightness results ranged from $Q_{n,out}$ of 0.02 (2 cfm to outside per 100 ft² at test pressure) to 0.09 with only two homes exceeding the maximum threshold of 0.06. The workforce involved in these renovations is clearly capable of hitting the performance target with the type of homes in the community set. If the work write-up had called for the performance testing in the two homes that did not meet the target, the contractor could have been called back to the site to address common leakage points and attend to any specific leakage points identified by the tester. The two lowest test results ($Q_{n,out}$ of 0.02 and 0.03) were achieved by the same contractor who is credentialed through ACCA’s Quality Installation certification in homes where the work write-ups called for testing and leakage below 0.06 $Q_{n,out}$. ACCA is an HVAC Quality Installation Training and Oversight Organization.

A potential gap in the labor force could arise if neither the tester (e.g., HERS rater) nor the contractor can identify where the illusive duct leakage is occurring. This may be a particular problem when a portion of the air distribution system is inaccessible such as those located in a floor cavity or single assembly roof as described in the next section.

5.4 Enclosed Porches

Panned floor and ceiling joist cavities are other examples of difficult-to-eliminate duct leakage. These commonly arise when a porch with a shed roof has been enclosed and converted into conditioned living space. The shed roof framing intersects the roof trusses on the main house within about two feet of the eave where the head room in the main attic is severely limited (Figure 9).



Figure 9. Intersection of shed or flat roof with conventional trusses (left) at enclosed porches creates a very shallow connection (right) to the main attic. Limits room for routing ductwork.

Interior finish is adhered to the underside of the shed roof joists forming a “single assembly” roof. The connecting space between the Florida room ceiling cavity and the adjacent house attic is the depth of the roof/ceiling joists, which are usually 2 × 4s with nominal depth of 3.5 in. This affords very little room to run a supply duct to the new conditioned space.

Instead of a proper supply duct, a portion of the ceiling in the new space is often “panned” and turned into an air distribution path which is very likely in direct communication with the general ceiling cavity and the adjacent house attic. Removing the supply register often reveals that a cardboard or metal end cap spanning the height and depth of the joist bay has been installed to terminate airflow at the supply register (Figure 10).



Figure 10. Panned ceiling joist details common to enclosed porches

Note the lack of sealant at the edges of the end cap. Access to the joist bay from the main house attic is hampered by ceiling insulation and the limited head room. Not surprisingly, the duct leakage on this system was the highest among the seven tested, with $Q_{n,out} = 0.09$.

The best practices call for eliminating such building cavities being used for air distribution. The contractor is often working against difficult geometry to find an alternative way to direct conditioned air to that space. One of the City’s contractors constructed an interior duct chase at the common wall between the main house and the enclosed porch. Reference Figure 10 above to see the exterior geometry of the home shown in Figure 11 below. The duct chase continues around the room to serve a laundry room located in an extension off the enclosed porch.



Figure 11. Interior duct chase eliminates need for panned ceiling cavity

6 Conclusions

In Phase 2 of this retrofit research, we investigated three implementation scenarios for the current best practices and a community-scale partnership with the City of Melbourne. The conclusions section addresses the research questions outlined in Section 1.3.

6.1 Research Question 1

What level of whole-house efficiency improvement can be expected from implementation of the current best practices?

The answer varies with the pre-retrofit whole-house efficiency and condition of major energy-related characteristics. Fewer of the best practices are relevant to homes that do not need energy-related replacements or that have relatively high whole-house efficiency. Phase 1 of the research showed that when only a few best practices are applicable to a home, less improvement can be expected. In Phase 2, researchers conducted a simulation analysis of a pre-code base home in central Florida with HERS Index scores of 13 based on the home characteristics evidenced in Phase 1. The analysis assesses improvement potential under three different scenarios (Table 24) that represent three levels replacement need. Analysis shows homes of this level of whole-house efficiency can likely achieve 19%–28% savings (Table 24) in projected annual energy costs and 26%–39% HERS Index score improvement comparing post-retrofit to the minimal improvement case. Variations in condition and need for replacement of key energy-related components and equipment create the spread of savings potential. This is illustrated in analysis of three likely retrofit scenarios. Even higher performance replacements for water heating, HVAC, or windows would easily push projected annual cost savings over 30%. Cost effectiveness would depend on local market availability and cost.

Table 24. Summary of Scenarios 1, 2, and 3

(same as Table 15)

Description	Scenario 1 Efficiency Enhancement Package (No Replacements)	Scenario 2 Efficiency Enhancements and Higher Performance Replacements	Scenario 3 Scenarios 1 and 2 Plus HVAC and Window Efficiency Upgrades at Replacement
HERS Index Pre-Retrofit	131	131	131
HERS Index With Minimum Replacements (where applicable)	NA	130	113
HERS Index Post-Retrofit	94	96	69
HERS Index Improvement (over minimum, if applicable)	28%	26%	39%
Projected Annual Energy Cost Savings (% over minimum if applicable)	20%	19%	28%
Estimated Full Costs	\$2,880	\$12,221	\$23,379
Estimated Efficiency Cost Premium	\$2,880	\$1,921	\$5,538
Annual Mortgage (7% @ 30 years)	\$232	\$155	\$446
Projected Annual Energy Cost Savings	\$505	\$490	\$644
First Year Cash Flow	\$273	\$355	\$198
Simple Payback (years)	5.7	3.9	8.6

The base house closely approximates the average HERS Index score and characteristics found in the Phase 1 field study. Full implementation of the best practices in Scenario 3 resulted in a 39% improvement in the HERS Index score and 28% in projected annual energy cost savings comparing the post-retrofit to the minimum retrofit scenario. To reiterate, the minimum retrofit scenario includes minimum replacements at change out. Note, for instance, the HERS Index score for the minimum retrofit scenario is 113, significantly better than the as-found score of 131, because even the minimum efficiency replacements are significantly better than the as found conditions. Comparing the post-retrofit HERS Index score to the *pre-retrofit*, which was the Phase 1 metric, produces a 47% improvement in the HERS Index.

Researchers assert that homes of similar or worse whole-house efficiency than the base house that also need extensive energy-related replacements have a high potential for achieving a deep retrofit with positive first year cash flow under the reported mortgage terms. Thus Scenario 3 represents the likely practical threshold for achieving deep retrofits in central Florida pre-code homes that generate positive first year cash flow. Depending on equipment cost in the local market conditions, higher efficiency heat pumps may be cost effective and would without a doubt push projected annual energy cost savings over 30%. Installation of a heat pump water heater would be another measure to help the project attain over 30% energy cost savings. Due to space and location considerations, however, the heat pump water heater is only a recommended measure within the current best practices.

Homes that do not need as many (Scenario 2) or any (Scenario 1) energy-related retrofits can likely achieve around 25% or more improvement in whole-house efficiency with about 20% in projected annual energy use.

The savings expectations are in comparison to minimal efficiency upgrades. Program-wide improvement will be relative to the existing standard practice, which may or may not include efficiency measures beyond minimally available.

Lesson 1: Scenario 3, a comprehensive implementation of the best practices in an average home (HERS Index score 131) represents the likely practical threshold for achieving deep retrofits in central Florida pre-code homes that generate positive first year cash flow.

6.2 Research Question 2

To what extent are affordable housing partners willing and able to adopt and implement a standardized approach to energy efficiency and building science based on the best practices?

Achieving replicable results requires a standardized methodology that can accommodate predictable variances with practical quality control procedures. The City of Melbourne, our primary partner in Phase 2, was willing to adopt improvements if there was compelling evidence that the benefit to the occupants justified the investment, and that implementation would be practical given program boundaries and existing market conditions (labor, availability, code compliance, etc.). The City of Fort Myers also incorporated best practices into its standard specifications for retrofits.

With due consideration and evaluation, the City of Melbourne has successfully integrated the hot-humid climate retrofit best practices into its retrofit standards and bid document development processes. The following lessons for program developers emerged from our partnership.

Lesson 2: Undertake a preliminary evaluation period among decision-makers and program stakeholders.

Before the City program manager committed to implementation of the best practices, they discussed each practice individually with researchers and internal staff. This was a technical dialogue revolving around practicality and building science. Taking time to evaluate the pros and cons of individual practices builds consensus among decision-makers, which is crucial to establishing program-wide commitment. In addition to addressing internal concerns, program managers or field staff should query likely program participants (contractors, etc.) and code officials regarding any unfamiliar construction detailing. Taking time at this juncture to consider potential barriers can prevent a breakdown in program activity later. The objective here is for program staff to work out in advance the questions and limitation that might arise during implementation. This is part of a systems engineering approach that favors anticipating and developing solutions for problems before they arise in community-scale implementation.

Lesson 3: Review current market conditions.

In addition to building science principles and implementation, the preliminary discussions between the City and researchers addressed the costs of individual practices. We had cost data from the field study, which is useful for getting a ballpark idea of costs for discussion purposes. Before committing to a specification or practice, though, program staff need to check into local market conditions, even if they were investigated in the past. For example, the City had previously opted for lower performance HVAC and window specifications than those in the best practices because of cost premiums. However, after conducting a market survey, the program manager and staff found that prices had declined enough to permit adoption of the higher performance specifications.

Lesson 4: Involve staff at all levels in the decision to adopt high performance specifications.

At the City of Melbourne, researchers met with administrative, field, and financial staff to discuss the best practices. It appeared that each perspective contributed to the feasibility evaluation. In other BA-PIRC projects, multilevel buy-in, rather than a top-down approach, has resulted in a more thorough, enthusiastic, and sustainable integration of high performance principles into standard procedures (Thomas-Rees et al. 2013).

Lesson 5: Stage integration of new specifications at a pace manageable for staff and program participants.

The City took an incremental approach. Straightforward practices such as heat pump specifications were adopted quickly. Those that required changes in construction processes (and thinking) were adopted more slowly, as was illustrated in Section 5. Once these more complex changes were refined, the City was ready to include them in the master specification. This is the reverse order that researchers expected because The City of Fort Myers' approach was to change the master specification document first. Depending on individual initiative and organization of

staff, it may be necessary for staff to gain first-hand experience with unfamiliar details before program-wide adoption.

Lesson 6: Develop clear, standardized language for communicating specifications and expectations to contractors and subcontractors and other program stakeholders.

Clear communication is necessary to ensure that high performance specifications translate into high performance results. The City of Melbourne already had a standardized procedure for producing bid documents, which very formally communicate expectations to contractors. Standardized language for each adopted best practice was added to existing libraries in the City's spec writing software. Standardized language can foster consistent results across a community-scale retrofit program. The City's final walk-through requirement gives staff an opportunity to revisit the bid document at post-retrofit. Essentially, bid documents can serve as a quality control checklist. When multiple persons are conducting final inspections, a standardized level of acceptability must be established among program staff.

The bid development paradigm is fairly typical for local government housing entities; however, nonprofit organizations such as Habitat for Humanity that make use of an internal labor force rely more on a project management hierarchy than on scopes of work. In that case, developing a standardized procedure must be a collaboration of all the decision-makers and followed up with training for all affected staff to ensure specifications are implemented consistently across the community. A checklist format for each critical review point (e.g., prior to drywall installation) has proven effective in new construction projects as evidenced by inclusion of extensive use of checklists in the ENERGY STAR for New Homes Standards beginning with Version 2.0 and continuing with Version 3 (ENERGY STAR 2012a, 2012b).

6.3 Research Question 3

What steps (training, test houses, presentations to decision-makers, provision of research results, etc.) are necessary to engage partners in implementation?

The results from the Phase 1 field study raised awareness and sparked interest; however, providing access to the best practices and analysis of similar homes from previous partnerships was not sufficient to spur adoption. Group discussions with administrators, financial, and field staff that encompassed building science, practical applications, and financial considerations clearly helped to build momentum, confidence, and interest. True engagement seemed to arise coincident with conducting simulation analysis to answer their specific questions (e.g., SEER 13 versus SEER 15) and to compare their standard approach to the best practices in one of their real projects. The former contributed to confident decision-making. The latter quantified the benefit they were already providing to their buyers and clarified the magnitude of cost and cost savings associated with higher performance specifications. We have noticed with this and other partners that this type of "discovery analysis" is more influential than analysis of other partners' homes.

Lesson 7: Prototype unfamiliar details with key contractors prior to making them a requirement to gain first-hand experience with challenges and solutions.

The good rapport between City staff and the organizations responsible for the actual renovations made it easier to conduct some field prototyping of new construction detailing, like the AHU

closet, before they were incorporated into actual bid documents. A design and implementation plan should be developed in advance. However, prototyping provides an opportunity to test and modify strategies in a three-dimensional environment. Successful prototyping also develops confidence in all parties that different construction practices can be done well and within standard operating procedure.

Researchers had not intended to provide this level of direct support in Phase 2 of the research. The best practices include working with a certified home energy rater or other qualified consultant who could provide program administrators with this support. In the case of the City of Melbourne, there were no funds available for such support. This will likely be a barrier to wider adoption of the best practices.

6.4 Research Question 4

Which elements, if any, required technical assistance from BA-PIRC? Can the language of the best practices be adjusted to facilitate meeting the specifications without technical assistance?

The City of Melbourne did implement the majority of best practices applicable to its homes. For elements involving unfamiliar building science concepts, there was a need to provide training to both program decision-makers and field staff on heat, air, and moisture flow dynamics to allay concerns. In Phase 2, researchers provided this training, but this could constitute a significant barrier to implementation in absence of a qualified professional with a building science background. If the reasoning behind a practice is not well understood, there is a risk that it will receive a lower priority. It is unlikely that this can be resolved in the context of a document focused on best practices; however Building America publications available through the website and the emerging Building America Solution Center provide sufficient material to serve program staff motivated to learn building science principles and applications.

Lesson 8: Use available resources from the Building America Solution Center and the ENERGY STAR website to bolster organizational familiarity with building science and “house as a system” thinking.

