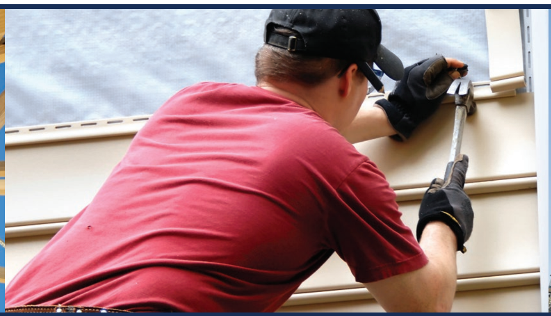
Assessment of ARRA Green and Energy Retrofits in HUD-Subsidized Housing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DISCLAIMER

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EXECUTIVE SUMMARY

As part of the American Recovery and Reinvestment Act (ARRA) of 2009,[1] the U.S. Department of Housing and Urban Development (HUD) was allocated funds to invest in energy efficiency and green building programs. Of approximately $13.6 billion in ARRA funds appropriated to HUD, about $4 billion was allocated to the Public Housing Capital Fund (PHCF) for the modernization and renovation of the nation's public housing stock, and $250 million was allocated to establish the Green Retrofit Program (GRP) for Multifamily Housing.

Of the $4 billion appropriated to PHCF, about $3 billion was allocated to public housing authorities (PHAs) via a capital fund formula that took into account relative sizes of the authorities and the numbers and types of housing units at each. The purposes of these monies included promotion of energy efficiency but extended to nonenergy improvements.

Another portion of PHCF, about $1 billion, was awarded to PHAs via a competitive process. The $1 billion Capital Fund Recovery Competitive grant program included $400 million for housing devoted to elderly and disabled tenants, public housing transformation, and gap financing for stalled projects. The remaining $600 million was awarded by competition to support energy efficiency or green building, approximately one-half for new or substantially rehabilitated public housing to be built to meet Enterprise Green Communities standards, and the rest for energy-efficient moderate rehabilitation or energy retrofits.

The $250 million allocated to GRP provided loans and grants for green building retrofits of privately owned rental housing receiving project-based rental assistance. These funds were awarded via an application process on a first-come, first-served basis.

To assess the results achieved through the three programs and to capitalize on that assessment, HUD established the Green and Energy Retrofit Assessment (GERA) project. This report covers four ARRA-funded programs assessed within the GERA project.

1. $3 billion in PHCF formula distributions.
2. $277 million in PHCF funds for competitively awarded energy-efficient substantial rehabilitation retrofits or new construction.
3. $323 million in PHCF funds for competitively awarded energy-efficient moderate rehabilitation or energy retrofits.
4. $250 million for GRP for privately owned, assisted housing.

The report does not address spending on housing for elderly and disabled tenants, public housing transformation, or gap financing.[2]

To carry out the GERA project, HUD engaged an assessment team, headed by LMI and including several other companies.[3] One of the assessment team's purposes is to assist HUD in providing well-researched information to Congress, the Office of Management and Budget, and other stakeholders regarding the results of the ARRA-

[1] *Pub. L. 111–5, 123 Stat. 115 (February 17, 2009).*

[2] *Funds were appropriated to other HUD programs in support of energy-efficiency and green building investment, but these appropriations also were not evaluated within the GERA project. The other programs included the Neighborhood Stabilization Program, the Indian Housing Block Grant Program, and the Tax Credit Assistance Program.*

[3] *These companies were The Federal Practice Group, Summit Consulting, Compass Group, Dominion Due Diligence Group, and Clean Energy Solutions, Inc.*

funded investments. Another is to leverage the information gained to assist HUD in decisionmaking for future energy-efficiency projects in the nation's public and subsidized housing stock.

The purposes of HUD's ARRA-supported expenditures include—

- Benchmarking projects demonstrating energy efficiency.
- Healthy, safe living environments.
- Lower utility costs.
- Conservation of energy, water, materials, and other resources.
- Utilization of renewable energy resources where feasible.
- Enhancement of local and regional ecosystems.

In addition, ARRA was enacted to help deal with a major recession affecting the United States. As such, its purposes included putting people to work and stimulating the economy. Funds spent on energy-related improvements to public housing were intended to contribute to these purposes. A timeline of HUD's actions regarding ARRA appropriations shows that the Department issued Notices of Funding Availability (NOFAs) within a few months of the enactment of ARRA and that retrofits were begun and a few finished later that calendar year.

INTERIM REPORTS

This report is the third and final report summarizing the results of HUD's ARRA-funded green energy programs. The assessment team submitted a first interim report to HUD on December 31, 2012. That report described a preliminary Energy Savings Model (ESM) used to estimate aggregate energy savings achieved by HUD's ARRA investments in its formula and competitive grants programs. The preliminary ESM was based on working experience, past analysis, and expert judgment regarding expected energy savings from individual Energy Conservation Measures (ECMs). The first interim report indicated that this model would be refined through further data analysis during the course of the GERA project.

On June 5, 2014, a second interim evaluation report was completed. That report focused on a data collection survey and other data collection activity then being designed and processed, on intended methodologies for site visits to 20 PHAs, and on a set of case studies to be constructed from a subset of the visited sites. The data collection efforts, site visits, and case studies constitute distinct parts of the GERA project.

DATA COLLECTION

The assessment team utilized several means to collect data with which to estimate aggregate energy savings, build a validated ESM, and draw lessons for future HUD energy-efficiency investment in the nation's public housing stock. These means included the following.

- HUD Recovery Act Management and Performance System (RAMPS).
- Survey of all moderate rehabilitation competitive grant recipients.
- Form HUD-52722/Utility Expense Level (UEL).
- Public and Indian Housing Information Center (PIC).
- Twenty site visits and seven case studies.

RAMPS provided an initial data set. These quarterly data, which showed ECMs undertaken at each Asset Management Project (AMP) within the public housing stock, ended with the fourth quarter of fiscal year 2011.

Through a survey of PHAs, the assessment team collected 12 months of data on preretrofit and postretrofit utility consumption. Such data were instrumental in the construction of the validated ESM. The survey was sent to 201 grantees and achieved an 84-percent response rate.

Energy consumption data also were captured through Form HUD-52722, which includes annual UEL data by AMP. This source provided data spanning the period 2004 to 2013.

PIC data described features of the public housing stock in local areas and supplemented information obtained from RAMPS.

Data also were obtained through 20 assessment team visits to competitive grantee sites. The purpose was to gather indepth data at sites with different PHA sizes, weather conditions, and types of public housing. The site visits involved reviews of audits and utility data and also of the quality of work done and oversight provided.

From these 20 site visits, seven case studies were constructed. These case studies involved even deeper study and evaluation of the actions taken at the 7 specific sites and the drawing of lessons learned.

AGGREGATE RESULTS

Table ES-1 shows estimated energy savings from HUD's ARRA-funded retrofit investments. The estimated savings include those from the formula and competitive grant programs for public housing and from GRP. The table also shows water savings, emission reductions, and unit equivalents affected by the investments in these programs.[4] Numbers other than for unit equivalents are rounded to the nearest thousand.

Table ES-1. Estimated Annual Energy/Water/Emissions Savings and Unit Equivalents in HUD's Energy Retrofit Programs

Category	Reduction
Electric/gas kilowatt-hour equivalents saved (annual rate)	315,000,000
Water hundred cubic feet saved (annual rate)	1,172,000
Carbon dioxide reduction (pounds/year)	384,600,000
Sulfur dioxide reduction (pounds/year)	1,431,000
Nitrogen dioxide reduction (pounds/year)	481,000
Energy conserving unit equivalents	102,042

ARRA = American Recovery and Reinvestment Act.
HUD = U.S. Department of Housing and Urban Development.

The amount of electricity saved would power about 29,000 average U.S. homes for 1 year. The water savings are sufficient to supply about 7,000 U.S. families for 1 year, and the carbon dioxide savings are sufficient to equal the removal of 37,400 U.S. vehicles from the road.[5] The retrofits may have been responsible for other environmental improvements (for example, to indoor air quality), but these improvements were not measured and therefore are not included in the table.

[4] *Unit equivalents are a means to estimate the number of HUD's housing units achieving a given level of energy efficiency. A unit equivalent is measured as one housing unit achieving 15 percent energy savings. Thus, for example, a unit achieving 10 percent savings would count as 0.67 of one unit equivalent and a unit achieving 20 percent would count as 1.33 unit equivalents.*

[5] *The number of homes powered is derived from an Energy Information Administration estimate that the average U.S. home consumes 10,900 kilowatt-hours per year. Water savings are derived from an Environmental Protection Agency (EPA) estimate that the average U.S. home consumes between 300 and 400 gallons per day. The equivalent number of vehicles estimate is obtained directly from a conversion factor supplied by EPA at https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle-0.*

COMPARISON OF AGGREGATE RESULTS WITH THOSE PROVIDED IN THE YEAR-ONE INTERIM EVALUATION REPORT

Table ES-2 provides a comparison of the savings estimated in the year-one interim evaluation report and those reported in this assessment.

Table ES-2. Comparison of Preliminary With Final Estimates of Savings From HUD's ARRA-Funded Energy Retrofit Programs

Category	Updated Estimate	Preliminary Estimate	Percent Change
Electric/gas kilowatt-hour equivalents	315,000,000	279,000,000	+15
Water hundred cubic feet saved	1,172,000	591,000	+98
Carbon dioxide reduction (pounds/year)	384,600,000	326,000,000	+20
Sulfur dioxide reduction (pounds/year)	1,431,000	1,268,000	+15
Nitrogen oxide reduction (pounds/year)	481,000	426,000	+15
Unit equivalents	102,042	102,342	-0.3

ARRA = American Recovery and Reinvestment Act.
HUD = U.S. Department of Housing and Urban Development.

The table shows that estimated energy and water savings increased from what was shown in the preliminary report, while the number of unit equivalents stayed essentially the same. The earlier report included only retrofits completed by the end of calendar year 2011 (others were still under way) and excluded GRP retrofits. On the other hand, the final estimates are based on actual utility data, which showed lower energy savings per unit than the previous estimates. Most of the emission estimates simply follow the change in overall energy savings, but the Environmental Protection Agency's factor for carbon dioxide per kilowatt-hour is slightly higher than what was used earlier, which increased that estimate more than the others.

OTHER KEY RESULTS

Energy Savings Among Competitive Grant Recipients

Data obtained from the survey of competitive grant recipients and from the 20 site visits enabled the assessment team to estimate the average energy savings achieved by these recipients. As the survey response rate was 84 percent, the estimate is statistically valid for the population surveyed. Also, the number includes a few instances in which energy consumption actually increased and some others in which solar panels were installed, resulting in decreased electricity bills. On average, the results indicate that competitive grantees achieved 20.33 percent energy savings from the ARRA-supported investment in ECMs.

Energy Savings at Site Visit Locations

Table ES-3 shows estimated energy savings at the 20 sites visited by the assessment team. In one case, utility spending actually increased, but in most it decreased, with a range of $22 per unit per year at Palms at Deerfield to $818 per unit per year at Ralph J. Pomeroy (Pomeroy) Apartments. In percentage terms, the savings ranged up to nearly 50 percent at Pomeroy Apartments and nearly 40 percent at W. Howard Day Homes and EJ Knight. Significant utility savings clearly were achieved for tenants at a good number of the 20 sites.

Table ES-3. Energy and Water Savings Results at the 20 Sites[a]

Project Name	Cost per Gallon ($)	Cost per kWh ($)	Cost per kWh	Estimated Annual Electric Savings ($)	Cost per Therm ($)	Estimated Annual Gas Savings ($)	Estimated Annual Total Savings ($)	Annual Expense/ Unit Reduction ($)	Annual Expense/ Unit Reduction (%)
Pinewood Village	NA	NA	0.15	(24,761)	1.22	11,225	(13,536)	(143)	– 9
W. Howard Day Homes	0.0084	(18,531)	0.13	(42,209)	1.16	213,318	152,578	700	38
Providence Place	NA	NA	0.10	54,905	NA	NA	54,905	366	30
Ralph J. Pomeroy Apartments	NA	NA	0.11	46,654	0.83	39,206	85,860	818	49
Brooklyn Homes	0.0084	187,622	0.15	86,241	1.16	111,374	385,237	793	26
Oak Pointe Apartments	NA	NA	0.10	990	1.47	11,749	12,739	51	8
EJ Knight (Newton Baker Village Gardens)	0.0084	2,904	0.10	6,612	1.47	10,700	20,216	505	39
Westlawn	NA	NA	0.15	17,938	NA	NA	17,938	90	11
Charlottetown Terrace	0.0084	17,841	0.10	40,993	NA	NA	58,834	365	25
King Kennedy	NA	NA	NA	NA	0.99	17,074	17,074	92	17
Parkdale Townhomes	NA	NA	0.10	393	NA	NA	393	25	2
North Loop	NA	NA	0.12	36,476	1.06	3,281	39,757	306	18
Boulevard Manor	0.0084	2,241	0.08	5,838	NA	NA	8,079	115	16
Powell Towers	0.0084	21,675	0.09	(15,614)	1.05	7,870	13,931	82	5
City Heights	NA	NA	NA	NA	1.02	39,078	39,078	107	13
Colonel Hamtramck Homes	NA	NA	0.11	98,709	1.62	5,109	103,818	346	32

(continued)

kWh = kilowatt-hours. NA = Not Applicable.

[a] *Numbers in parentheses indicate increased consumption.*

Table ES-3. Energy and Water Savings Results at the 20 Sites[a] *(continued)*

Project Name	Cost per Gallon ($)	Cost per kWh ($)	Cost per kWh	Estimated Annual Electric Savings ($)	Cost per Therm ($)	Estimated Annual Gas Savings ($)	Estimated Annual Total Savings ($)	Annual Expense/ Unit Reduction ($)	Annual Expense/ Unit Reduction (%)
Wichita Falls Apartments (AMP 4)	0.0084	27,211	0.12	(38,541)	1.02	52,424	41,093	337	16
Palms at Deerfield	NA	NA	0.11	2,244	NA	NA	2,244	22	9
Bangle Drive Apartments (Unnamed)	0.0084	76	0.09	836	1.05	2,109	3,021	252	28
Bay Park Tower	NA	NA	0.13	2,815	1.09	1,804	4,618	113	8

kWh = kilowatt-hours. NA = Not Applicable.

[a] *Numbers in parentheses indicate increased consumption.*

Paybacks

Calculation of paybacks on HUD's ARRA-supported green energy investments is complicated by the fact that many of these investments were in items providing important services beyond pure energy savings. For example, investment in new, more energy-efficient heating, ventilation, and air-conditioning units provide not only energy savings but also years of heating and cooling. Calculation of payback therefore requires isolating the premium paid for more energy-efficient capital equipment than standard equipment and the energy savings attributable to that incremental investment.

This calculation could be done for energy-efficiency investments at only a few of the 20 sites visited. The results of this effort are shown in table ES-4. Paybacks at these sites varied from as low as 2.4 to as high as 13.8 years, with 3 sites showing paybacks of 5 years or less.

Table ES-4. Simple Payback Calculations

Project Name	Total Retrofit Amount, ARRA+ Leverage ($)	ECM and WCM Incremental Cost Increase (%)	ECM and WCM Incremental Cost Increase ($)	Adjusted Annual Utility Savings ($)	Payback (Incremental Cost Increase/ Savings) in Years
Providence Place	702,850	45.9	322,608	54,905	5.9
Brooklyn Homes	5,768,917	33.4	1,928,650	385,237	5.0
Oak Pointe Apartments	245,000	39.2	96,040	12,739	7.5
EJ Knight (Newton D. Baker Village Gardens)	550,000	31.8	175,038	20,216	8.7
City Heights	240,500	39.2	94,276	39,078	2.4
Wichita Falls Apartments (AMP 4)	322,076	33.0	106,178	41,093	2.6
Bay Park Tower	205,000	31.2	63,892	4,618	13.8

AMP = Asset Management Project. ARRA = American Recovery and Reinvestment Act. ECM = Energy Conservation Measure. WCM = Water Conservation Measure.