A few best practices warranted technical assistance discussions. The outside air ventilation practice was challenging for the City and its team of contractors, but no more so than was typical among other partners. Because the system design must factor in house size, operating static pressures, and physical constraints specific to each home, the detailing cannot really be standardized. An off-the-shelf ventilation system such as an energy recovery ventilator may be easier to implement; however we need more data before we can confidently recommend such systems in the subject housing type. BA-PIRC has two monitored ventilation studies planned for 2013.

The sealing of the return plenum was discussed extensively at the onset of the project. Once the field manager had a clear understanding of the desired end result, he worked with participating contractors to implement the detail with no researcher field support. The duct airtightness test results (Table 23) attest to their success.

The duct testing specification is now integrated into the City’s standard specifications. One of the general contractors hired a home energy rater to conduct the testing. Under another general

contractor, the mechanical contractor was certified under the ACCA's Quality Assurance program for new homes. He tested the duct system using an alternative to the depressurization method used in the home energy rating industry and called for in the best practices. We found the two duct systems he installed were tighter (measured with standard depressurization test conditions) than the results he reported from his alternative test method. They were the best ducts systems we tested, with Qn,out of 0.03 and 0.02.

The number of ACCA-certified HVAC contractors in the labor force may rise if participation in the ENERGY STAR for New Homes Standard, version 3.0/3.1 program ramps up. Several related test methods are outlined in ACCA's Quality Installation Specification Standard (ANSI/ACCA 2010). These warrant further investigation for community-scale retrofit programs, though there may be a conflict of interest if contractors are testing systems they installed.

Passive return air pathways are required for new construction in Florida and called out specifically in the best practices using the language and sizing guidelines in Florida's residential building code (ICC 2011c). Though contractors met this criterion with transoms and transfer ducts, one inspector required the contractor to take them out. This reemphasizes Lesson 2 above regarding a preliminary evaluation period. Any out-of-the-ordinary detailing should be discussed with contractors, subcontractors, code officials, suppliers, and other program stakeholders in advance to identify and resolve potential red flags before adopting as standard practice. Discussions can be improved using material from the Building America Solution Center and materials from the DOE Challenge Home and Energy Star for Homes programs.

6.5 Final Remarks

The simulation analysis exercise and the City of Melbourne partnership illustrates that deep retrofit goals can be met in pre-energy code homes with off-the-shelf technology and moderate changes in remodeling practices outlined in the hot-humid retrofit best practices.

Analysis Scenarios 1, 2, and 3 and the City of Melbourne's master specifications show that efficiency measures and replacement upgrades can produce positive cash flow when implemented and financed at the time of sale. Depending on local market conditions and labor force readiness, some measures may be more cost effective than others. A home energy rater or other building science professionals can assist with evaluation of the best practices to build confidence and momentum for retrofit programs.

Lessons 1–8 presented in the conclusions provide valuable insight for program developers based on field experience with local governments and nonprofit housing providers in approximately 80 central Florida homes (including Phase 1 and Phase 2).

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Appendix A: Current Best Practices, Version 2

(McIlvaine et al. 2013b)

This material is excerpted in entirety from *Current Best Practices for High Performance, Deep Energy Retrofits in Florida Affordable Housing* and provided here for the reader's quick reference. The best practices will be periodically refined or updated. For the latest version, visit the "Publications" page at www.ba-pirc.org or contact the Buildings Research Division at the Florida Solar Energy Center.

1.0 Overview

In the fall of 2009, researchers at the Florida Solar Energy Center (FSEC) began a field study with affordable housing entities in central Florida that were conducting major renovation projects in unoccupied, foreclosed homes. The study was funded initially funded by the Florida Energy Systems Consortium, subsequently funded by the U.S. Department of Energy's Building America program (www.buildingamerica.gov), and conducted by researchers of the Building America Partnership for Improved Residential Construction led by FSEC.

The study was comprised of 70 homes. When partners were replacing components and equipment because they were worn out, researchers provided savings projections for higher-efficiency choices. Additionally savings were projected for improvements that were strictly for energy efficiency, such as adding ceiling insulation. Improvement was gauged using the Home Energy Rating System (HERS) Index and projected annual energy use. Average whole-house improvement was 34% in HERS Index score and 25% in projected annual energy use savings.

The contents of this document are a refinement of the best practices presented in the original field study report ("Energy Retrofit Field Study and Best Practices"⁸) and a direct excerpt from a follow-on implementation study (Applying Best Practices to Florida Local Government Retrofit Programs"⁹). Report and periodic updates based on user feedback will be posted on the BA-PIRC website publications page (<http://www.ba-pirc.org/pubs/index.htm>).

In the field study, project managers had the ultimate decision over what retrofit options to implement in each home. Researchers tracked the choices and culled the best practices from a sub-set of 46 homes that achieved a 30% improvement in efficiency. The homes with 30% improvement all included "deep" retrofit measures that involved major system and/or component replacements. They also included "shallow" retrofit measures that contribute to but have a smaller impact on overall savings.

The best practices summarized in this document are specific to the hot-humid climate and market environment of central Florida. They are a mixture of assessment, design, specification, quality assurance, and verification measures. They represent *either* the most commonly adopted practice observed in this field work or, in some cases, the highest performance practice that did not involve additional cost. For example, although "medium" was the most commonly chosen exterior paint color, "white" is the highest performing color and herein the recommended

⁸ For further details see, "Energy Retrofit Field Study and Best Practices" (McIlvaine, Sutherland, Martin) <http://www.fsec.ucf.edu/en/publications/pdf/FSEC-RR-404-13.pdf>.

⁹ Report currently in peer review as of September 2013. The final report will be available on the BA-PIRC website publications page www.bapirc.org/pubs.

practice. Additional building science measures from the *ENERGY STAR for Homes* program and Department of Energy’s *Challenge Home* programs have been included in the best practices to address occupant health, safety, building durability, and comfort concerns.

The checklist is organized by building component or equipment type. Best practices applicable to “All Homes” are distinguished from those applicable only at the time of “Replacement”. For example, ceiling insulation levels are applicable to all homes; however, some mechanical system efficiency practices are only applicable at the time of equipment replacement. Predictions show that it is cost-effective to choose higher-efficiency mechanical equipment at the time of replacement, but not to replace functioning equipment strictly for the efficiency gain. The projected annual energy use for practices recommended for “All Homes” justifies the full expense of the measure (or has been included for occupant health, safety, building durability, and comfort). Those components or equipment recommended for “Replacements” justify only the *incremental* cost for higher-performance choices, not the total cost for replacing a functioning system with useful life.

As with all recommendations, common sense must prevail. The projected savings may not justify costs that exceed customary and reasonable bounds. For example, space constraints may increase labor and material costs. We highly recommend working with a home energy rater or other qualified consultant to evaluate the cost and benefit of specific measures in the context of a specific home or set of similar homes. However, in the absence of such individualized evaluation, these best practices may aid the decision-making process.

2.0 Critical Cautions

- For all homes with existing or planned atmospheric combustion furnaces or water heaters, refer to the Combustion Safety section (3.11) at the end of this checklist for cautions to be observed throughout the renovation process.**
- Do not implement measures that conflict with code or manufacturer instructions.
- Normal print indicates required measures for participation with the Building America Partnership for Improved Residential Construction (BA-PIRC), a U.S. Department of Energy Building team led by FSEC. Additional recommendations are in italics.
- Be advised that the required items affecting air, heat, or moisture flow should be implemented collectively to prevent safety, durability, and comfort issues.
- These recommendations are not a substitute for evaluation of individual homes. We highly recommend working with building science professionals with certifications in home energy rating and combustion safety (e.g. a certified HERS rater or a Building Performance Institute (BPI) certified professional.)

3.0 Current Best Practice Recommendations

3.1 Heating, Ventilation, Cooling, and Air Conditioning (HVAC) Distribution Systems

Caution: Reference the Combustion Safety section (3.11) if a gas furnace exists or is planned.

3.1.1 Existing HVAC Equipment Not Being Replaced

- Hire a heating, ventilation, and air conditioning (HVAC) contractor to evaluate, and service if needed, refrigerant charge, inside and outside coil condition, condensate drain lines, and gas furnace components including exhaust flues, combustion air supply, gas lines, and other major equipment components.
- Implement all items in “All Homes Regardless of System Replacement” below.

3.1.2 Full or Partial HVAC System Replacement

- Install, at minimum, an ENERGY STAR heat pump (seasonal energy efficiency ratio (SEER) 14.5 or greater). In south Florida, an ENERGY STAR air conditioner is acceptable.
- Equipment Sizing: Perform ACCA Manual J calculations (now required for replacements by the Florida Energy Code). Use projected home characteristics provided by house supervisor.
- Supply and Return Ducts: Seal accessible (30” clearance) ducts left in place with code-approved sealant (required at equipment change out by Florida Energy Code), including the return plenum air barrier (drywall, duct board, etc.). Provide air barrier if not present.
- Air Handler (AHU) Closet at AHU Replacement: Modify AHU closets to create a dedicated, sealed return plenum with a correctly-sized wall or ceiling-mounted return air grille.
- Duct Replacement: Install new ducts with R-value ≥ 6 .
- Implement all items in “All Homes Regardless of System Replacement” below.
- AHU Location: When equipment and ducts are replaced, relocate AHU into conditioned space.*
- Perform ACCA Manual S equipment selection.*
- Perform ACCA Manual D duct sizing.*
- Produce a schematic duct design for field crew showing sizes for each component and conduct rough-in inspection to ensure installation meets design intent.*

3.1.3 All Homes Regardless of HVAC System Replacement

- Duct Sealing: Hire an HVAC contractor to seal all duct connections with UL181-rated materials, preferably fiberglass mesh embedded mastic, including joints and edges in supply and return runs, return plenum, and connections to AHU.
Important note: Contractor will revisit site to conduct additional sealing for all duct systems (new and existing) that do not pass the post-renovation leakage test.

- Maximum acceptable test result is six cubic feet of air per minute (cfm) per 100 square feet of conditioned area at the test pressure of 25 pascals ($Q_{n,out} \leq 0.06$).
- Duct Airtightness Testing: Have a certified home energy rater conduct a duct airtightness test as outlined in the Duct Testing section (4.1).
 - AHU Closet: Eliminate louvered doors that serve as returns. Eliminate metal AHU stands. Where the return plenum is formed by open framing and a plywood platform, install and seal an air barrier (drywall or duct board) to separate return from adjacent wall cavities. Provide partial door above return (or solid door on side wall) for AHU access. If necessary, extend platform to form door sill.
 - Flex Ducts: Ensure flex duct insulation covers all collar and boot connections. Flex duct runs should not be kinked or have sharp bends, and they should have as little contact as possible with ceiling insulation. Strap flex ducts to trusses, 5' or less spacing, to achieve clearance over anticipated ceiling insulation. Ideally, locate ducts midway between roof deck and insulation.
 - Outside Air Ventilation: Given pre-retrofit whole house airtightness test results with estimated natural infiltration ≤ 0.35 , seek technical support from home energy rater or other qualified consultant regarding possibility of mechanical ventilation system including need, space availability, and physical challenges. General guidance on a passive, run-time, outside air ventilation system is included in Appendix A.
 - Filter: Do not obstruct under-AHU filter cavity, if present. Install MERV 6 filter.
 - Ensure operational bathroom and kitchen exhaust fans ducted to outside. (Upon completion, ensure ceiling is insulated.)
 - Vent clothes dryer to outside (not crawl spaces or attics).
 - Bedroom Return Air: In homes with only one centrally-located return, hire an HVAC contractor to install passive return air pathways sized per guidelines in Florida Mechanical Code Section 601.4.*
 - Install a bath fan timer.*

3.2 Whole-House Airtightness

- Ensure whole-house air leakage of 6 or less air changes per hour at the test pressure of 50 pascals ($ACH50 \leq 6.0$), similar to new construction in Florida.*
- Whole-House Airtightness Testing: Have a certified home energy rater conduct a whole-house tightness test as outlined in the Whole-House Testing section (4.2).*
- Seal with code-approved sealant the following common air infiltration points:*
 - *Windows*
 - *Doors – replace weather-stripping if missing or degraded*
 - *Lighting fixtures and ceiling fans (drywall gap behind cover/trim)*
 - *Kitchen exhaust fan chase (at ceiling)*
 - *Switches and outlets – if replacing covers, seal boxes to drywall*
 - *Plumbing penetrations through interior and exterior walls (e.g. under sinks)*
 - *Plumbing access panels – secure tightly and/or weather-strip*
 - *Attic hatch or stair – weather-strip*
 - *Interior AHU closet – seal all edges and seams of walls, ceiling, and ducts*
 - *Soffits over cabinets or housing lighting – add air barrier above*

- *Holes in drywall*
- *Frame floor penetrations for plumbing and electrical*

3.3 Roof Finish and Replacement

- If asphalt shingle, choose light or white-colored finish, Solar Reflectance ≥ 0.25 .
- Ensure proper installation of roof flashing.
- Install roof drip edge.*
- If replacing roof decking, install radiant-barrier roof decking. Reference roofing manufacturer specifications to assure no void in warranty.*

3.4 Attic Insulation

Caution: Complete mechanical, electrical, and plumbing rough-in prior to ceiling insulation.

3.4.1 Vented Attics

- Add insulation to achieve RESNET Grade I R-38 throughout.
- Prior to adding ceiling insulation, box-in or eliminate all recessed lighting fixtures not rated air tight and approved for insulation contact (ICAT).
- Strap flex duct above ceiling insulation. See description in section 3.1.3 above.
- Insulate interior attic hatches and stairs with rigid foam or batt insulation to R-19 and weather-strip edge.
- Where attics extend over porches, provide air barrier (house wrap, blue board, etc.) to prevent ceiling insulation spillage onto porch ceiling.*
- Where floor cavities abut attic space, provide air barrier to keep attic air out of floor cavity.*
- Install ventilation baffles at eaves.*

3.4.2 Attic Knee Walls

- Insulate knee walls to RESNET Grade I R-13 or greater. Ensure a durable installation that will hold insulation in contact with drywall.