EXPECTED VERSUS ACTUAL ENERGY SAVINGS

Grantees participating in the moderate rehabilitation competitive grant program were required to submit energy audits as part of their grant applications, and in the initial design of the assessment project these audits were expected to be available. That would have allowed for a comparison between energy savings projected in the audits and what actually occurred.

Not many of these audits were available from HUD in practice, however. An effort then was made to gather audit data directly from grantees included in the 20 site visits; however, of the 20, audit data were available from only one-half, and only one was at American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Level II.[6] The survey, which was primarily aimed at obtaining utility consumption data, did not unearth many more. Therefore, it was not possible to make a valid comparison between initial targets as estimated in energy audits and savings actually achieved.

ENERGY SAVINGS MODEL AND TOOL

The preliminary ESM was intended to provide an initial estimate of energy savings from HUD's ARRA-funded formula and competitive grant retrofits, to be updated with estimates based on actual utility consumption savings as they became available. The ability of the preliminary ESM to predict actual energy savings was tested with data taken from GRP and found to be deficient in some respects. In particular, the test revealed that the preliminary ESM was overpredicting savings from some ECMs, thereby biasing its overall energy savings predictions.

The assessment team eventually obtained UEL data covering several years. Although these data contained a number of flaws, they enabled the building of a statistical model to validate the preliminary ESM's energy conservation estimates for many ECMs and to account for factors such as weather and building characteristics. Because of data shortcomings, however, not all the validated model's estimates were considered accurate. Therefore, choices had to be made between estimates provided by the preliminary ESM and the validated model, with the validated model chosen when possible, because of its use of actual utility data, but the more conservative of the two chosen when the two differed markedly. This choice was made to avoid providing biased estimates of actual energy savings achieved.

This exercise was backward looking; that is, the model was constructed to estimate savings that had already occurred. As discussed in chapter 3, the validated model's estimate of energy savings from the formula and competitive grant programs taken alone was similar to that of the preliminary ESM. The validation model is discussed in chapter 6.

Using information from both the validated and preliminary ESMs, an energy savings tool was developed. The tool is forward looking in that it is intended to help HUD predict the Net Present Value (NPV) to be earned from future investment in any of 36 ECMs,[7] allowing for geographic location, type of building, numbers of units receiving the investment, and so on. This tool should help PHAs and others to identify potentially cost-effective energy-efficiency investment options anywhere in the country, whether in public housing, other HUD-assisted apartment properties, or market-rate apartment properties.

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[6] *An ASHRAE Level II audit is an industry standard investment-quality energy audit that estimates energy and also money savings from each ECM.*

[7] *The original sample included 38 ECMs, but two were duplicates, so that actually 37 unique choices were in the sample. The tool covers most of these ECMs but does not cover solar photovoltaic panels or other onsite energy generation (for example, wind, combined heat and power, geothermal heat pumps), the results from which tend to be location specific.*

Although the GERA project did not require estimation of water savings, such an estimate has been provided, and the tool includes water-saving measures. Thus, users of the tool can employ it to calculate the NPV of water efficiency investments as well. The tool is presented in chapter 6 of this report.

RECOMMENDATIONS

Many lessons were learned and recorded by the assessment team. From these lessons, a series of recommendations have been formulated and are presented in the following section. Chapter 7 includes a more extensive list of assessment team recommendations plus suggestions from individual PHAs.

Enhancing Program Benefits

- Make clear to grant recipients the purposes of HUD's investment program. For example, if one intent of grant programs, such as the moderate rehabilitation or new construction options, is to earn at least a minimum return on the capital invested, that should be stated up front, in the NOFA, and should be included as a selection criterion for grant award.
- Identify the data and measurements that will be used to evaluate overall program success and communicate them to program participants up front, within the NOFA.
- Include within the terms of the NOFA all data to be collected, and hold recipients to that requirement as part of the grant reporting and final closeout process. Doing so has two main benefits.
    - It will define data collection for grant management purposes within the NOFA, which will avoid a separate Paperwork Reduction Act clearance process to collect program outcome data.
    - It will ease the burden on PHAs and HUD, enabling PHAs to provide the desired data as they become available.
    - Preretrofit energy use analysis, such as that required of moderate rehabilitation grantees, should include property benchmarking and also a project-specific whole-building energy audit that follows the ASHRAE Level II protocol and is procured by the building owner, not by an energy performance contractor.
    - Unless both efficient and traditional components are competitively bid out, the true incremental cost of an efficient component cannot be calculated. Segregating efficient equipment incremental costs is imperative to calculating return on investment (ROI) or even simple payback values. It may not be practical in some instances to obtain such incremental cost information, but, if it is not practical, recognize that no valid estimate of ROI on energy-efficiency investment can be calculated.
    - GRP limited eligibility to retrofits that exceeded local code minimum efficiency, whereas the public housing programs did not. As a result, opportunities were missed in the competitive grant program because some PHAs selected or were provided code-minimum equipment when more efficient versions were available that would have yielded attractive returns on investment. Contractors should be informed that green (better than code) is a goal to which they will be held accountable.

Speeding Up the Program Review Process

Solid, thorough postimplementation program evaluation is a time-consuming process. Nevertheless, HUD can take steps to expedite this process. These steps include the following.

- Best practice in program evaluation is to design the evaluation at the same time as the program. One of the delays to the GERA project was a required change to the evaluation design to involve data collection from a full census of competitive grantees rather than a statistical sample of both formula and competitive grantees. The delays might have been avoided had the initial evaluation design more thoroughly assessed the feasibility of collecting retrofit-related data from formula grantees.

- Shortcomings in timeliness and quality of data were major reasons for the long timeframe of the GERA project. Upfront identification of data requirements to grant recipients and strong enforcement of such requirements would help to reduce this problem.
- The review process would have been expedited had competitive grantees been required to conduct ASHRAE Level II energy audits, submit them to HUD, and use the results to select retrofits. GRP recipients were subject to this requirement, but competitive and formula grantees were not.
- Case studies and site inspections could be executed as each site's retrofit is done; waiting until the whole program is completed is unnecessary.

CHAPTER 1

INTRODUCTION

As part of the American Recovery and Reinvestment Act[8] (ARRA) of 2009,[9] the U.S. Department of Housing and Urban Development (HUD) was allocated $13.6 billion for a variety of building upgrades and other programs, including funds to invest in energy-efficiency and green building programs. The legislation included a $4 billion appropriation to the Public Housing Capital Fund (PHCF) for modernizing and renovating the nation's public housing stock and a $250 million appropriation for establishing the Green Retrofit Program (GRP) for Multifamily Housing. GRP provides loans and grants for green building retrofits of privately owned rental housing receiving project-based rental assistance.

The $4.25 billion allocated to PHCF and GRP was divided into three parts. The first and largest portion of the monies, about $3 billion, was allocated to public housing authorities (PHAs) throughout the country via a formula grant program that took into account relative sizes of the authorities and the numbers and types of housing at each. The formula grants were made available for a variety of building improvements, which included but were not limited to energy efficiency. As of the fourth quarter of fiscal year (FY) 2011, 4,418 Asset Management Projects (AMPs) within the nation's PHAs had received formula grants.[10]

In addition to disbursing the formula grants, HUD set aside a second portion of the ARRA PHCF monies to be awarded among PHAs via a competitive grant process. This program totaled approximately $1 billion. To receive monies under this program, PHAs were obliged to apply for grants, which then were awarded on the merits of the applications. Monies received by PHAs via this program were in addition to monies received via formula grants.

The competitive grant program included four categories, only one of which was pertinent for purposes of this study. This category was the fourth, which was called "Creation of Energy Efficient, Green Communities" and contained two options. Option 1 grants were allocated to energy-efficiency investments related to new construction or to facilities undergoing substantial rehabilitation, and Option 2 grants were allocated to facilities undergoing moderate rehabilitation. In total, 37 Category 4 Option 1 grants totaling $277 million and 238 Category 4 Option 2 grants totaling $323 million were awarded. Of the 238 Option 2 grants, 201 were aimed directly at energy savings programs.[11]

The third portion of ARRA funds was used to fund GRP for assisted multifamily housing. In all, 227 grants were awarded to properties under this $250 million program.[12]

To assess the results achieved through these programs, HUD established the Green and Energy Retrofit Assessment (GERA) project. The GERA project covers the formula grants, the Category 4 Option 1 and Option 2 grants, and GRP. Among these four grant programs, about $3.85 billion was made available for energy

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[8] Pub. L. 111–5, 123 Stat. 115 (February 17, 2009).

[9] The various abbreviations used in this report are spelled out in appendix K.

[10] An AMP is a single property or group of properties that is managed as a unit and for which a PHA submits a single financial statement to HUD. According to Public and Indian Housing Information Center data, 9,268 total AMPs were within the nation's public housing stock at the time of the analyses.

[11] A few of the grants involved conservation measure investments that were aimed at saving water or at various other measures, such as the use of recycled products or non-VOC (volatile organic compound) paints, that were not expected to save energy.

[12] Each grant was awarded to a specific property. Among the 227 properties receiving grants, the median number of units was 60.

improvements in the nation's public and subsidized private housing. GERA does not cover several other HUD ARRA-funded programs that supported energy-efficiency improvements.[13]

One of the project's purposes is to analyze and report the results of HUD's ARRA-funded housing investments. A second is to assist HUD in decisionmaking for future energy-efficiency projects in the affordable housing stock. This report summarizes information collected during the GERA that addresses both purposes.

TIMELINE OF HUD's ARRA-FUNDED ENERGY PROGRAMS

Table 1-1 lays out a timeline of major events surrounding HUD's ARRA-funded green housing programs. The timeline shows that, within a few months of the enactment of ARRA, HUD had publicly announced its formula, competitive, and green retrofit programs; that, by later in 2009, not only were retrofit programs under way but a few had been completed; that, by FY 2010, approximately one-half had been completed; that, by FY 2011, HUD had a data collection process in place to track what was being done; and that, by FY 2012, the GRP retrofits had been completed. The data system in place for the formula and competitive programs was the Recovery Act Management and Performance System, and a separate data collection effort was conducted under GRP. Both were sources of input to the GERA project.

Table 1-1. Timeline of HUD's ARRA-Funded Green Housing Programs

February 17, 2009	ARRA is enacted into law.
March 18, 2009	HUD publishes PIH-2009-12, announcing HUD's $3 billion formula grant program.
April 10, 2009	HUD issues additional guidance regarding its formula grant program.
May 7, 2009	HUD publishes a NOFA covering its $1 billion competitive grant program (clarified June 3, 2009).
May 13, 2009	Notice H-09-02 is published, seeking GRP applications.
June 15, 2009	First applications for GRP funding are obtained by HUD.
4th Q, FY 2009	First competitive and formula grant projects are completed.
3rd Q, FY 2010	About one-half of planned competitive and formula grant projects are completed.
September 30, 2010	Funding obligated, retrofits are begun for GRP.
March 23, 2011	First retrofits are completed under GRP.
By FY 2011	Data collection is under way on individual retrofit projects.
September 24, 2012	GRP retrofits are completed.
1st Q, 2013	About 95% of planned competitive and formula grant projects are completed.
November 26, 2013	GRP postretrofit utility data collection is completed.

ARRA = American Recovery and Reinvestment Act of 2009. FY = fiscal year. GRP = Green Retrofit Program for Multifamily Housing. HUD = U.S. Department of Housing and Urban Development. NOFA = Notice of Funding Availability.

[13] *These programs include the Neighborhood Stabilization Program, the Indian Housing Block Grant Program, the Tax Credit Assistance Program, and others.*

PREVIOUS GERA REPORTS TO HUD

This report is the third and final report summarizing the results of HUD's ARRA-funded green energy programs. A first interim evaluation report was submitted on December 31, 2012.[14] That report described a preliminary Energy Savings Model (ESM) used to estimate aggregate energy savings achieved by HUD's ARRA investments. The report indicated that the preliminary model would be refined through further data analysis during the course of the GERA project.

The first interim report also provided first year estimates of energy and water savings from the ARRA investments made to date and of greenhouse gas emission and sulfur dioxide reductions. It further provided a list of 37 Energy Conservation Measures (ECMs) ranked by cost effectiveness. Within that list, 18 were found to be cost effective, 7 not cost effective, and 12 others either not actually energy savers or else exhibiting results too varied to reach a clear conclusion.

On June 5, 2014, a second interim evaluation report was submitted.[15] This report focused on a data collection survey and other data collection activity then being designed and processed, on intended methodologies for site visits to 20 PHAs, and on a set of case studies to be made up of a subset of the visited sites. The data collection efforts, site visits, and case studies constitute distinct parts of the GERA project.

SUBSEQUENT CHAPTERS

Chapter 2 describes the analytic approach taken, and the principal sources of data used, to refine the preliminary ESM. The analytic approach includes an examination of how well the preliminary ESM was able to predict actual savings resulting from ECMs implemented in GRP. In that chapter, we discuss the difficulties of relating energy savings directly to total ARRA monies spent by HUD. We describe the various sources of data used in the GERA analysis and a survey process that was undertaken to elicit energy savings data from Category 4, Option 2 (moderate rehabilitation) competitive grantees.

Chapter 3 provides estimates of the aggregate energy savings achieved in each of the three main components of HUD's ARRA-funded energy-efficiency efforts—(1) the formula grant program, (2) the competitive grant program, and GRP for Multifamily Housing.

Chapter 4 describes the approach taken to site visits and the results obtained. In the course of GERA, 20 competitive grant sites were visited. From these visits, individual site visit reports and a comprehensive final report were prepared.

Chapter 5 discusses the results obtained from seven case studies that followed the site visits. The seven were chosen to reflect a diversity of sites by size, weather zone, and so on. They also were sites where information was sufficient and staff members were available to record the retrofit experience.

Chapter 6 describes the updated ESM developed with the data gathered during the course of the GERA project. In that chapter, we describe a tool constructed for HUD's use in forecasting the results of future energy-efficiency investments in the nation's public housing stock. The tool is a standalone product of the GERA project, to be used by HUD as needed to help guide its future energy-efficiency investment programs.

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[14] *This report is attached as appendix A.*

[15] *This report is attached as appendix B.*

The final chapter summarizes lessons learned during the course of the GERA project. These lessons pertain to data gathering methods and other aspects of HUD's efforts to revitalize the energy-efficiency capabilities of the nation's public housing stock. They also include lessons learned by PHAs in the course of implementing HUD's ARRA-funded green energy programs. The report concludes with recommendations, including a few describing how the GERA process might be facilitated to achieve results more quickly than what actually occurred.

CHAPTER 2

METHODOLOGY AND DATA SOURCES

STUDY APPROACH

In this study, we constructed a preliminary Energy Savings Model (ESM) for use in estimating savings from particular types of energy investments and then sought to improve that model by (1) assessing its ability to predict actual energy savings, (2) testing with preretrofit and postretrofit energy use data, and (3) constructing a new version. The preliminary model, which specified the expected energy savings from about 37 different Energy Conservation Measures (ECMs), was based on conventional estimates published in the open literature, feedback from people who had installed such ECMs in the past, and expert judgment from people who had analyzed the effects of similar past measures. To obtain a preliminary aggregate energy savings estimate from HUD's energy-efficiency investments, the model was applied to data on numbers of ECMs actually installed, information that formula and competitive grantees were required to report to the Recovery Act Management and Performance System (RAMPS).

The 37 individual ECMs, by number, are shown in table 2-1. ECMs 18 and 31 were the same but were written differently, so 31 is not listed in the table.