3.4.3 Unvented Attics

- Consult an energy rater regarding existing or planned unvented attics. Careful detailing and quality control are required to prevent uncontrolled heat, air, and moisture flow.

3.5 Windows

3.5.1 Window Replacement

- Install, at minimum, ENERGY STAR-labeled windows (U-value ≤ 0.6 or lower and solar heat gain coefficient (SHGC) ≤ 0.27 or lower).
- Retain National Fenestration Rating Council (NFRC) label to provide project manager proof of window performance specification, including SHGC and U-value.
- Ensure proper window flashing installation.

- If installing house wrap, follow manufacturer instructions for cutting and wrapping at window openings.
- Check for and replace any rotted materials around window (e.g. studs, sheathing).
- Air seal between window frame and rough opening with a sealant designed for windows.

3.5.2 All Homes Regardless of Window Replacement

- Replace rotted materials around window (e.g. rough opening, sheathing).
- Replace missing head flashing at wood siding.
- Caulk edges of window frame/trim on both interior and exterior.*
- For existing clear windows not being replaced, apply window tint to achieve combined (glass + tint) SHGC ≤ 0.5 and preferably visible transmittance ≥ 0.5 . Note: Mock up tinting (e.g. tape in place) to assess aesthetics. For windows with active warranties, check with manufacturer before installing.*

3.6 Exterior Walls

- Eliminate vinyl wall paper.
- If painting, use light or white color.
- If replacing drywall in frame construction, install RESNET Grade I R-13 insulation
- If replacing drywall in block construction, install a continuous layer of rigid insulation followed by furring strips for drywall attachment.
- If replacing siding, check for and replace rotted materials, install and integrate continuous drainage plane with window and door flashing, and if concrete masonry unit, assure weep holes at bottom of siding.*
- If replacing drywall or siding, implement applicable criteria on the Thermal Enclosure System and Water Management System checklists of the Energy Star for New Homes version 3 Standard.*
http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_v3_guidelines

3.7 Floors

- If crawl space, repair or install 6 mil polyethylene ground cover, lapping joints 6", and continuing up stem wall and supports 2'. Add sump pump if potential for flooding.

3.8 Water Heating

Caution: Reference the Combustion Safety section (3.11) if a gas water heater exists or is planned.

3.8.1 Water Heater Replacement

- Discuss the following options and implications with home energy rater:*
 - *Solar: solar access, cost and maintenance implications of different systems, and local incentives.*
 - *Gas: direct-vent or tankless unit (energy factor (EF) ≥ 0.8 , may require exterior wall).*

- *Electric: integrated heat pump water heater (COP \geq 2.0, space constraints) or standard tank-type unit, EF \geq 0.92.*

3.8.2 All Homes Regardless of Water Heater Replacement

- Insulate accessible hot water pipes.
- Wrap tank with R-5 blanket (for gas units, read instructions carefully).*

3.9 Appliances, Lighting, and Fans – All Homes

- Install ENERGY STAR-rated refrigerator upon replacement.
- Clean refrigerator coils, if not replacing.
- Install screw-in or pin-based compact fluorescent lamps (CFL).
- Install electronic ballast with T8 lamps upon replacement or repair in fluorescent tube fixtures.
- Eliminate all recessed fixtures not rated air tight and approved for insulation contact (often labeled “ICAT”).
- Select ENERGY STAR-rated ceiling fans upon replacement.
- Install air barrier above soffit-mounted light fixtures to separate soffit from attic or floor cavity.*

3.10 Site

- Remove moisture loading at walls and foundation (e.g. irrigation system, roof runoff, soil contact).
- Add pool cover to all pools.
- Plant drought-tolerant shade trees near east and west-facing windows (Deciduous trees in North Florida).*

3.11 Combustion Safety

3.11.1 Combustion Appliance Replacement

No new atmospheric combustion furnaces or water heaters should be installed inside the conditioned space. Replacement gas furnaces should be high-efficiency, sealed combustion units. Replacement gas water heaters should be direct-vent (tank type or tankless). These options are not likely to be cost-effective; however, health and safety considerations are the first priority. Work with a home energy rater to conduct an evaluation of projected savings for these options. Consult the U.S. Department of Energy’s Technology Fact Sheet “COMBUSTION EQUIPMENT SAFETY” for additional information on combustion safety¹⁰.

3.11.2 All Homes With Combustion Appliances Regardless of Replacement

Renovations can significantly alter combustion air-flow dynamics, potentially creating unsafe, life threatening situations that did not previously exist. Extreme caution is needed to ensure occupant and worker health and safety as well as building durability in any

¹⁰ http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/26464.pdf

home with an atmospheric combustion furnace and/or water heater, even if it is not located inside the conditioned space. If combustion appliances exist and are being replaced with non-combustion appliances, disable appliances and remove from premises prior to retrofit, otherwise:

- Pre-retrofit: In addition to defining equipment specifications and installation details for combustion air supply and exhaust components, work with a BPI-certified home professional, or other qualified professionals such as a certified HERS rater with additional combustion safety training, to evaluate and devise a combustion safety plan to prevent accidentally back drafting exhaust fumes into the conditioned space before, during, and after renovation. Tests should be conducted to assess air pressure conditions in the combustion air zone where the furnace and/or water heater are located and air pressure differences between the combustion air zone and the occupied areas of the home. Conducting testing prior to renovation will help identify existing air flow and pressure dynamics.
- During retrofit: Disable combustion furnaces and water heaters unless a plan has been executed specifically to ensure combustion safety. Unpredictable activity during construction could inadvertently create dangerous conditions.
- Post-retrofit, prior to occupancy: Arrange for post-renovation testing to verify that no air pressure conditions have been created that jeopardize either combustion air supply or exhaust or that would result in combustion exhaust gases entering the conditioned space.
- Install carbon monoxide (CO) detectors and post an action plan near all combustion appliances and all bedrooms for occupants in the event of alarm.

4.0 Certified Home Energy Rater Minimum Scope of Activity – All Homes

Conduct all activity in accordance with RESNET standard, including taking all due combustion safety precautions prior to, during, and after testing.

4.1 Duct Testing

- Pre-retrofit (recommended only if AHU and duct system is not being replaced): Conduct standard RESNET duct airtightness assessment. If leakage to outside exceeds target of 6% ($Q_{n,out} \geq 0.06$), assess the following common leakage points, and where leakage exists, advise house supervisor of corrective action (→):*
 - *AHU closet → install drywall finish on all walls and ceiling, if not present. Seal all edges and seams.*
 - *Central ducted return → seal return grille connection to framing; return plenum (e.g. duct board) connection to framing and connection to AHU.*
 - *Open platform → seal all edges and seams.*
 - *Registers → if supply registers are being removed (e.g. for painting), seal between drywall and boot.*
 - *Joints → seal any loose connections, and ensure flex duct insulation fully covers collars.*

- Post-retrofit: Conduct/repeat duct testing to ensure target of 6% ($Q_{n,out} \geq 0.06$) is met. If not, assess leakage points and advise house supervisor of recommended action.

4.2 Whole-House Testing

- Pre-retrofit: Conduct standard RESNET whole-house airtightness assessment. If test results exceed target of 6 or less air changes per hour at the test pressure of 50 pascals ($ACH_{50} \leq 6.0$), identify major leakage points (reference the Whole-House Airtightness section (3.2) for common leakage areas), and communicate prioritized list of sealing points to house supervisor.*
- Post-retrofit: Repeat whole-house testing to ensure target is met. If not, assess leakage points and advise house supervisor of recommended action.*

Table 1. Example Project Manager Verification Checklist for Heating, Cooling, and Air Distribution Systems

PRE-RETROFIT:

- Bid documents:
 - o Include all applicable HVAC requirements from master specifications in the bid documents.
 - o Alert general and HVAC contractors to duct testing requirements.
 - o Provide list of common duct leakage points.
 - o Include “retest at contractor’s expense if target is not met” in scope of work.
 - o If passive outside air ventilation is being installed, provide general and HVAC contractors ‘General Guidance on Passive, Runtime, Outside Air Ventilation System’ (see Appendix).

POST-RETROFIT:

- Acquire documentation for Manual J calculation (required for permit at replacement in Florida). Verify system is within 125% of Manual J calculation. If not, request explanation and justification. Keep with house records, for reference, in the event of discomfort complaints.
- Visually inspect the duct system and verify:
 - o Duct R-value ≥ 6 for new ducts.
 - o Flex duct insulation fully covers collars and boot at connection insulated.
 - o Ductwork strapped to trusses above insulation.
 - o Recall contractor to attend to deficiencies.
- Work with home energy rater to determine if duct airtightness targets have been met. Target test result is leakage to the outside ≤ 6 cfm per 100 square feet of conditioned space ($Q_{n,out} \leq 0.06$). If target is not met, visually inspect the following duct details, and recall contractor to attend to deficiencies (note: all sealants in air flow path must be code approved):
 - o Dedicated, sealed path for return air through a return air grille. Louvered doors that serve as returns and metal AHU stands have been eliminated.
 - o Gap between return air grille and rough opening is sealed.
 - o Gap between AHU and platform is sealed.
 - o Gap between AHU platform and return plenum is sealed.
 - o Gap between drywall and supply boots (behind supply register).
 - o No visible holes or loose connections in duct system.

- Retest to verify target is met.
- If a mechanical ventilation system has been installed, inspect system to ensure proper installation of intake register, ducts, filters, and dampers. (See Appendix for guidance.)

○

Table 2. Example Project Manager Verification Checklist for Envelope Components, Post-Retrofit

- Visually inspect the building envelop and work with home energy rater to determine if whole-house airtightness targets have been met. Target test result is $ACH50 \leq 6.0$. If target is not met, work with rater to assess airtightness at the following common air infiltration points:
 - Windows – caulk edges of window/frame/trim on both interior and exterior
 - Doors – replace weather-stripping if missing or degraded
 - Lighting fixtures and ceiling fans (drywall gap behind cover/trim)
 - Kitchen exhaust fan chase (at ceiling)
 - Switches and outlets – if replacing covers, seal boxes to drywall
 - Plumbing penetrations through interior and exterior walls (e.g. under sinks)
 - Plumbing access panels – secure tightly and/or weather-strip
 - Attic hatch or stair – weather-strip
 - Interior AHU closet – seal all edges and seams of walls, ceiling, and ducts
 - Soffits over cabinets or housing lighting – add air barrier above rough framing, seal all edges and seams
 - Holes in drywall
 - Frame floor penetrations for plumbing and electrical
- Recall contractor to correct deficiencies.
- Retest to verify target is met.
- Visually inspect the attic to assess:
 - Even level and proper depth of new insulation, if installed.
 - Flex ducts are strapped above ceiling insulation.
 - Attic insulation does not obstruct ventilation at eaves (baffles are in place were possible).
- Acquire NFRC documentation for all newly-installed windows and glass doors to assure required performance specifications (SHGC and U-value) have been met.

5.0 Best Practices Review and FSEC Partnership:

All readers are encouraged to submit feedback and questions on the practicality and clarity of the best practices. Umbrella associations interested in adopting the Current Best Practices as required or recommended policy to member organizations are eligible for FSEC technical assistance. Please direct correspondence to:

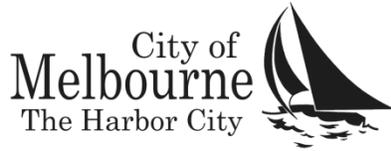
Janet McIlvaine or Karen Sutherland
Florida Solar Energy Center
1679 Clearlake Road
Cocoa, FL 32922

Janet McIlvaine – 321-638-1434, janet@fsec.ucf.edu,
Karen Sutherland – 321-638-1474, ksutherland@fsec.ucf.edu

Please include the term “Building America” in your subject line.

Appendix B: City of Melbourne Retrofit Standards

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MINIMUM REHABILITATION STANDARDS

PURPOSE

The purpose of these standards is to protect the health, safety, and general welfare of homeowners by providing a reasonable set of provisions for the physical rehabilitation of dwelling units to be assisted through the City of Melbourne's Neighborhood Stabilization Program (NSP).

All assisted units shall be in compliance with the *International Property Maintenance Code* upon completion and with Melbourne zoning ordinances. These *Minimum Rehabilitation Standards* shall be the guiding document that sets forth the standard by which homes assisted under the Neighborhood Stabilization Program will be assisted.

SCOPE

The provisions of these standards shall apply only to existing residential buildings or those which will be residential upon completion of rehabilitation.

These standards are intended for use as a supplement to applicable local codes and ordinances which regulate the design, construction, quality of materials, use and occupancy, location, and maintenance of buildings and structures.

Additions and alterations: The provisions in these standards shall not prohibit additions and alterations that meet the requirements of building codes and zoning ordinances for new construction.

Application of Local Codes and Ordinances:

Any repair, alteration, or replacement of structural elements or equipment in buildings, which may be required by the provisions of these standards, shall be done in accordance with the applicable sections of the Florida Building Code (latest edition) as well as local building, electrical, plumbing, or other applicable codes or ordinances. The provisions in these standards shall not permit the abridgement or violation of the zoning ordinance of the jurisdiction.

Rights Reserved by the City of Melbourne:

The City of Melbourne, hereinafter "the City", reserves the right to, at any time, impose requirements in addition to those set forth herein or waive any of said requirements when the City determines that doing so is in the best interest of the Neighborhood Stabilization Program.

DEFINITIONS

Scope:

Unless otherwise expressly stated, the following terms shall, for the purpose of these standards have the meanings indicated.

General:

Terms not defined: Where terms are not defined under the provisions of the standards of the Florida Building Code or other locally adopted codes, the terms shall have their ordinarily accepted meanings or such as the context herein may imply.

Technical definitions: The appropriate definitions of the applicable codes and ordinances duly adopted by the jurisdiction and defined therein shall be used in the interpretation of these standards, except that the definitions of words or phrases contained in these standards shall be used in determining which code or ordinance, as defined in this article, is acceptable.