Table 2-1. List of ECMs by Number

ECM Number	ECM
1	Air sealing
2	Attic or roof insulation
3	Advanced utility metering
4	Boiler temperature controls
5	Clothes washers replaced
6	Clothes washing machines converted to cold rinse
7	Cogeneration/micro combined systems
8	Compact fluorescent lighting and fixtures
9	Constant air regulating dampers
10	Conversions to electronic ignition
11	Dishwashers replaced
12	Domestic hot water tanks insulated
13	Energy-efficient storm doors
14	Energy-efficient storm windows
15	Energy-efficient window film
16	ENERGY STAR-qualified replacement exterior doors
17	Green roofs installed
18	Replace inefficient heating plants

(continued)

Table 2-1. List of ECMs by Number *(continued)*

ECM Number	ECM
19	HVAC pump motors replaced
20	Install gray water recycling systems
21	Install programmable thermostats
22	LED exit signs
23	Low-VOC/no-VOC paint
24	Low-flow showerheads and faucet aerators
25	Outdoor and common areas light controls
26	Outdoor and common areas light fixtures replaced
27	Radiator controls installed
28	Using recycled building products
29	Refrigerators replaced
30	Replace central air-conditioners
32	Replace inefficient hot water heaters
33	Replacement windows
34	Solar photovoltaic panels
35	Solar thermal hot water system installations
36	Spot ventilation
37	Toilets replaced with water-saving toilets
38	Window air-conditioners replaced

ECM = Energy Conservation Measure. HVAC = heating, ventilation, and air-conditioning. LED = light-emitting diode. VOC = volatile organic compound.
Note: ECM 31 is not listed because it is the same as ECM 18.

To gain insight into the strengths and weaknesses of the preliminary ESM, its ability to forecast energy savings was tested with actual energy savings results taken from the Green Retrofit Program (GRP) for Multifamily Housing. The predictions of the ESM also were compared with predictions taken from an approach that was part of GRP (hereafter called the GRP approach). Even if the ESM were not predicting accurately, the assessment team wanted to see whether it would be superior to the GRP approach.

The results indicated that the preliminary ESM was incomplete in several respects and was not forecasting energy savings accurately. It was no better in making such predictions than the GRP approach, with neither predicting very well. This work is described further in the following section. The complete study is appended to this report (appendix C).

Insights gained from the work and the gathering of energy use data were used to develop a more sophisticated ESM, which is presented in chapter 6. This model is more robust, incorporating features not present in the preliminary version. For example, it has the ability to take weather and individual building characteristics into account. It was constructed through a series of statistical regressions in which energy savings were related to various features of the buildings where the investments had been made. The results thus represent projections drawn from analysis of actual data drawn from the public housing stock.

The statistical relationships within the model and other information have been incorporated into an energy-efficiency investment tool intended to assist HUD in considering future energy-efficiency investments in the nation's public housing stock. The tool provides a cost-benefit calculation for any of 36 different ECMs, matching the amount spent to obtain energy efficiency with the expected returns over the lifetime of the investment.[16] It is further discussed in chapter 6.

MODEL ACCURACY REGARDING THE GREEN RETROFIT PROGRAM FOR MULTIFAMILY HOUSING

As noted previously, the preliminary ESM's ability to accurately estimate energy savings was tested by comparing its predictions with actual energy savings achieved by GRP. In addition, the ESM's prediction capability was compared with the ability of a simple GRP approach to estimating energy savings at its properties.

The GRP approach produced property-specific savings estimates by combining a property-specific American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Level II energy audit[17] with a Property Condition Assessment (PCA)[18] that enumerated the estimated savings for each ECM. The audits showed which ECMs likely would be cost effective at a given property, and the collective PCAs then estimated the property's expected energy savings.

RESULTS OF THE ANALYSIS

GRP Approach

To provide a basis for comparison with the preliminary ESM, we first describe the accuracy of the GRP approach. The results indicate that the type of upfront energy analysis utilized in this approach is not an accurate predictor of actual utility savings. As shown in table 2-2, only 36 percent of properties had actual savings as a percentage of preretrofit utility consumption that fall within five percentage points of the utility savings predicted by combining the GRP upfront energy audit with the PCAs. Thus, for example, if the approach predicted 10 percent energy savings for a particular ECM at a particular building, nearly two-thirds of the time the actual savings would be greater than 15 percent or less than 5 percent, implying an error of at least 50 percent.

Table 2-2. Predicted Versus Actual Energy Savings: Green Retrofit Program for Multifamily Housing Approach

Prediction Range	Number	Percent
Predictions within ± 5 percentage points of actual savings	50	36
Predictions within ± 5–10 percentage points of actual savings	34	25
Predictions within ± 10–15 percentage points of actual savings	25	18
Predictions more than 15 percentage points away from actual savings	29	21
Total properties (excluding outliers)	138	100

16 *The tool does not analyze expected savings from solar voltaic or other onsite energy supply options, which tend to be site specific.*

17 *An ASHRAE Level II audit consists of a thorough building survey and energy use analysis, accompanied by financial analysis to determine where the most promising opportunities are to cost-effectively improve building energy efficiency.*

18 *A PCA consists of a careful physical assessment of the major components of a building (for example, roof; heating, ventilation, and air-conditioning; plumbing; electrical), an assessment of potential risks or liabilities associated with the condition of these components, and potential energy savings from potential improvements.*

The study assessed whether the accuracy of the estimates varied based on scope of work; inclusion of heating, ventilation, and air-conditioning (HVAC) retrofits; owner-paid versus tenant-paid utilities; or electricity only versus gas and electricity. This analysis revealed no significant effects from any of these factors; however, further analysis indicated a number of other factors that appeared to contribute to the GRP approach's estimating errors. These additional factors included—

- The replacement components included in the GRP PCA tool not necessarily reflecting the final scope of work. In some cases costs were less than expected, so more ECMs could be performed, whereas in others costs were higher than expected, and fewer ECMs than planned were done.
- Simple reporting problems (for example, getting a data point wrong by a factor of 10 or 100, entering the wrong unit of measure, entering a wrong quantity).
- The interaction between multiple retrofits. For example, installing efficient windows, plus adding insulation, plus upgrading with a more efficient heating plant does not save 2.5 percent for windows, plus 1.1 percent for insulation, plus 20.0 percent for heating plant (23.6 percent total). Instead, the retrofit consumption is 97.5 percent x 98.9 percent x 80 percent = 77.1 percent of the preretrofit consumption, which is 22.9 percent savings.
- Insufficient tenant education and incorrectly anticipated tenant energy-consumption habits, including rebound effects (that is, tenants taking advantage of increased energy efficiency to consume more energy than implied by the efficiency improvement).
- Underlying plant problems (for example, leaky air ducts) not being addressed.
- Inconsistent means of weather and occupancy normalization among properties.
- Reporting errors such as omitting a meter in one or both baselines.

GERA Preliminary Energy Savings Model

As the preliminary ESM did not take account of public housing location or building characteristics, the model was not expected to perform well in estimating energy savings at particular properties. Instead, the main aim of the model was to offer an initial estimate of aggregate energy savings from HUD's total American Recovery and Reinvestment Act (ARRA) investment that would be reasonably close to actual savings.

In fact, the preliminary Green and Energy Retrofit Assessment (GERA) ESM did not perform better than the simple GRP approach. As can be seen in table 2-3, the model predicted energy savings within 5 percentage points of actual for only 29 percent of properties, even less than the GRP approach.

Table 2-3. Predicted Versus Actual Energy Savings: Preliminary Energy Savings Model

Prediction Range	Number	Percent
Predictions within ± 5 percentage points of actual savings	46	29
Predictions within ± 5–10 percentage points of actual savings	44	27
Predictions within ± 10–15 percentage points of actual savings	25	16
Predictions more than 15 percentage points away from actual savings	46	28
Total properties (excluding outliers)	161	100

The exercise, however, resulted in some key findings. For example, of 171 instances (including outliers), the GERA model overpredicted savings 109 times (64 percent) and underpredicted savings 62 times (36 percent). Compared with the GRP approach's ratio of 78 overpredictions and 60 underpredictions, the GERA model had a greater tendency to overestimate savings. This tendency suggests that some of the individual ECM energy savings estimates within the preliminary ESM likely were too high.

As with the GRP estimating procedure, the scope of work undertaken was roughly consistent across all properties, and no discernable correlation exists between the extent of rehabilitation and the model's ability to predict actual energy savings.

In a similar way, the GERA estimates were just as likely to be inaccurate for properties where owners pay for energy usage as for properties where tenants pay some utilities. Approximately one-third of the accurately predicted properties are master-metered and approximately one-third of the less accurate estimates are master-metered. As with the GRP approach, no significant trends were discernible.

The purpose, however, was to identify specific ECMs for which the GERA model tended to inaccurately predict savings. Most notable was the discrepancy between 20 percent expected savings from heating plant retrofits and the average GRP expected savings of 7.2 percent. Given the observation that the preliminary ESM shows a tendency to overpredict propertywide savings, a likely cause is the overestimation of the savings potential associated with heating plant upgrades. This likelihood was demonstrated by the relatively neutral estimates of the GRP approach, because the heating plant is by far the largest driver of savings estimates and HVAC upgrades were one of the most commonly performed retrofits. As a consequence, given the prevalence of this ECM and the large savings estimate assigned to it, it is a likely driver of the overestimation.

The analysis revealed additional ECMs with high energy savings estimates that in retrospect appear to have been too aggressive.

- ECM4: 3.0 percent for boiler temperature controls.
- ECM12: 1.0 percent for domestic hot water insulation.
- ECM27: 2.5 percent for radiator controls.
- ECM32: 6.0 percent for hot water heaters.
- ECM35: 5.0 percent for solar thermal hot water system.

In light of GERA's overestimates of savings, these leading energy saving components were revealed as candidates for further analysis and potential revision. Overall, the analysis revealed that a better methodology, grounded in actual data, would be needed to provide more accurate estimates of the savings to be expected in individual circumstances from each ECM.

Calculating Returns on Energy-Efficiency Investments

The compilation of savings from energy-efficiency investments is complicated by several factors. One is that many confounding factors affect energy savings, a second is missing or poor-quality data, and a third is that many such investments are made in capital equipment that provides services beyond energy efficiency and it is difficult to separate the value of those services from the energy-efficiency gains. A fourth is that some of the investments were not made in energy efficiency at all, and a fifth is that ARRA had multiple objectives, of which some come into play in HUD's investments in energy-efficient public housing.

That confounding factors affect energy savings is evident. These factors include weather, building occupancy, other expenditures made simultaneously on the housing in question, size of the units being studied, and so on. Particularly when only 1 year of preretrofit and 1 year of postretrofit utility data are available to compare with one another, other factors (particularly weather) are likely to have a confounding effect. The study weather normalized preretrofit and postretrofit data through the use of heating and cooling degree days and performed multiple regressions to separate other factors in an attempt to isolate the energy savings effects of such investment. Still, different ways to weather normalize exist, and some data (for example, on preretrofit and postretrofit building occupancy rates) were not generally available. Therefore, some error is inevitable in relating energy savings directly to efficiency investment.

A second factor was incomplete data. Despite HUD's requirement that competitive and GRP grantees maintain at least 1 year's worth of preretrofit and postretrofit energy-consumption data, not all recipients did so. On several occasions, missing data had to be interpolated or otherwise adjusted for. To the extent that data errors remain or were not adjusted for adequately, the energy savings estimates are rendered less accurate.

It was often difficult to separate out the energy savings component of energy-efficiency capital investments from other components. In general, the data covered aggregate expenditures on ECMs at a given property, not spending on an ECM-by-ECM basis, and those data did not reveal how much was spent directly to save energy and how much was spent for other features of capital equipment. This factor resulted in seemingly more investment in energy efficiency than actually was taking place.

Two examples may help make the point. First, investment in insulating materials basically are made for the purpose of saving energy, though such materials may also provide improved comfort for public housing inhabitants. In such a case, if utility data are readily available, it is relatively straightforward to calculate what was spent and what energy was saved.

Second, some of HUD's investments took the form of new capital equipment, such as energy-efficient refrigerators or hot water heaters. In such cases, the energy-efficiency component is the difference between a standard version and one that is more energy efficient. Of a certain amount spent to obtain—for example, new refrigerators—only the difference in cost between the standard and more efficient versions should be counted as an investment in energy efficiency. The rest of the monies cover the basic functions of either type of refrigerator; however, the data did not separate out the two. Instead, investments made in new refrigerators were simply provided as lump sums (usually contained within aggregate expenditures that included other ECM investments). Thus, any attempt to relate this investment to the amount of money saved would understate the actual return on energy-efficiency investment, because it would include the base monies spent simply to obtain refrigerator services. This problem cropped up repeatedly in the GERA project. For that reason, it is inadvisable to simply compare the monies spent by HUD on energy efficiency to the energy saved; too many other services were obtained from the investments for that number to have significant meaning.

Also, in a number of instances, investments were made for purposes other than energy savings. Many of these investments involved water savings, but several were in other building infrastructure. For example, only 201 of 238 Category 4 Option 2 competitive grant recipients reported within RAMPS that they had made one or more energy-efficiency investments.

The final confounding factor is that ARRA was enacted to stimulate economic activity in the United States at a time of deep recession. Therefore, one objective in spending ARRA monies was to put people to work and generate income that in turn would be spent elsewhere, generating yet further economic activity and ultimately economic recovery. Although no assessment was made of how much economic activity was stimulated by HUD's ARRA-supported investments, chapter 1 of this report indicates that HUD moved quickly to put its program into place and begin awarding grants to public housing authorities (PHAs) around the country. A metric aimed at capturing HUD's ability to productively get monies into the private economy during a deep recession would therefore largely show positive results.

Data Sources for the GERA Study

At the beginning of the GERA project, it was envisioned that a data collection survey would be conducted covering virtually all of HUD's ARRA-funded energy-efficiency grant recipients. This data collection would be in addition to other data sources, such as RAMPS. The original plan for this data collection was later modified and, in its place, a survey was conducted that was limited to all competitive moderate rehabilitation grantees. In addition, several other data sources were utilized, which are briefly described in the following subsections.

RAMPS Data

Quarterly RAMPS data were supplied almost from the inception of the GERA project. PHAs receiving formula or competitive grants from ARRA-funded programs were required to supply quarterly data on what ECMs they were initiating with the monies received, how many of each they were doing, progress made, and so on, which were compiled into RAMPS. The last quarterly RAMPS data received by the assessment team went through the fourth quarter of fiscal year 2011. In these data, not all projects had yet been completed; however, the assessment team's final energy savings estimates included all planned and all completed projects.

HUD-52722/UEL Data

Each PHA annually submits a Form HUD-52722/Utility Expense Level (UEL) through the Public and Indian Housing Information Center (PIC) inventory management system. This form includes utility consumption data at the meter level, with a single property often reporting consumption across several meters, and includes water, sewer, gas, fuel oil, propane, and electrical consumption. UEL data were supplied spanning 2007 through 2013 and include annualized consumption going back to 2004.

These data provided a stronger basis with which to make estimates of savings from particular ECMs, but they have key limitations. First, the data are collected only annually, not monthly. Second, data are provided only for meters that are subject to UEL calculation—in some cases these data include only common areas, in others common areas and select units, and in yet others an entire property. To deal with this latter situation, per-Asset Management Project comparisons were made across years for the same meters.

PIC Data

PIC data on the nation's public housing stock were available for purposes of this study. These data describe features of the public housing stock in local areas and were useful as a supplement to information obtained from RAMPS.

Site Visit Data

Data pertaining to specific properties were obtained through 20 site visits (the results of the site visits are described in chapter 4). All the sites visited were competitive grantees, so it was usually possible to obtain preretrofit and postretrofit UEL data directly from each. These data were used in estimating energy savings at these various properties. In addition, the site visits were able to identify other sources of funding for energy retrofits, how the retrofits were done, how well they were being maintained, and so on.