General Definitions:

Addition: An extension or increase in the floor area or height of a building or structure.

Alteration: A change or rearrangement in the structural parts, or in the exit facilities, of a building or structure.

Approved: As applied to a material, device, or mode of construction, means approved by the City in accordance with the provisions of these standards, or by the authority designated by law to give approval of the matter in question.

Habitable Room: Conditioned space (heat and air conditioning) which includes a living room, dining room, bedroom, kitchen, or den.

Rehabilitation: Construction that includes the following categories:

1. Repairs to, or replacement of, present elements of any existing building, such as windows, stairs, flooring, wiring, plumbing, heating, etc.; or
2. Rearrangement of rooms, by the relocation or partition of walls, or by the installation of new bathrooms or kitchens; or
3. The general replacement of the interior or portions of the interior of a building which may or may not include changes to structural elements such as floor systems, roof systems, columns, or load bearing interior or exterior walls.

SITE CONDITIONS

The site and neighborhood must be free of conditions which do not provide for a safe and healthy living environment.

Site Improvements:

The site improvements shall conform to the following requirements:

Exterior Grade: The exterior grade, adjoining footings, and basement walls shall be sloped so as to drain all surface water away from the building.

Drainage: In areas showing evidence of adverse ground water conditions, an approved method, as defined by a civil engineer, of correcting conditions shall be provided as part of the rehabilitation work.

Walkways: Hard surface walkways shall be provided for all-weather access from the street or other public open space to at least one (1) entrance to the building.

Surfacing: Parking and driveway areas shall be surfaced for all-weather access.

Utilities:

Water Supply: The building water supply distribution system shall be connected to an approved public or private water supply system that is sanitary and free from contamination.

Sanitary Drainage: The building sanitary drainage system shall be connected to an approved public or private sanitary disposal system (including a locally approved septic system).

Electrical: The building electrical system shall be connected to an approved source of electric power.

Fuel: The building fuel systems shall be connected to an approved supply source (bottled gas, natural gas, oil, electricity).

Occupancy Limitations, Light and Ventilation:

The City anticipates that most rehabilitation will be undertaken using the existing configuration of the units; however, where possible, the Space Standards the City suggests are as follows:

Dwelling Unit: At minimum, the dwelling unit must have a living room, a kitchen area and a bathroom. Every dwelling unit shall have at least one habitable room of not less than 120 square feet of floor area. The dwelling unit must provide adequate space and security for the occupant(s).

Sleeping Area: Every dwelling unit shall contain at least one room occupied for sleeping purposes for every two persons. For one occupant, the room occupied for sleeping purposes shall contain at least 70 square feet, and for two occupants, the room occupied for sleeping purposes shall contain at least 120 square feet. Children of opposite sex, other than the very young, may not occupy the same sleeping area.

Room Lighting: Room lighting shall be as required in the following provisions:

1. **Natural Light**: All habitable rooms and spaces shall be provided with aggregate glazing area of not less than eight (8%) of the floor area of such room or space.

Required glazed openings shall open directly to the outdoors, such as onto a street or alley, or into a yard or court located on the same lot as the building. Size of the opening shall conform to the Florida Building Code as well as local codes.

2. **Artificial Light**: All habitable or occupiable rooms and spaces shall be provided with artificial light by means of permanent electrical fixtures or convenience receptacles. The distribution of fixtures and/or outlets shall be so as to provide satisfactory illumination throughout all rooms and spaces. The living area and each bedroom must have, at least, the required number of outlets in proper working condition as per the Florida Building Code as well as local code requirements. Permanent overhead or wall mounted light fixtures may not count

as one of the required outlets. The kitchen area and the bathroom must have a permanent ceiling or wall light fixture in proper operating condition.

Room Height: Habitable rooms shall have a ceiling height of not less than 7'6". In rooms having a sloping ceiling, the required ceiling height shall be provided over at least fifty percent (50%) of the room, and a portion of a habitable room having a ceiling height less than five (5) feet shall not be considered as contributing to the minimum required area.

Combustion Safety: No new atmospheric combustion furnaces or water heaters should be installed inside the conditioned space. Replacement gas furnaces should be high-efficiency, sealed combustion units. Replacement gas water heaters should be direct-vent (tank type or tankless). If combustion appliances exist and are being replaced with non-combustion appliances, disable appliances and remove from premises prior to retrofit; otherwise:

1. Pre-retrofit: In addition to defining equipment specifications and installation details for combustion air supply and exhaust components, work with a BPI-certified home professional, or other qualified professionals such as a certified HERS rater with additional combustion safety training, to evaluate and devise a combustion safety plan to prevent accidentally back drafting exhaust fumes into the conditioned space before, during and after renovation. Tests should be conducted to assess air pressure conditions in the combustion air zone where the furnace and/or water heater are located and air pressure differences between the combustion air zone and the occupied areas of the home. Conducting testing prior to renovation will help to identify existing air flow and pressure dynamics.

2. During retrofit: Disable combustion furnaces and water heaters unless a plan has been executed specifically to ensure combustion safety. Unpredictable activity during construction could inadvertently create dangerous conditions.

3. Post-retrofit, prior to occupancy: Arrange for post-renovation testing to verify that no air pressure conditions have been created that jeopardize either combustion air supply or exhaust or that would result in combustion exhaust gases entering the conditioned space.

4. Install carbon monoxide (CO) detectors and post an action plan near all combustion appliances and all bedrooms for occupants in the event of alarm.

For fireplaces, glass doors shall be installed. Return air pathways and pressure relief to be provided as necessary to avoid depressurization.

Consult the U.S. Department of Energy's Technology Fact Sheet "COMBUSTION EQUIPMENT SAFETY" for additional information on combustion safety (http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/26464.pdf).

Air Quality: The dwelling unit must be free from dangerous levels of carbon monoxide, sewer gas, dust and other harmful pollutants. There must be adequate air circulation for the dwelling unit.

Room Ventilation: Room ventilation shall be as required in the following provisions:

1. Natural Ventilation: Windows, doors, or other approved means of natural ventilation shall be provided, and be in proper working condition, in living room and each bedroom. An area of ventilating opening of forty-five percent (45%) of the minimum window area size shall be provided or as required by the Florida Building code.

2. Mechanical Ventilation of Habitable Rooms: When feasible, install a dampered, passive mechanical ventilation duct to provide outside air to the return plenum. Note that the system must be designed with occupant shut-off and so that the outside air passes through a filter before entering the air handler.
3. Cooking and Bathroom and Toilet Compartment: These spaces shall be provided with mechanical ventilation that is directly vented outdoors as required under the Florida Building Code. Kitchen exhaust fan ventilation of 100 CFM. Bathroom exhaust fans ventilation of 50 CFM. Exception: Where installed in accordance with the manufacturer's installation instructions and where mechanical or natural ventilation is otherwise prohibited, listed and labeled ductless mechanical ventilation systems shall not be required to discharge to the outdoors.

Ventilation of Structural Spaces: Natural and/or mechanical ventilation of spaces such as attics, under floor areas and crawl spaces shall be provided as required to overcome dampness and to minimize the effect of conditions conducive to decay and deterioration of the structure.

Room Facilities: Each dwelling unit shall be provided with space necessary for storage, cooking, laundry, and sanitary facilities.

Kitchen Facilities:

1. The dwelling unit must have an oven, and a stove or range and a refrigerator of appropriate size for the family. All of the equipment must be in proper operating condition.
2. The dwelling unit must have a kitchen sink in proper operating condition, with a sink trap and hot and cold running water. The sink must drain into an approved public or private system. Sink and all related plumbing shall be installed in accordance with the Florida Building Code.
3. The dwelling unit must have space for storage, preparation and serving of food.
4. There must be facilities and services for the sanitary disposal of food waste and refuse, including temporary storage facilities (e.g. garbage cans).
5. There must be a minimum of one receptacle at work surface which must be ground fault interruption (GFI) protected if within 6' of the sink, one non-GFI receptacle adjacent to the refrigerator, and one ceiling fixture. All electrical work shall conform the Florida Building Code.

Bathroom Facilities: Bathroom facilities must be located in the unit, a separate and private room in nature and shall include the following:

- 1, Water Closets: Each dwelling unit shall contain a water closet supplied with running water in an enclosed area not less than thirty (30) inches in width not less than eight (18) inches clear space in from of the water closet therein and must be in proper working condition.
2. Bathing: Each dwelling unit shall contain a bathtub or shower with a supply of hot and cold running water in proper working condition.

3. Lavatory: Each dwelling unit shall contain a lavatory with a sink trap and a supply of hot and cold running water and must be in proper working condition. The lavatory shall be located in the same room as the water closet or immediately adjacent thereto.
4. A minimum of one GFI receptacle and one permanent wall or ceiling fixture. All plumbing work shall be in accordance with the Florida Building Code as well as all local code requirements.

Room Arrangements: Access to all parts of a dwelling unit shall be possible without passing outside the dwelling unit, or passing through another dwelling unit.

A bathroom shall not be used as the only passageway to a habitable room, hall, basement, or dwelling unit.

A utility room, sleeping room, closet, or storage room shall not be used as the only passageway to a habitable room or to a dwelling unit.

Habitable rooms below grade: Habitable rooms below grade or partially below grade shall comply with all the requirements of these standards pertaining to habitable rooms.

MEANS OF EGRESS

Not less than one exit, sized in accordance with the Florida Building Code as provided herein shall be provided for each dwelling unit.

Every sleeping room shall have at least one operable window or exterior door approved for emergency egress or rescue, as per the Florida Building Code. The window or exterior door must be operable from the inside to a full clear opening without the use of separate tools. Windows that are accessible from the outside, such as basement, first floor and fire escape windows must be lockable (such as window units with sash pins or sash locks and combination windows with latches). Exterior doors must be lockable. Where windows are provided as a means of egress or rescue they shall have a sill height in accordance with the Florida Building Code and have a minimum net clear opening in accordance with the Florida Building Code. The minimum net clear opening dimension should be in accordance with the Florida Building Code.

Each sleeping room or room with a required exit door that has security bars, grilles, grates or similar devices installed shall have at least one emergency escape and rescue opening as per the Florida Building Code. Bars, grilles, grates, or screens placed over windows must be releasable or removable from the inside without the use of a key, tool, or excessive force as per the Florida Building Code.

FIRE RESISTANCE REQUIREMENTS

Dwelling-Garage Separation: The common wall or floor-ceiling, if any, between a garage and a dwelling shall be protected as required by the Florida Building Code for new construction.

Smoke Detector: Each dwelling unit must include at least one battery-operated or hard-wired smoke detector, in proper working condition, on each level of the unit including basement but excluding crawlspaces and unfinished attics. Smoke detectors must be installed in accordance with and meet the requirements of the National Fire Protection Association Standard (NFPA) 74 or successor standards. It should be located, to the extent practicable, in a hallway adjacent to a bedroom. If the unit is occupied by hearing-impaired persons, smoke detectors must have an alarm system, designed for hearing-impaired persons, as specified in NFPA 74 or successor

standards, in each bedroom occupied by a hearing-impaired person, connected to the smoke detector located in the hallway. Smoke detectors must be installed in accordance with local code requirements.

CONSTRUCTION

General Requirements:

All components of the building shall be in sound condition or shall be restored to a sound condition.

Roofs should be given particular attention in any inspection to be certain of the long term serviceability of the system. Roofs must be structurally sound and weather tight.

Provisions shall be made for roof drainage as required by applicable code or ordinance. Ensure proper installation of flashing and installation of a drip edge. (See Energy-Efficiency and Environmentally-Friendly Green Elements for efficiency specifications.)

All exterior walls shall be weather tight. The surface of the exterior walls must not have any serious defects such as serious leaning, buckling, sagging, large holes or defects that may result in air infiltration or vermin infestation.

All new construction shall be in accordance with the Florida Building Code.

Interior Finish:

Floors: Floors shall comply with the following provisions:

1. Floors must not have any serious defects such as severe bulging or leaning, large holes, loose surface materials, severe buckling, missing parts or other severe damage.
2. Floors of habitable or occupiable rooms in basements or cellars shall be surfaced or paved in an acceptable manner when in direct contact with the grade.
3. Floors in bathroom and water closet compartments and kitchens shall be impervious to water, and shall be constructed so as to permit the floor to be easily kept in a clean and sanitary condition. The floor finish shall be of a durable, waterproof, non-absorptive material such as asphalt, vinyl-plastic, rubber tile, ceramic tile, terrazzo, linoleum, concrete or other approved material.
4. Finish floors in habitable rooms or common spaces shall meet the requirements of the Florida Building Code for new construction.

Walls and Ceilings: Interior walls and ceilings shall conform to the following requirement:

1. Walls and ceilings must not have any serious defects such as severe bulging or leaning, large holes, loose surface materials, severe buckling, missing parts or other serious damage.
2. The finished surfaces shall not have excessive detrimental or unsightly irregularities or cracking.
3. The finish surfaces shall be waterproof and hard surfaced in areas of rooms or spaces subject to direct moisture contact, such as bath and shower areas. Kitchen and baths shall be painted or papered to provide a washable finish surface.

- Existing interior and exterior finish surfaces containing any lead content shall be removed and replaced or covered with a lead-free material utilizing an approved lead-hazard reduction activity which uses safe work practices and clearance as required by Title X of the 1992 Housing and Community Development Act (24 CFR Part 35).

Doors and Openings: Interior doors and openings shall conform to the following requirements:

- Doors and openings shall be six (6) feet, eight (8) inches minimum in height with minimum widths as shown in *Table 1*:

TABLE 1 - MINIMUM DOOR WIDTHS

Room or Space	Minimum Door Width
Habitable or occupiable rooms	2 ft. 6 in.
Bathrooms, water closet compartments, storage closets (over 4 sq. ft. in area)	2 ft. 0 in.
Exit access or service stairs	2 ft. 0 in.
Exit doors	3 ft. 0 in.
Handicap unit doors	2 ft. 8 in. free opening

- At least one (1) scuttle or access hatch to attic or crawl spaces shall be provided in a convenient location and shall have a minimum opening of eighteen by twenty-two (18 x 22) inches, except where permanent access is provided.

Stairways: All interior and exterior stairways must not present a danger of tripping and falling and shall conform to the requirements of the building code.

Chimneys: Chimneys, flues and vents shall be structurally safe, durable, smoke tight and capable of withstanding the action of the flue gases; or shall be restored to such a condition.

Extending Chimneys: Tops of chimneys and flues shall be extended sufficiently so as to provide proper draw venting characteristics (draft) as required by the Florida Building Code or other applicable code or ordinance for new construction.

ELECTRICAL, MECHANICAL AND PLUMBING SYSTEMS

General:

Existing Systems: Existing electrical, heating, mechanical, ventilation, air conditioning, plumbing, or any systems that do not provide the services for which they were originally intended, or that are potential fire or health hazards, shall be replaced, altered or repaired, so as to make them safe and serviceable.

Electrical Systems:

Habitable rooms, occupiable rooms, utility spaces and common spaces, normally requiring electrical service shall be provided with a system of wiring, wiring devices, fixtures and equipment to safely supply electrical energy for proper illumination and other electrical equipment. Number of electrical sources (outlets) shall be in accordance with the Florida Building Code.

The electrical system shall be connected to the source of electrical power, in accordance with the electrical code of the locality.

Existing Wiring and Equipment: Existing wiring which conformed to the code in effect at the time of installation and which has been maintained in good condition which is not being altered or extended, and is being used in a safe manner, may continue in use.

Existing electrical systems which are of inadequate capacity shall be replaced with a new system or shall be supplemented with new wiring and equipment as necessary to meet the requirements of the Florida Building Code as well as local codes.

New Electrical Systems: New electrical systems, equipment, fittings and devices shall be installed in accordance with the Florida Building Code as well as the local electrical code.

Heating:

Heating facilities which are properly installed with automatic temperature control, connected and maintained shall be provided for each dwelling unit and for the common spaces and utility spaces of the building to assure interior comfort by providing a minimum inside temperature as required by the applicable Florida Building Code as well as local code or ordinance and must be in proper working condition. When feasible, locate all atmospheric combustion furnaces in unconditioned space. Caution: Refer to the Combustion Safety section if a gas furnace exists or is planned.

Existing Systems: Existing non-conforming systems components or devices may continue in use if there is evidence of satisfactory performance, safety, and adequate capacity.

New Systems: New heating systems and equipment shall be designed and installed in accordance with the requirements of the applicable section of the Florida Building Code as well as local code or ordinance. No atmospheric combustion furnaces to be installed in conditioned space.

Room (Space) Heaters: Space heaters shall conform to the requirements of the building code, or other applicable section of the Florida Building Code as well as or local code or ordinance for new installations. Space heaters may not be un-vented room heaters that burn gas, oil or kerosene.

Miscellaneous: Portions of heating system not specifically mentioned in this section shall be deemed to meet the intent and requirements of this code if constructed and installed in accordance with the applicable section of the Florida Building Code as well as local code or ordinance.

Mechanical Ventilation and Air Conditioning:

Existing Systems: Existing systems and mechanical ventilation may continue in use if of adequate capacity, or they may be supplemented or replaced with a new system as required to meet the applicable section of the Florida Building Code as well as local codes and must be in proper working condition. Specify that, where feasible, a duct board plenum is retrofitted into platform returns, louvered doors on air handler closets are replaced with a correctly sized central return grille mounted in the wall (if adjacent to a living space) or in a solid door, and air handler stands are replaced with a ducted return plenum.

New Systems: New mechanical ventilation and air-conditioning equipment and systems shall be designed and installed in accordance with the requirements of the mechanical code or other applicable section of the Florida Building Code as well as local code or ordinance. Specify ENERGY STAR® (min. SEER 14.5) qualified air conditioner with heat pump. Ensure a ducted return.

Existing Duct Work: Ensure duct work is strapped to trusses to achieve clearance over anticipated ceiling insulation with hanger supports no more than 5 feet apart. Ideal location is midway between roof deck and top of insulation.

New Duct Work: Ensure duct work is strapped to trusses to achieve clearance over anticipated ceiling insulation with hanger supports no more than 5 feet apart. Ideal location is midway between roof deck and top insulation. Ensure duct sizes specified on design are installed and that flex duct collars are fully insulated. Specify joints and edges in supply ducts, return plenum, and connections to air handler to all be sealed, preferably with mesh and mastic. Ensure ducts insulated to R-Value ≥ 6 or higher.

All Systems: HVAC Duct System Air Tightness Test: A post-test is required to verify that duct leakage to unconditioned space does not exceed 6 cubic feet per minute per 100 ft² of conditioned space at test pressure of negative 25 pascals ($Q_{n,out} = 0.06$, commonly referred to as “6%”). If measured leakage exceeds 6% ($Q_{n,out} \geq 0.06$), leakage points to be identified and sealed to reduce measured leakage to 6% threshold or below. Include testing, and retesting as necessary, in the mechanical contractor scope of work.

Testing is required to ensure pressure difference between main body of the house and each bedroom of ≤ 2.5 pascals when air handler is operating at maximum capacity and with all interior doors closed. If in excess of 2.5 pascals, passive air pathways must be provided from pressurized bedroom to main body of home via “jump ducts” or “high-low” passive returns to achieve balanced return air. For size guidelines reference to Florida Mechanical Code section 601.4.

Plumbing Systems:

Plumbing facilities which are properly installed, connected and maintained shall be provided or each dwelling unit, and as necessary for the common or utility spaces of the building, to provide satisfactory:

1. Hot and cold water supply and distribution;
2. Sanitary drainage;
3. Venting of sanitary drainage system; and
4. Operation of fixtures.

Water Heating Facilities: Every dwelling unit shall have water heating facilities which are properly installed and maintained in a safe and good working condition and are capable of heating water to such a temperature as to permit an adequate amount of water to be drawn at every required kitchen sink, lavatory sink, bathtub and shower. All water heaters shall be fitted with a pressure relief valve with a drain line to the exterior of the unit. When feasible, locate all atmospheric combustion furnaces in unconditioned space. Caution: Refer to the Combustion Safety section if a gas water heater exists or is planned. For electric fuel specify standard tank type with $EF \geq 0.92$ or tank with integrated heat pump water heater and a $COP \geq 2.0$. For gas

fuel specify tankless with $EF \geq 0.80$. Consider insulating hot water pipes and insulating tanks with R-5 or greater.

Existing Plumbing Systems: Existing plumbing systems, or portions thereof, including sewers, to remain in use shall operate free of fouling and clogging, and shall not have cross connections which may permit contamination of the water supply or backsiphonage between fixtures.

New Plumbing Systems: New plumbing systems or alterations and additions to plumbing systems shall be installed in accordance with requirements of the applicable section of the Florida Building Code as well as local plumbing code.

SITE AND NEIGHBORHOOD

The site and neighborhood may not be subject to serious adverse environmental conditions, natural or manmade, such as dangerous walks or steps; instability; flooding, poor drainage, septic tank back-ups or sewage hazards; mudslides; abnormal air pollution, smoke or dust; excessive noise, vibration or vehicular traffic; excessive accumulations of trash; vermin or rodent infestation or fire hazards.

SANITARY CONDITIONS

The dwelling unit and its equipment must be free of vermin and rodent infestation.

INSPECTIONS

The City may make periodic inspections and written reports during construction to ensure that work is being done according to plans and specifications.

The City will require that the contractor document his conformance with federal requirements including the payment or prevailing wages under the Davis Bacon Act and equal employment objectives and requirements, where applicable.

ENERGY EFFICIENCY STANDARDS

Thermal Insulation Requirements:

Where accessible, the following minimum R-values are to be used (*Table 2*):

TABLE 2 - MINIMUM R-Values

	R-Value
Common Walls – Frame Common to two separate conditioned tenancies	R-13
Common Walls – Masonry Common to two separate conditioned tenancies	R-3 Both Sides
Frame Walls – 2 x 4	R-13
Frame Walls – 2 x 6	R-19
Frame Walls – Concrete or Masonry Exterior and Adjacent	R-5
Attic/Ceiling/Roof (Conventional wood frame)	R-38
Knee Walls (Vertical Attic Surfaces)	R-13
Floors over unconditioned spaces	R-5
Interior Attic Hatches	R-19

Insulation shall be designed and installed to achieve RENSET Grade I installation quality as well as local code or ordinance.

Air Filtration Requirements:

1. All exterior joints, cracks or openings in the building envelope that are sources of air leakage shall be caulked, gasketed, weatherstripped or otherwise sealed. Common air infiltration points must be properly addressed and include:
 - a. Windows – caulk edges of window/frame/trim on both interior and exterior
 - b. Doors – replace weather-stripping if missing or degraded
 - c. Lighting fixtures and ceiling fans (drywall gap behind cover/trim)
 - d. Kitchen exhaust fan chase (at ceiling)
 - e. Switches and outlets –if replacing covers, seal boxes or drywall
 - f. Plumbing penetrations through interior and exterior walls (e.g. under sinks)
 - g. Plumbing access panels – secure tightly and/or weather-strip
 - h. Attic hatch or stair – weather-strip
 - i. Interior AHU closet – seal all edges and seams of walls, ceiling, and ducts
 - j. Soffits over cabinets or housing lighting – add air barrier above rough framing, seal all edges and seams
 - k. Holes in drywall
 - l. Frame floor penetrations for plumbing and electrical
2. Ventilation of the ceiling/roof area shall be in ratios in accordance with the Florida Building Code as well as local building codes.
3. A blower door test is required to assess whole house air tightness and identify leakage points (see list below). Target test result is 6 or less air changes per hour at the test pressure of 50 pascals ($ACH50 \leq 6.0$). If test result exceeds target of $ACH50 \leq 6.0$, check and repair the common leakage points identified in number 1 (particularly important if there are atmospheric combustion water heaters or furnaces in the home). If gas appliances exist, refer to the Combustion Safety section for post-retrofit verification of safe air pressure conditions prior to blower door test.

Doors, Windows and Glass:

1. Exterior doors shall be weather-stripped at jambs, head, and sill where the door is in contact with the threshold.
2. Exterior doors, other than glass doors, shall be solid core wood, wood panel, painted metal doors or insulated doors. Hollow core doors shall not be used. Exterior doors may have glass sections.
3. When window replacement is required, all replaced windows shall meet the Florida Building Code for hurricane. Install ENERGY STAR® labeled windows with U-value ≤ 0.6 and SHGC ≤ 0.27 . Ensure proper flashing installation. If installing house wrap, follow manufacturer instructions for cutting and wrapping at window openings. Replace any rotted materials. Air seal between window frame and rough opening. Caulk between edges of window frame and exterior finish.
4. When window replacement is not required, edges of window frame and exterior finish shall be caulked. Ensure proper head flashing (above top of window) with wood siding, install if necessary. Check for and replace any rotted materials around window (e.g. studs,

sheathing.) For untinted windows consider specifying window tint to achieve SHGC ≤ 0.5 and visible transmittance ≥ 0.5 .

5. Protection of windows shall be in compliance with the Florida Building Code.
6. Replacement garage doors shall meet the wind and impact resistance standards of the Florida Building Code.

ENERGY EFFICIENT AND ENVIRONMENTALLY-FRIENDLY GREEN ELEMENTS

To the extent feasible, the following additional energy efficient and environmentally-friendly Green elements will be incorporated into the design of each rehabilitation project.

Renewable Energy:

1. *Passive Solar:* Orient the building to make the greatest use of passive solar heating and cooling.
2. *Photovoltaic-ready:* Site, design, engineer and wire the development to accommodate installation of photovoltaic panels in the future.

Sustainable Site Design:

1. *Transportation Choices:* Locate projects within a one-quarter mile of at least two, or one-half mile of at least four community and retail facilities.
2. *Connections to Surrounding Neighborhoods:* Provide three separate connections from the development to sidewalks or pathways in surrounding neighborhoods.
3. *Protecting Environmental Resources:* Do not locate the project within 100 feet of wetlands; 1,000 feet of a critical habitat; or on steep slopes, prime farmland or park land.
4. *Erosion and Sediment Control:* Implement EPA's Best Management Practices for erosion and sedimentation control during construction.
5. *Sustainable Landscaping:* Select native trees and plants that are appropriate to the site's soils and microclimate.
6. *Energy Efficient Landscaping:* Locate trees and plants to provide shading in the summer and allow for heat gain in the winter.

Water Conservation:

1. *Efficient Irrigation:* Install low volume, non-spray irrigation system (such as drip irrigation, bubblers, or soaker hose).
2. *High Efficiency Toilets:* Install HETs to reduce waste removal. One type of HET is the dual-flush toilet, which allows users to choose between a short flush and a longer flush.
3. *Low-Flow Showerheads and Faucets:* Install flow limiters or use faucets and showerheads with built in flow limiters.

Energy Efficient Materials:

1. *Durable Materials:* Use materials that last longer than conventional counterparts such as stone, brick or concrete.
2. *Resource Efficient Materials:* Use layouts and advanced building techniques that reduce the amount of homebuilding material required.
3. *Heat Absorbing Materials:* Use materials that retain solar heat in winter and remain cool in summer.
4. *Solar-reflective Paving:* Use light-colored/high-albedo materials with a minimum Solar Reflective index of 0.6 over at least 30 percent of the site's hardscaped areas.
5. *Local Source Materials:* Use materials from local sources that are close to the job site.
6. *Green Roofing:* Use ENERGY STAR®-compliant and high-emissive roofing. If asphalt shingle, specify light or white colored finish, Solar Reflectance ≥ 0.25 .
7. *Solar-reflective Walls:* If painting, specify light or white color when possible.