Data Collection Survey

In the initial design of the GERA project, a survey of a sample drawn from all of HUD's ARRA-funded recipients of energy-saving grants was envisioned. This data collection effort was intended to provide data needed to refine the preliminary savings model and to provide HUD with better estimates of the energy savings actually achieved.

Such a data collection effort would have involved a survey of a sample of approximately 10 percent of recipients of formula and competitive grants. It was envisioned that the survey would be submitted to the Office of Management and Budget (OMB) for Paperwork Reduction Act (PRA) review and eventual approval.

After further reflection, a decision was made to limit the survey collection effort to recipients of moderate rehabilitation competitive grants (Category 4, Option 2). The thinking was that recipients of formula grants already would have submitted most if not all the data they had to HUD within RAMPS. These data already had been made available, so little if any new information would be obtained by surveying the formula grantees.

Preparing and Implementing the Survey

The assessment team designed a survey form in Microsoft Excel to send to Public Housing Capital Fund moderate rehabilitation competitive grantees. While the survey form was being cleared through OMB, it was pointed out that competitive grantees were already required to hold the information being sought, so little if any additional burden on them would result. In particular, the survey asked for a year's worth of preretrofit and postretrofit utility consumption data, which recipients already were required to keep as a condition of their grants. Following review by HUD, the form eventually was submitted to OMB for PRA review. Few comments on the survey were received, and in the fall of 2014 OMB gave it the necessary clearance.

The survey was implemented in January 2015 and fielded for approximately 3 weeks. Of 118 PHAs surveyed, 99 responded, for an 84-percent response rate.

CHAPTER 3

AGGREGATE ENERGY SAVINGS

This chapter presents aggregate energy savings derived from HUD's American Recovery and Reinvestment Act (ARRA)-funded investments in energy efficiency and also unit equivalents that received Energy Conservation Measures (ECMs). Water savings and certain environmental gains also are shown. Estimates in this chapter are compared with those offered in the assessment team's year-one interim evaluation report, *Interim Evaluation Report: Year One.*

As stated in chapter 1, HUD's ARRA-funded energy-efficiency program was divided into three parts: (1) the formula grant program, (2) the competitive grant program, and (3) the Green Retrofit Program (GRP) for Multifamily Housing. Aggregate energy savings from each is presented in turn.

FORMULA GRANT PROGRAM

The formula grant program made up most of HUD's ARRA-funded energy retrofits to the public housing stock. The program took account of the relative size of public housing authorities (PHAs), the numbers of housing units at each, and other factors. Formula grants were issued to 4,418 Asset Management Projects (AMPs), within which 276,854 units implemented ECMs.[19]

The validated model was used to estimate annual aggregate energy savings pertaining to formula grants. This estimate was done by applying updated energy savings parameters estimated from Utility Expense Level (UEL) data and other sources for each ECM to all ECMs reported in the Recovery Act Management and Performance System (RAMPS), including those that earlier were in the planning stage but later were assumed completed. All energy savings were converted to kilowatt-hours saved. Overall, the result showed annual energy savings of 153,003,079 kilowatt-hours from the formula grant program.

COMPETITIVE GRANT PROGRAM

As the result of a competitive process, the Office of Public and Indian Housing awarded approximately $323 million in Capital Fund Recovery Competitive grants to PHAs for energy savings in moderate rehabilitation of existing public housing (Category 4, Option 2) and $277 million to PHAs for such savings in substantial rehabilitation of existing housing and in new housing construction (Category 4, Option 1). Grantees were able to pursue a wide variety of eligible activities and types of retrofit with grant funding. The proposed scope of retrofit usually included ECMs and Water Conservation Measures but also included retrofits driven by the goals of economic stimulus and creating healthy homes.

Survey Findings

As reported in chapter 2, the assessment team conducted a survey of moderate rehabilitation competitive grant recipients to obtain data on energy savings achieved.[20] The survey revealed the following.

[19] *Many more units are reported within the Recovery Act Management and Performance System, but this number was reported as receiving energy-related ECMs.*

[20] *The comprehensive competitive moderate rehabilitation grantee survey report submitted to HUD as part of GERA accompanies this study as appendix D.*

- Of the 238 Public Housing Capital Fund moderate rehabilitation grants awarded, 201 grants (defined as an AMP at which grant funding was used) reported in RAMPS that they had funded the implementation of one or more ECMs.[21]
- The 118 PHAs awarded these 201 grants were each required to provide to HUD 1 year of preretrofit and 1 year of postretrofit utility usage data. These data were requested via the survey.
- Usable data were obtained from 97 PHAs covering 917 unique utility meters, including data for natural gas, electricity, and steam.
- Of reporting grantees, raw, non-weather-normalized savings for properties fully reporting on a year of preretrofit and postretrofit utility savings usage are as follows.
    - Electricity usage changes ranged from a decrease of 78 percent to an increase of 18 percent, with approximately 60 percent of properties (65 of 106) reporting a decrease in raw electricity usage.
    - Gas usage changes ranged from a decrease of 79 percent to an increase of 37 percent. Nearly 80 percent of properties (63 of 79) reported a decrease in gas usage.

As noted, the data showed energy consumption increased at some properties. In a few cases, air-conditioning was added or upgraded. In others, major appliances such as stoves were added or upgraded that provided additional services but also increased energy usage. In yet others, the data may have contained errors.

This last reason is plausible because the assessment team found reporting errors and missing pieces throughout the data collection process. Corrections were made involving units reported, scaling to proper magnitudes, and other factors; however, it seems likely that some data errors were not discovered or that they were insufficiently corrected.

Estimated Energy Savings

In some instances, competitive grantees developed new units, which were required to be certified with either Enterprise Green Communities criteria (the vast majority) or LEED (Leadership in Energy & Environmental Design). By definition, these units were at least 15 percent more efficient than standard new construction units. The assessment team assumed 15 percent energy savings, though actual savings may have been more in some instances. Given that 2,504 new units were constructed under the competitive grant program, aggregate annual energy savings for these units were estimated at 6,009,600 kilowatt-hours.

For moderate retrofits, the previously described survey data plus site visit data were used. The 201 AMPs that reported they had implemented ECMs included 42,054 units. On average, these AMPs showed energy savings of 20.33 percent. This savings average includes units that showed actual increases in energy usage but is not weather normalized. Applying the percentage to average annual energy consumption among competitive grantees,[22] annual savings from retrofits of 112,977,300 kilowatt-hours were achieved. Total annual savings from the competitive grant program therefore are estimated as shown in table 3-1.

[21] *The remaining 37 grantees reported no retrofit affecting energy costs. These grantees conducted other types of green retrofits, including to conserve water or to use low-VOC (volatile organic compound) materials, recycled materials, and so on.*

[22] *The grants were issued to AMPs. Given the number of units among these AMPs, the average energy consumption per unit was about 1,100 kilowatt-hours per year.*

Table 3-1. Estimated Energy Savings From Competitive Grant Programs

Program Type	Estimated Energy Savings (kWhs)
New construction	6,009,600
Retrofit	112,977,300
Total	118,986,900[a]

kWhs = kilowatt-hours.

[a] In an earlier report that is part of this assessment (see appendix H), it was estimated that HUD's competitive grant program had achieved savings of approximately 279 billion British thermal units (BTUs) per year, which converts to 81,747,000 kWh. That estimate, however, excluded units for which ECMs had been planned but not completed and also new construction. Adding those categories increases the annual savings to 406 billion BTUs, which converts to 118,086,900 kWhs.