Energy Saving Features:

1. *Energy Saving Light Fixtures:* Specify compact fluorescent lamps (CFLs) and T8 linear fluorescent lamps with electronic ballasts as a replacement for incandescent lamps and T12 lamps with magnetic ballasts. When possible, specify hard-wired CFLs for any new and replacement light fixtures, otherwise install screw in CFLs. Select ENERGY STAR® rated ceiling fans. Any recessed cans should be insulation contact air-tight (ICAT) compact fluorescent models. Specify LED exit signs to replace fluorescent and incandescent exit signs in all feasible applications. This measure reduces electricity use, maintenance costs, greenhouse gas emissions and air pollution.
2. *ENERGY STAR® Appliance Replacement:* Specify ENERGY STAR® refrigerators, dishwashers, and clothes washers as part of any appliance replacement. Additionally, select refrigerator models that are listed on the American Council for an Energy Efficient Economy (ACEEE) website at www.aceee.org.

Healthy Homes:

1. *Green Label Certified Floor Covering:* Do not install carpets in basements, entryways, laundry rooms, bathrooms or kitchens; if using carpet, use the Carpet and Rug Institute's Green Label certified carpet and pad.
2. *Healthy Flooring Materials Alternatives:* Use non-vinyl, non-carpet floor coverings in all rooms.
3. *Sealing Joints:* Seal all wall, floor and joint penetrations to prevent pest entry; provide rodent and corrosion proof screens (e.g., copper or stainless steel mesh) for large openings.
4. *Moisture Management:* If crawl space, ground cover for vented areas shall be repaired or installed, lapping joints 6", and continuing up stem wall 2'. Moisture loading at walls and foundation to be removed (e.g. irrigation system, roof runoff, soil contact).
5. *Termite-Resistant Materials:* Use termite-resistant materials in areas known to be infested.

6. *Can Lights:* All recessed lighting fixtures including “can” lights and fluorescent tube fixtures should be boxed in to prevent insulation contact or replaced with units rated for insulation contact and air tightness (ICAT) prior to adding ceiling insulation.
7. *Bathroom Ventilation:* To the extent physically and financially feasible, all bathrooms should have an exhaust fan that is vented to the outdoors with a minimum flow rate of 50 CFM and have controls that exhaust moisture automatically. Control strategies include:
 - Timer connected to the light switch that runs for a pre-set time after being turned on (independent of being turned off).
 - Continuously running ventilation fan.
 - Humidistat sensor that automatically runs when moisture is present.
 - All fans should be ENERGY STAR® qualified. See www.energystar.gov for product lists.
8. *Tub and Shower Enclosures Moisture Prevention:* Use one-piece fiberglass or similar enclosure or, if using any form of grouted material, use backing materials such as cement board, fiber cement board, fiber-glass reinforced board or cement plaster.
9. *Kitchen Ventilation:* To the extent physically and financially feasible, all kitchens should have an exhaust fan that is vented to the outdoors with a minimum flow rate of 100 CFM.
10. Vent clothes dryer to the outdoors.
11. *Green Maintenance Guide:* Provide a guide for homeowners and renters that explains the intent, benefits, use and maintenance of Green building features, and encourages additional Green activities such as recycling, gardening and use of healthy cleaning materials.
12. *Resident Orientation:* Provide a walk-through and orientation to the homeowner or new tenants.

Appendix C: City of Fort Myers Renovation Standards

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EXHIBIT B MANDATORY IMPROVEMENTS Contractor Specifications/Cost Estimate Sheet

Owners Name
Address
Fort Myers, FL

Contractors Name: _____

Date Proposal Received: _____ Proposal Due Date: _____

MATERIALS & PRODUCTS TO BE USED ON THIS JOB SHALL BE MANUFACTURED IN THE U.S.A. WE ALSO RECOMMEND THE USE OF LOCAL AREA VENDORS. *CUT SHEETS MUST BE SAVED AND PROVIDED TO THE PROJECT MANAGER.*

INFORMATION

All work to be done shall be in compliance with the 2010 Florida Building Code Residential Construction standard and all applicable codes in the jurisdiction. Contractor is responsible for obtaining all the required permits. Failure to comply with all applicable laws may incur in fines or legal action at the contractor's responsibility.

The housing programs aim to provide a good quality end product with an efficient, safe and healthy environment. The program also aims to certify the homes as green homes therefore the contractor is responsible for ensuring that all materials used for the rehabilitation are in line with green building standards based on previous training and specifications. Any inquiries regarding the materials during construction must be discussed with the project manager for approval.

- A. All mechanical equipment, plumbing fixtures, electrical fixtures, gas appliances, electrical appliance, salvageable and unsalvageable debris replaced by the contractor, shall be removed by the contractor unless otherwise specified. A construction debris

management plan shall be provided and approved at the Pre-Construction meeting to minimize waste going to land fields and promote recycling practices. All debris within City of Fort Myers limits shall be removed by the City of Fort Myers Solid Waste Division; dumpster services shall be contracted through them in compliance with section 70-31 and 70-33 of the City of Fort Myers municipal code and Florida Statutes.

- B.** Where equipment, material, or articles are referred to in the specifications as "or equal", "equal to", "approved alternate", "the equivalent", etc. to any particular standard, the Housing & Real Estate Division staff shall decide the question of equality prior to installation. No exposed urea formaldehyde particle board shall be used for this project.
- C.** Work areas on interior of house shall be "broom-clean" at end of each work day. At the end of the project and prior to Notice of Completion, contractor shall remove all rehabilitation waste material, excess materials, and restore original site topography & professionally detail dwelling ready for permanent occupancy.
- D.** The written dimensions on the plans are presumed to be correct, but before signing contracts, the Contractor shall be required to check and is responsible for the accuracy of all dimensions required to perform work. All improvements on plans and/or in the specifications are considered part of the contract and are to be completed per same and all pertinent codes and ordinances apply. If any errors or omissions are discovered, the Housing & Real Estate staff shall be so advised in writing and will make the proper corrections.
- E.** An energy audit will be conducted during construction and testing at completion of work. Proper corrections shall be made after the analysis as directed by Housing and Real Estate Division staff. If corrections are part of the original scope of work it is responsibility of the contractor to make the required changes, if corrections are not part of the original scope of work a change order is necessary before continuation of work. The duct work will be tested to ensure minimal duct leakage to unconditioned space. Test will also measure whole house air tightness to ensure that there is minimum infiltration from unconditioned spaces or the exterior. The target test result is 6 or less air changes per hour at the test pressure of 50 pascals (ACH50 less than 6.0).
Failure to pass the test may incur in additional cost at the contractor's expense to retest the house.
- F.** **Bonding requirements may apply on jobs where the valuation on the scope of work exceeds the following threshold: \$100,000, the following bond requirements must be met:**
- Bid bond: Must be included in the proposal package (5% of bid amount).
 - Performance bond: Must be provided after the selection is done and prior to the contract being issued (100% of contract price).
 - Payment bond: Must be provided after the selection is done and prior to the contract being issued (100% of contract price).
- G.** Control sediment runoff (silt fences) shall be in place at time of construction.

H. Scope of work

PROVIDE ALL LABOR AND MATERIALS TO COMPLETE IN A WORKMANLIKE MANNER THE FOLLOWING:

1. DEMOLITION

a.) Interior & Exterior Demolition: Removal /demolition and disposal of all debris shall be in accordance with local, state and federal requirements for permanent disposal.

Remove all wall & ceiling framing, sheetrock, floor covering, windows, doors, trim, equipment, cabinets, plumbing and plumbing fixtures, electrical components, mechanical equipment (including duct work), debris and household items from structure.

Remove the roof in its entirety including, trusses, sheathing, shingles, soffit and fascia.

Around the exterior of the house, remove all additions not part of the original block construction, all out buildings/ storage sheds and perimeter concrete slabs (driveway to apron & walkway included)..

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2. DRIVE & WALK WAY

a. Pour In Place Concrete: Pour a new drive way from apron to house with new walkway to front entry. Concrete shall be no less than 2500 PSI at 28 days, 4" thick with 6/6 10/10-wire mesh reinforcing or fiber mesh. Concrete shall be poured over compacted and treated soil free of foreign material. When pouring for a habitable area a barrier of 6 mill visqueen is required. Visqueen and wire shall have a 6" overlap. New concrete shall be floated and troweled to a smooth finish if for interior work and broom finished if exterior work. Walkways shall have controlled joints every 4' with a depth of not less than 1/4 pad thickness. All work will be completed in a workmanlike manner and shall be in compliance with the 2010 Florida Building Code Standards.

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3. BUILDING

a. Wall Framing: All exterior walls shall be a minimum 2 x 4 studs 16" o.c. Framing lumber shall be stud grade Douglas Fir or Spruce. Lumber in contact with concrete shall be pressure treated and a minimum of R-13 insulation shall be provided. Walls to be plumb and erected in a workmanlike manner. (i.e. header size in relation to width of opening, etc.) Insulation shall be installed per manufacturer's instructions without compression or gaps, fully filling the stud bay. Window and door locations shall be per drawing. Window and door openings shall be flashed per manufacturer instructions. Wall(s) must comply with the 2010 Florida Building Code Standards.

Note: All the components and finishes of a single family home with added 1 car garage required by code shall be provided by the contractor. These specifications, drawings and current required codes will identify a number of specific items required to fulfill the intent of this project. Interior

of the house and fixtures shall accommodate for individuals with disabilities including but not limited to door lever handles and grab bars reinforcement backing in most accessible bathroom.

Rehabilitated house shall consist of 3 bed rooms, 2 baths, living, dining room and garage; laundry area and hot water heater to be located at rear of new garage. Living space is limited to the square footage of the existing building; accommodations shall be made to locate the AHU in conditioned space, and design should provide for compact plumbing areas. The house egress door openings and window egress openings shall be maintained as required per code. Top plates shall be sealed at contact with drywall from interior/exterior walls of the house.

All penetrations through the slab such as piping or conduit shall be sealed around its perimeter with an elastomeric or vulcum type sealer.

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4. GYPSUM WALLBOARD

Gypsum Wallboard: Install new sheet rock to all newly (framed walls and all furred walls) throughout dwelling. All new sheetrock and green board will be finished with a (skip trowel application). All joints and internal angles will be finished using tape joint system. Galvanized or plastic corner beads shall be applied to all external corners. All sheet rock will be per code thick by 4' X 8', 10' or 12' lengths with tapered edge. Use water resistant sheet rock (green board) on all work in tub surround and wet wall in baths and wet wall in kitchen. All holes in drywall must be sealed. Whole house air tightness testing will be conducted to ensure that there is minimum infiltration from unconditioned spaces to the exterior. The target test result is 6 or less air changes per hour at the test pressure if negative 50 pascals (ACH50 no greater than 6.0) All work will be completed in a workmanlike manner and shall be in compliance with the 2010 Florida Building Code Standards.

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5. ROOFING

a. Hip Roof system: (6 in 12 roof slope) with engineered trusses, and large overhangs as permitted by the 2010 Florida Building Code. Include sheathing, and self-adhesive polyethylene, rubberized asphalt underlayment, felt and asphalt shingles per code. Preformed aluminum, flashing, drip edge, ridge vent, and vent pipe boots. Provide new one ply 30# felt, 240 lb., 30 year, dimensional, class A fungus resistant fiberglass shingles and pre-painted aluminum drip edge. Shingles shall be (Owens Corning, Elk, G.A.F. or equal). Color shall be approved by Owner but must have a Solar Reflectance Index (SRI) greater than 0.25. (Light colors only, provide samples before proceeding). Owner will be furnished with the standard manufacturer's warranty and a minimum one year contractors warranty on labor upon completion.

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b. Gutters/ Fascia and Soffit: Install pre-finished seamless aluminum storm gutter on front fascia () LF and on rear fascia () LF. Gutters will be completed with properly located downspouts for water run off discharging at least 30" away from the structure. **Color will be of**

owner's choice from readily available stock. Gutters and downspouts shall be caulked at all joints where a connection is made. No seams shall be allowed over entry to structure. All work will be completed in a workmanlike manner and shall be in compliance with the 2010 Florida Building Code Standards.

Install aluminum fascia and (aluminum) ribbed or V-groove continuous vented soffit on entire overhang. **Color shall match gutters** Soffit shall be at 90 degrees to wall and not attached to rafter tails and be spaced a maximum 24" O.C. All work to be completed in a workmanlike manner and shall be in compliance with the 2010 Florida Building Code Standards.

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6. DOORS

a. Exterior Entry Door(s): Install () new exterior insulated steel pre-hung door (s) in () exterior entry to () respectively of structure. Door (s) will be a six panel style (with/without) window panels having a threshold as an integral part of the frame (Jeld-Wen, Perma Tru or equal). New door(s) size, swing and location shall be as per (existing/drawing). Prior to installation of new exterior door(s), all deteriorated lumber pertaining to the sills, heads, jambs, casings, brick molding and frames shall be removed and new lumber shall be provided to meet local codes. Caulk and paint wood frames of new doors within 5 working days. Contractor shall repair any area affected by this door installation to match the surrounding finish. Allow for all new hardware, locking hinges and safety chain if outswing style, viewer if non-windowed style, matching keyed alike lock set(s) and dead bolt lock (s) (Weiser quality or equal). Exterior door(s) on completion will be weather-tight, in good working order and be installed in a workmanlike manner. **NOTE: Doors shall comply with 2010 Florida Building Code Standards for wind loads**

b. Interior Entry Door(s): Install new entry door(s) as shown on drawing. New door(s) shall be colonial style with wood stiles and rails, pre-hung and hollow core. Doors will open as per drawing, be hung plumb and be in good working order. Provide and install all new brass plated hardware and passage latches (privacy lock sets for all bath(s) and bedroom(s). Provide and install brass plated, base mounted spring doorstops for all entry doors. All work will be completed in a workmanlike manner. Paint for doors shall be low VOC.

c. Interior Closet Door(s): Install new closet door as shown on drawing. New door(s) will be (bi-fold) style. Doors will be hung plumb and be in good working order. Provide all new hardware. All work will be completed in a workmanlike manner. Paint for doors shall be low VOC.

d. Garage Door: Install a new 9'x 7' roll up garage door. Garage door shall be a raised panel style equal to or better in quality than a Raynor Charleston Classic. Garage doors shall be in compliance with the 2010 Florida Building Code Standards. Note: See drawing.

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e. Garage Door Opener: Provide and install electrical garage door opener. Garage door opener shall be installed, with all necessary wiring, one remote control and wall mounted control. Patch and repair all affected areas to match surrounding surfaces. All work will be completed in a workmanlike manner and meet manufacturer's specifications.

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f. Exterior Entry Door(s) retrofit (if doors are not being replaced): Replace all weather stripping in exterior doors. Fasten any loose frames, caulk between edges of door frame and exterior finish, and ensure proper head flashing (above top of door).

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7. WINDOWS

a. Windows: Install all windows (window openings) located throughout the house. Egress windows shall have a minimum clear open area of 5.7 sq. ft. All replaced windows will be aluminum or vinyl style windows white color. All bath window replacement, if existing shall have obscure glass. If window sill height in tub surround is less than 60" off finish standing surface, window shall receive tempered glass. Prior to installation of new windows in existing openings, all grooves, offsets and projections on the sides, heads, jambs and sills shall be finished flush and new window shall be sized to accommodate existing opening. Ensure proper flashing installation, seal all air gaps between window frame and rough opening, caulk between edges of window frame and exterior finish, replace any rotted materials around the window.

New windows shall be certified with weather-strips, nylon bushings, locking hardware, and fiberglass screen. New windows shall be installed in the prepared opening to manufacturer's specifications. Frames must be caulked and made weather tight, operate easily and glass cleaned. Contractor shall repair any area affected by the installation of window to match the surrounding finish. All work will be completed in a workmanlike manner.

Windows shall meet the ENERGY STAR® window criteria requiring a U-factor of 0.60 or lower and a SHGC of 0.27 or lower a cut sheet must be provided. Windows shall be from Florida manufacturers.

All windows shall have screens installed as needed to allow for passive ventilation.

For resources visit http://www.energystar.gov/index.cfm?c=revisions.windows_spec

NOTE: New windows shall comply with 2010 Florida Building Code.

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a.a. Window retrofit (if windows are not being replaced): Lubricate all windows throughout unit and repair to function properly. Remove all damaged or deteriorated weather-strips, bushings, hardware, locks, etc., and replace with new. Fasten any loose frames, caulk between edges of window frame and exterior finish, and ensure proper head flashing (above top of window). Paint touch up on any scratched frames. Repair all window surroundings to match existing as needed. Check and replace any rotted materials around window.

Replace any damaged or missing window screens. Windows frames when repaired shall be in weather tight, clean and in like new condition.

Install energy efficient window film 3M, Prestige, Solar Gard or equal quality to all windows. Film shall meet the ENERGY STAR® criteria requiring a SHGC of 0.50 or lower and visible transmittance of 0.50 or greater; a cut sheet must be provided to the Housing and Real Estate Division. Installation is to be completed in a workmanlike manner.

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a.b. Impact Resistant Windows: Install all windows (window openings) located throughout the house. Egress windows shall have a minimum clear open area of 5.7 sq. ft. All replaced windows will be aluminum or vinyl style windows white color and be impact resistant as required by code with approved NOA by Miami-Dade County. All bath window replacement, if existing shall have obscure glass. If window sill height in tub surround is less than 60" off finish standing surface, window shall receive tempered glass. Prior to installation of new windows in existing openings, all grooves, offsets and projections on the sides, heads, jambs and sills shall be finished flush and new window shall be sized to accommodate existing opening. Ensure proper flashing installation, seal all air gaps between window frame and rough opening, caulk between edges of window frame and exterior finish, replace any rotted materials around the window. New windows shall be certified with weather-strips, nylon bushings, locking hardware, and fiberglass screen. New windows shall be installed in the prepared opening to manufacturer's specifications. Frames must be caulked and made weather tight, operate easily and glass cleaned. Contractor shall repair any area affected by the installation of window to match the surrounding finish. All work will be completed in a workmanlike manner. Windows shall meet the ENERGY STAR® criteria requiring a U-factor of 0.60 or lower and a SHGC of 0.27 or lower a cut sheet must be provided. Windows shall be from Florida manufacturers.

All windows shall have screens installed as needed to allow for passive ventilation. For resources visit http://www.energystar.gov/index.cfm?c=revisions.windows_spec

NOTE: New windows shall comply with 2010 Florida Building Code.

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b. Storm Panels: Provide and install storm panels to all exterior windows and sliding glass door opening in building. Panels shall be installed as per manufacturer's recommendations. Panels shall be 24 gauge galvanized steel panels or equivalent and approved for the Miami-Dade County (impact resistant coverings shall be labeled as required by the 2010 Florida Building Code.) Panels shall be sized and secured by manufactures hardware as required per code. An area of the garage shall be set for storage of the storm panels in a secure way. All work shall be completed in a workmanlike manner and in compliance with the 2010 Florida Building Code Standards.

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8. PLUMBING

a. Install a New Water, Drain, Waste, Vent System and Fixtures per 2010 Florida Building Code.

To including 2 exterior hose bibs.

A new 2 way clean out shall be installed (in front area of the house) and brought up to grade. Back flow preventer as required per code.

All hot water pipes to be insulated, use reinforced hoses for supply lines and quarter turn or push-pull valves. Seal all penetrations through interior and exterior walls (from water service, under sinks, at access panels, etc.)

ALL fixtures shall be Water Sense certified, cut sheets must be provided.

Fixtures to include:

1-Fiberglass tub shower unit in Main Bath & 1-fiberglass walk in shower unit (5' wide) in Master Bath.

Tub/ Shower Faucets: (All bath rooms) Install approved LOW FLOW (less than 1.6 gpm) shower heads and faucets "water sense". Faucets shall be (metal) lever handled with anti-scald Moen or equal quality.

Lavatory Faucets (All bathrooms): Install approved LOW FLOW (less than 1.6 gallon per minute) "water sense". Moen (or equal) metal single lever lavatory faucet complete with pop up, brass angle stops and risers.

Toilets (all bathrooms): Install "water sense" toilets of UNAR Map (maximum performance) rating of 350 GPF or greater. Installed toilet maximum flow rate shall be of a maximum 1.28 gallons/flush.

Kitchen Faucet: Install an approved metal faucet with aerators for 1.5 gpm Moen or equal quality single handle chrome faucet with spray spout (spout or sprayer must have at least a 9-inch hose).

Electric Water Heater (garage): Install a new most energy efficient (EF > 0.92) 40 gallon (regular or low boy) glass lined, quick recovery. Heater shall be equipped with a high limit safety cut off, pan, and pressure relief valve piped to the outside, all hot water pipes to be insulated. HWH is to be located outside conditioned space. Heater shall be 220 volts, double with all state and local codes and be completed in a workmanlike manner. Water heater must be wrapped with R-5 blanket. **Note: If water service is not available at property site, contractor shall be responsible for activating water service for construction including all related costs.**

Installation shall comply with 2007 Florida Plumbing Code.

\$ _____

a.a. Retrofit for existing houses:

Ensure that a proper inspection of the plumbing system is performed by a license plumber prior to start any work. Install a Back flow preventer as required per code.

All accessible hot water pipes to be insulated, replace hoses as required and use reinforced hoses for supply lines and quarter turn or push-pull valves.

ALL fixtures shall be Water Sense certified, cut sheets must be provided.

Tub/ Shower Faucets: (All bath rooms) Install approved LOW FLOW (less than 1.6 gpm) shower heads and faucets “water sense”. Faucets shall be (metal) lever handled with anti-scald Moen or equal quality.

Lavatory Faucets (All bathrooms): Install approved LOW FLOW (less than 1.6 gallon per minute) “water sense”. Moen (or equal) metal single lever lavatory faucet complete with pop up, brass angle stops and risers.

Toilets (all bathrooms): Install “water sense” toilets of UNAR Map (maximum performance) rating of 350 GPF or greater. Installed toilet maximum flow rate shall be of a maximum 1.28 gallons/flush.

Kitchen Faucet: Install an approved metal faucet with aerators for 1.5 gpm Moen or equal quality single handle chrome faucet with spray spout (spout or sprayer must have at least a 9-inch hose).

\$ _____

Electric Water Heater (garage): Install a new most energy efficient (EF > 0.92) 40 gallon (regular or low boy) glass lined, quick recovery. Heater shall be equipped with a high limit safety cut off, pan, and pressure relief valve piped to the outside, all hot water pipes to be insulated. HWH is to be located outside conditioned space. Heater shall be 220 volts, double with all state and local codes and be completed in a workmanlike manner. Water heater must be wrapped with R-5 blanket. Note: If water service is not available at property site, contractor shall be responsible for activating water service for construction including all related costs. Installation shall comply with 2010 Florida Plumbing Code.

\$ _____

Alternate spec for Hot Water Heater

Heat Pump Water Heater (garage): Install a new ENERGY STAR® 50 gallon heat pump water heater (COP>=2.0) where there is a minimum of 1,000 cubic feet of air. Heater shall be equipped with a high limit safety cut off, pan, pressure relief valve and condensate line piped to the outside. Heater shall be 220 volts, double with manufacturer instructions for clearances, all state and local codes and be completed in a workmanlike manner. Installation shall comply with 2010 Florida Plumbing Code.

A cut sheet must be provided.

\$ _____

9. ELECTRICAL

a. New Service and Distribution: Install a new 200 amp 120/240 V single phase electrical service. Service shall include: weatherproof panel box if exteriorly located 200 amp main disconnect and all necessary circuit breakers. New service shall have a separate 220 V circuit for water heater, electric range, clothes dryer, combination in wall heat-air unit Central HVAC with disconnect for air handler and condensing unit. All 220 V. receptacles will be **amped per mfg. specifications** circuits complete with proper ground. All additional newly wired receptacles will be a minimum 15 amp circuit with ground. Direct wire smoke/CO detectors located centrally to

all bedrooms and at garage entrance will be required. GFI will be required in bath/kitchen receptacles servicing countertop surface and one centrally located exterior receptacle if existing. ARC-Fault Receptacle Outlets shall be required in all bedrooms in new construction.

The following listed items shall also be included:

3 wired phone outlets

1 cable outlet in living room and 1 in each bedroom

2 Exterior electrical outlets

Exterior lights on both sides of garage door area and two at rear of house (with motion sensor included).

Exterior light in front of house (with motion sensor included).

Bathroom fixtures ENERGY STAR® with Max 100w output for the entire fixture

Bathroom fans: ENERGY STAR® low sone (CFM 50) with timers, occupancy sensor or humidistat with required ducting to the outside and electrical circuit.

Light/ fan combo in bed rooms, living/dining room. Install new ENERGY STAR® combination light/fan in all bedrooms, living room & dining room with electrical wiring and light switch at entry. Compact Fluorescent Light bulbs are to be installed with fixture. / The alternative will be to use the ENERGY STAR® Advanced Lighting Package. This is a comprehensive package that includes ceiling fans, indoor lighting, and outdoor lighting. Also includes ventilating fans.

Any penetrations from exterior walls or unconditioned areas (i.e., attic, walls at receptacles, fixtures at ceilings, ducts at ceiling or wall, electrical panel service entrance, etc) must be air sealed and gaskets must be used to seal all receptacles and switches. Seal air gaps between electric boxes and walls. Recessed lighting fixtures including can lights and fluorescent fixtures (as applicable) should be boxed in to prevent insulation contact or be replaced with units rated for insulation contact and air tightness (ICAT).

All lighting fixtures to have Compact Fluorescent Lights installed (CFL).

Cut sheets for all the fixtures must be provided.

Note: If electricity is not available at property site, contractor shall supply approved electrical temporary power pole for construction including all related costs. All electrical work shall comply with the 2008 National Electric Code and be completed in a workmanlike manner.

\$ _____

a.a. Retrofit for existing houses: Ensure that a proper inspection of the electrical system is performed by a licensed electrician prior to starting any work. Ensure that the service is of 200 amp 120/240 V single phase electrical service, if not a service shall be installed to those requirements. Service shall include: weatherproof panel box if exterior located 200 amp main disconnect and all necessary circuit breakers. Service shall have a separate 220 V circuit for water heater, electric range, clothes dryer, combination in wall heat-air unit Central HVAC with disconnect for air handler and condensing unit. All 220 V. receptacles will be **amped per mfg. specifications** circuits complete with proper ground. All additional newly wired receptacles will

be a minimum 15 amp circuit with ground. Direct wire smoke/CO detectors located centrally to all bedrooms and at garage entrance will be required. GFI will be required in bath/kitchen receptacles servicing countertop surface and one centrally located exterior receptacle if existing. ARC-Fault Receptacle Outlets shall be required in all bedrooms in new construction.

The following listed items shall also be included:

- 3 wired phone outlets
- 1 cable outlet in living room and 1 in each bedroom
- 2 Exterior electrical outlets

Exterior lights on both sides of garage door area and two at rear of house (with motion sensor included).

Exterior light in front of house (with motion sensor included).

Bathroom fixtures ENERGY STAR® with Max 100w output for the entire fixture

Bathroom fans: ENERGY STAR® low sone (CFM 50) with timers, occupancy sensor or humidistat with required ducting to the outside and electrical circuit.

Light/ fan combo in bed rooms, living/dining room. Install new ENERGY STAR® combination light/fan in all bedrooms, living room & dining room with electrical wiring and light switch at entry. Compact Fluorescent Light bulbs are to be installed with fixture. / The alternative will be to use the ENERGY STAR® Advanced Lighting Package. This is a comprehensive package that includes ceiling fans, indoor lighting, and outdoor lighting. Also includes ventilating fans.

Any penetrations from exterior walls or unconditioned areas (i.e., attic, walls at receptacles, fixtures at ceilings, ducts at ceiling or wall, electrical panel service entrance, etc) must be air sealed and gaskets must be used to seal all receptacles and switches. Seal air gaps between electric boxes and walls. Recessed lighting fixtures including can lights and fluorescent fixtures (as applicable) should be boxed in to prevent insulation contact or be replaced with units rated for insulation contact and air tightness (ICAT).

All lighting fixtures to have Compact Fluorescent Lights installed (CFL).

Cut sheets for all the fixtures must be provided.

Note: If electricity is not available at property site, contractor shall supply approved electrical temporary power pole for construction including all related costs. All electrical work shall comply with the 2008 National Electric Code and be completed in a workmanlike manner.

\$ _____

10. MECHANICAL

a. Central Heat and Cooling System: Provide and install a new ENERGY STAR® central cooling and heating system. The installation shall include equipment with a minimum efficiency

of 15.0 SEER, R-410A refrigerant and electric heat strip. Equipment sizing shall be according to ACCA manual J. System will be complete with all electrical connections, piping and duct work. Ventilation shall be provided to all living areas including den. Return air ducts shall be provided to all bedrooms for balanced air return. The new heating and cooling systems will be a complete system with all necessary components to function according to code and manufactures specifications. No exposed interior duct work.

The air handler is to be located in the conditioned space. The interior of the air handler closet shall be sealed, taped and mudded drywall finish on all walls and ceiling and provide a continuous air barrier. The closet shall have an access door to allow for replacement, repair and maintenance. The air handler shall be installed with ready access to filter. If there is an existing interior closet for the AHU, replace louvered doors with a correctly sized central return grille mounted in the wall with a solid access door above. AHU platform must be extended to meet the wall and completely separate return plenum from space above. Existing closets containing air handlers supported by stands (instead of wood frame platforms), will be handled on a case by case basis.

The return air duct and register shall be sized according to approved methods. The condensing unit pad to be furnished by the G.C. or the H.V.A.C. contractor if none is present. The new complete system will be installed to all manufactures specifications with warranty submitted to the Housing & Real Estate Division, in addition, the mechanical contractor must provide documentation certifying that the system has been tested and is operating as it was designed. All work shall be completed in a workman like manner.

The system shall include an ENERGY STAR® programmable thermostat and include all equipment sizing and energy calculations as required per code. All documentation must be provided at permit application.

Install all new duct work (return and supply), joints to be sealed properly with mesh mastic compound. Duct work shall be leak free, insulated with a minimum of R-6 insulation as required per code with a vapor barrier. For flex duct work, ensure outer insulation sleeve fully covers connection collars to prevent condensation. All ducts to be properly stapled, taped and sealed according to manufactures installation instructions. Ducts shall be supported above insulation with approved hanger supports in accordance with manufactures installation instructions and code requirements. Register boxes shall be sealed between drywall and boot.

Clean and seal all register boxes and other duct openings until all work is completed in the interior of the house. Remove and clean all grills and paint if necessary. Include a quality filter when work is completed.

LEAK FREE means that all ductwork must be properly sealed with mastic and performance test of duct work must verify that duct leakage to unconditioned space does not exceed 6 cubic feet per minute per 100ft² of conditioned space at test pressure of negative 25 pascals (commonly referred to as 6%). If performance is over 6% air leakage, contractor is responsible for addressing the issue and this may include the responsibility to pay the energy rater to retest the house.

\$ _____

11. INSULATION

Note: Mechanical, electrical and plumbing rough-in must be completed prior to ceiling insulation.

a. Above Ceiling: Use blown insulation RESNET grade I, R-38 value and ensure that it is properly labeled at attic access, (existing homes) if insulation is missing or in poor condition add insulation to achieve RESNET R-38 grade I throughout. Attic access door must be insulated with rigid foam or batt insulation to R-19 and weather-strip at edges.

Where attic or other unconditioned space (such as floor cavities) extends over porches, provide insulation damn and an air barrier to prevent insulation spillage onto porch ceiling and air infiltration into attic or floor cavity. On knee walls ensure RESNET grade I installation to R-13 or greater insulation.

Suggested insulation materials are cotton, expanded polystyrene (EPS), formaldehyde-free fiberglass, water spray foam, or Greenguard certified insulation.

\$ _____

12. CABINETS & COUNTER TOPS

a. Kitchen Cabinets: Install new kitchen wall mount cabinets and base cabinets with new good quality pre-finished cabinets (containing NO exposed Urea Formaldehyde), clad with mica on all interior and exterior areas of all doors, sides, base and shelves with built in area for new dish washer.

New cabinets shall be mid-range quality and price (American Woodmart, Brandum, Merillat or equal). Color, finish and style of new kitchen cabinets to be chosen by Owner from appropriate selection supplied by contractor (solid color or woodgrain). All door and drawer pulls selected shall be selected by owner and shall be from readily available stock and be included in the cabinet installation costs. All base cabinets shall be installed plumb, level and scribed to fit floors and walls. Seal all joints in an approved manner. Wall cabinets will be hung with proper clearance between base cabinets and ceiling and be plumb and level. All work will be completed in a workmanlike manner and meet manufacturer's specifications. Cut sheets must be provided.

b. Kitchen Countertops: Install mica laminated countertops over new base cabinets. Top should be 25" in width with a 4" back splash or mica "curve-a-top" style. Countertops shall be fastened down per manufacturer's specifications. Owner shall be consulted as to color of countertops from appropriate selection supplied by contractor (**Wilsonart Series 60 or similar**). All work will be completed in a workmanlike manner and be to manufacturer's specifications.

c. Lavatory Base Cabinet: Install new good quality lavatory base cabinet (containing NO Urea Formaldehyde), properly sized to lavatory (American Woodmart, Brandum, Merillat or equal). New cabinet shall be clad with mica on all sides, shelves, base and doors. Owner shall select

type, style and color from readily available stock. Unit will be installed in a workmanlike manner and be level and plumb.

d. Lavatory Sink/ Counter Comb: Install new cabinet lavatory sink /counter combination. Cabinet lavatory shall be cultured marble (color white). Installation will comply with standard plumbing code and be completed in a workmanlike manner.

\$ _____

13. PAINTING

a. Exterior Elastomeric Paint: Patch and repair exterior walls as required skip trowel wall surfaces, prime and paint with color selected by owner and approved by the Housing & Real Estate Division, paint reflectivity shall be over 50. Prepare surface and apply elastomeric paint as per manufacturer's specifications to all exterior surfaces of dwelling. Any obstruction shall be pulled away from the house to allow painting of entire surface to a minimum of 6" below grade. The filling and patching of all holes and cracks is to be done as per manufacturer's requirements. Caulking of all trim and window/door shall be part of the surface preparation prior to application of paint.

Base color shall be approved by the Housing and real estate Division. Exterior doors, columns and trim are to be painted white. Remove all nails or strange objects from the surfaces and repair surface. All raw wood and siding (if applicable) will be primed prior to the application of paint. All sides and edges of exterior door(s) shall be primed within 3 days of installation. Entire exterior of the building must be pressure washed prior to application of paint, cleaning of the exterior for preparation of paint must include cleaning of soffit. On completion, entire exterior of structure shall be free and clear of dirt, all chipping, peeling, and checkered paint. Paint shall be Sherwin Williams, Loxon XP, ICI Decra-Flex 300, Valspar Duramax Ext, Behr masonry, or equal quality. All work will be completed in a workmanlike manner.

\$ _____

b. Interior Low VOC paint: Prepare surface and apply paint as per manufacturer's specifications to all painted interior surfaces of unit to include doors, frames and baseboards. The filling, patching and repairing of all holes, cracks and the caulking of all trim shall be a part of surface preparation, all wall paper shall be removed as well as decorative trim and wainscoat in the kitchen area and wall texture shall match all existing. Garage wood shelving system must be removed to paint the area wall. Paint will be either an interior latex flat (preferred), semi-gloss or satin high hiding interior wall paint. In bath, kitchen and all trim (Semi-gloss or gloss latex enamel) shall be used. Interior doors will be painted with (latex semi-gloss or gloss paint/stained and sealed). Base paint shall be approved by Housing & Real Estate Division and color white baseboards, trim and doors.

Paint will be (Sherwin Williams, Flex Bon 14-1 series, Glidden 5300 series, Best or equal quality). Painted raw wood will be primed prior to application of paint. Walls will be clean and free of any damaged, peeling, chipping or checkered paint. Prepare the surface to include cleaning must be done before painting application. All work will be completed in a workmanlike manner.

Use only low VOC or No VOC (Volatile Organic Compound) paint throughout the interior of the house and follow the above specifications for color, preparation and application.

For resources go to http://www.greenseal.org/findaproduct/paints_coatings.cfm

\$ _____

14. FLOORING

a. Ceramic Floor Tile: Install ceramic floor tile throughout the house. Installed tile shall be nominal 12" x 12" with a minimum thickness of 1/4". Tile shall be (Color Tile quality or equal). Color and pattern selection shall be owner's choice within manufacturer's availability (light colors as beige preferred). Installation adhesive and other application material shall be those as recommended specifically by the manufacturer. All work will be completed in a workmanlike manner.

c. Base Boards: Install 3 1/4 colonial base board throughout; and paint color white use low VOC paint.

\$ _____

d. Steam Clean: Clean/steam clean floors and grout and repair grout as seal as needed throughout the house (not including bedrooms). Pressure wash ground at exterior areas and garage.

\$ _____

15. APPLIANCES

a. Range/Oven and Hood Vent: Install a new -ENERGY-EFFICIENT- (CFM \geq 100) 30" four burner electric range/oven with clock and timer and self-cleaning feature. Install a 30" electrical range hood with light and two speed fan (Sears Kenmore or equal quality). Vent must be ducted to exterior and properly sealed.

b. Refrigerator: Install brand new refrigerator of 21 cu ft ENERGY STAR® (Maytag, LG brand or equal). Model shall have top-mounted freezer and be color white.

c. Dishwasher: Install a brand new ENERGY STAR® dishwasher compact size model (Maytag, LG brand or equal) color white.

\$ _____

16. MISCELLANEOUS

a. Wire shelving: Install wire shelving in all closets and pantry.

b. Window treatments: Install vertical window treatments (blinds w/ no lead components in its manufacturing) to all windows in living areas with slat width of 3.5 –inch minimum. (Color shall be white, egg shell or beige, owner to select) If vertical treatments are not available for

the window sizes, horizontal treatments may be installed with prior approval by the Housing and Real Estate Division.

- c. Mail box/ house numbers & door bell

\$ _____

d. A/C cage: Install an A/C condensing unit enclosure cage made of heavy duty galvanized steel. Cage shall be properly anchored to a/c pad and shall have removable panel(s) for service access including a security lock. Housing and Real Estate Division must approve the cage and lock type prior to installation.

\$ _____

17. LANDSCAPING

a. Site shall be graded and sloped to drain away from the foundation as necessary without impacting any adjacent properties as necessary. Remove any existing plantings that are closer than 30 inches from the house and any dead shrubs around the house. Trim existing trees (if any) in the property to stay away from the structure.

The proposal for this item is of \$2,000.00 which should include Bahia grass and plants to be determined by Housing & Real Estate Staff. New landscape should be planted 30 inches away from the building foundation. Location of plants will be determined by Housing & Real Estate Staff. Additional landscape resources can be found at www.sjr.state.fl.us/ . Or at the Guide to Environmentally Landscaping: Florida Yards and Neighborhoods Handbook. All landscape must be Florida friendly, native or adapted with low watering needs. Contractor is responsible for providing temporary irrigation to new plantings until they are established, ensure that temp irrigation does not spray the exterior of the house. Contact Diana Giraldo at (239)321-7926 for additional information regarding this item.

\$ 2,000 _____

18. ASBESTOS

a. **Asbestos Survey:** A limited Asbestos Survey for renovation purposes was conducted on _____. The Asbestos Analysis of this report indicates Asbestos Containing Materials _____. Adequate protection for employees from airborne asbestos fibers must be maintained in the workplace.

This project is subject to the Florida Department of Environmental Protection (FDEP) and the National Emission Standards for Hazardous Air Pollutants (NESHAP). Please refer to the attached limited Asbestos Survey for required asbestos removal.

\$ _____

19. TERMITE INSPECTION

a. A licensed termite inspector has inspected the existing property for termite infestation and damage. Please refer to attached termite report dated _____ and complete recommendations.

\$ _____

20. MOLD INSPECTION

a. A licensed mold inspection was conducted on this site on _____. The mold report indicates the presence of mold WAS/WAS NOT found at this property (please refer to inspection report). Complete recommendations as provided on the report.

\$ _____

21. CHINESE DRYWALL INSPECTION

A visual Chinese drywall inspection was performed on _____ (please refer to attached report). The Inspection report indicates NO/YES Chinese drywall was present.

\$ _____

22. PERMITS, FEES, ENG, ETC

a. **Permits:** Obtain all necessary permits, fees and all necessary documents (Concurrency Requirements, etc.) from Federal, State and Local governmental agencies prior to commencement of any work. Furnish copies of permits to City prior to commencement of any work. Permits will cover all work to be completed under schedule of work.

\$ _____

WORK EXPECTED TO BE COMPLETED IN _____ DAYS.

Exhibit "A" Total \$ _____ (if applicable)

Exhibit "B" Total \$ _____

Proposal Total \$ _____

Authorized Contractor Signature

Date

NOTE: All materials used, to be of standard grade or better according to current building codes, unless otherwise indicated. Contractor will be responsible for all of the physical measurements (e.g. sewer laterals, distances, etc.) that have to be taken or found to perform the work.

Under no circumstances shall the contractor furnish or apply any paint materials containing a lead base, lead dryer, or lead tinting colors. Contractor to be responsible for clean up after rehabilitation jobs.

For homeowner occupied projects

I, the undersigned, have had the above listed Contract Specifications explained to me and fully understand said specifications. I agree that these specifications constitute all of the work to be done on the property and authorize The City of Fort Myers personnel to incorporate these specifications into a Contract Bid Package.

Owner

Date

Owner

Date



DOE/GO-102013-4316 • December 2013

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