GREEN RETROFIT PROGRAM FOR MULTIFAMILY HOUSING ENERGY SAVINGS

GRP was launched in 2009 and provided an opportunity for eligible properties to apply for a grant or loan to fund energy and green rehabilitation (rehab) improvements. The objectives of the program were to create "green collar" jobs, improve property operations by reducing expenses, benefit resident health, and improve the environment. HUD's Office of Affordable Housing Preservation selected 227 properties to receive investments totaling $250 million. Federally assisted, low-income housing types eligible for GRP included: Section 8 housing, Section 202 senior housing, Section 811 disabled housing, and U.S. Department of Agriculture Section 515 rural housing.[23]

Energy and water savings obtained from GRP have been separately estimated for HUD by Bright Power/Stewards of Affordable Housing for the Future (Bright Power/SAHF).[24] The Bright Power/SAHF estimates are shown in table 3-2.

Table 3-2. Estimated Green Retrofit Program for Multifamily Housing Savings by Fuel

Utility Type	Number of Properties	Energy/Water Savings (usage per year)	Cost Savings ($ per year)	Savings (%)
Electricity	179	16,848,000 kilowatt-hours	1,861,000	16
Natural gas	137	892,000 therms	994,000	19
Water	162	141,000 kilogallons	1,232,000	28

To put energy savings into comparable units for all the programs, therm savings are converted into kilowatt-hour savings (29.3 kilowatt-hours per therm). The converted therm savings therefore are 26,135,600 kilowatt-hours, and total savings in kilowatt-hours for GRP were 42,983,600 kilowatt-hours.

[23] U.S. Department of Housing and Urban Development, "Green Retrofit Program (GRP) Overview," http://portal.hud.gov/hudportal/documents/huddoc?id=grn_retro_overview.pdf.

[24] The full report is available at http://www.brightpower.com/wp-content/uploads/2016/09/Energy-and-Water-Savings-in-Multifamily-Retrofits.pdf.

TOTAL ENERGY SAVINGS FROM HUD's ARRA-FUNDED ENERGY RETROFITS

Table 3-3 shows estimated annual energy savings by program and in total. Overall, HUD's ARRA-funded energy savings programs are saving approximately 315 million kilowatt-hours per year, enough to power nearly 29,000 average U.S. homes for 1 year.[25]

Table 3-3. Estimated Total Annual Energy Savings

Program	Estimated Savings (kWh equivalents)
Formula grant	153,003,079
Competitive grant	118,986,900
Green Retrofit Program for Multifamily Housing	42,983,600
Total savings	314,973,579

kWh = kilowatt-hour

COMPARISON OF ENERGY SAVINGS WITH THE YEAR-ONE INTERIM EVALUATION REPORT ESTIMATE

With the use of RAMPS data, the preliminary Energy Savings Model (ESM) estimated that HUD's ARRA-funded energy retrofit programs saved 279,000,000 kilowatt-hours. That estimate, however, did not include GRP. Subtracting its total, aggregate savings from the formula and competitive grant programs are now estimated at about 272,000,000 kilowatt-hours, a slightly lower number. The assessment analysis indicated that some parameter estimates within the preliminary ESM tended to overpredict savings, whereas the second estimate includes units that had not completed their retrofits at the time. On balance, the revised parameter estimates had the bigger effect. Because the present estimate of total savings makes use of UEL data that were not available earlier, it is probably a more accurate indicator of the actual savings achieved through HUD's ARRA-funded energy retrofit programs.

ENERGY-EFFICIENT UNIT EQUIVALENTS

The year-one interim evaluation report noted that HUD defines an energy-efficient unit as one experiencing 15 percent total energy savings through one or more implemented ECMs.

Thus, for example, if a particular unit implemented five ECMs in which total energy savings amounted to 18 percent, it would be counted as 1.2 unit equivalents (18/15). The interim evaluation report indicated that, to calculate how many units achieved this level of energy savings, a series of assumptions had to be made about which units received which ECMs. Given those assumptions, the assessment team calculated the numbers of unit equivalents by combining units achieving less than 15 percent energy savings with those achieving more. For example, a unit achieving 12 percent energy savings was treated as 0.80 unit equivalent (12/15), and one achieving 20 percent was treated as 1.33 unit equivalent. These two units combined therefore would equate to 2.13 unit equivalents.

[25] *According to the Energy Information Administration, the average U.S. home uses about 10,900 kilowatt-hours per year. Therefore, the savings from HUD's energy retrofits would power approximately 28,900 homes.*

In this report, the definition of an energy-efficient unit equivalent as one achieving 15 percent in total energy savings is maintained. For comparability with the earlier report and coverage completeness, we provide unit equivalent estimates for each of the programs here reviewed—competitive grants, formula grants, and GRP.

Competitive Grant Program

Option 1 (new construction and substantial rehabilitation) investments led to installation of ECMs in 2,504 units. As indicated previously, these units were required to be certified with either Enterprise Green Communities criteria (the vast majority) or LEED, and therefore are at least 15 percent more energy efficient than standard new construction. A conservative assumption is that all these grantees met the 15 percent criterion exactly, implying that 2,504 unit equivalents were in this program.

Option 2 (moderate rehabilitation) grants led to ECM investment at 42,054 units. From UEL data collected to assess the competitive grant program and from site visit information, the average energy savings at these units was calculated to be 20.33 percent. This number includes some units where energy consumption increased and also a few units where solar photovoltaic was installed, resulting in a savings of utility-supplied energy. Given the method of calculating unit equivalents, 20.33/15 x 42,054 = 56,997 unit equivalents were within this program. Although the number of unit equivalents exceeds the total number of units in this instance, it is consistent with HUD's methodology, which seeks to offer a standard way to express energy-efficiency improvement among the public housing units receiving investment.

Formula Grant Program

From formula grant reporting in RAMPS, ECMs were installed in 276,854 units on top of what was awarded in the competitive grant program. Formula grantee unit equivalents are composed of an estimate of savings based on the ECMs installed in each unit and the estimated savings for those ECMs from the assessment team's validated ESM. For example, suppose a gas-heated formula rehabilitation unit had its heating plant replaced, programmable thermostats and compact fluorescent light bulbs installed, and its windows replaced. Then, given the savings estimated in the validated model, energy efficiency in the unit would be calculated to have increased by 9.3 percent + 1.9 percent + 2.4 percent + 2.7 percent = 16.3 percent.[26] This calculation would generate 16.3 percent/15 percent = 1.087 unit equivalents. Estimates are for all units planned as of the latest reporting in RAMPS, therefore, an estimated 25,076 equivalent units were in the formula grant program.

Green Retrofit Program for Multifamily Housing

An estimate of unit equivalents for GRP is taken from data supplied in the Bright Power/SAHF report referenced previously. According to that report, the average savings per unit was $213 per year and total savings were $3.1 million per year. By implication, 14,554 total units were in the GRP data set.

The Bright Power/SAHF report also indicates that energy savings were 18 percent across the portfolio of properties receiving GRP grants. We utilize this figure to estimate unit equivalents in this program—18/15 x 14,554 = 17,465 unit equivalents.

[26] *We recognize that when multiple ECMs are implemented, the percentage savings that each would achieve on its own may not be strictly additive. Given the broad nature of the estimate in this case, however, simple addition of those percentages is sufficiently accurate.*

TOTAL UNIT EQUIVALENTS

Table 3-4 summarizes the unit equivalent numbers from the foregoing sources.

Table 3-4. Unit Equivalents

Program	Unit Equivalents
Competitive grant, Category 4, Option 1	2,504
Competitive grant, Category 4, Option 2	56,997
Formula grant	25,076
Green Retrofit Program for Multifamily Housing	17,465
Total unit equivalents	102,042

COMPARISON OF THE UNIT EQUIVALENT ESTIMATE WITH THE YEAR-ONE INTERIM EVALUATION REPORT ESTIMATE

The year-one interim evaluation report estimated 102,342 unit equivalents. That number did not include unit equivalents among the GRP grantees, and it excluded savings yet to be achieved from formula or competitive retrofits not yet completed. On the other hand, estimates of savings from individual ECMs were taken from the preliminary ESM, and several of these estimates were reduced in the validated model. On balance, these factors approximately cancel out, so that the number of unit equivalents is not much changed from the earlier estimate.

WATER SAVINGS

The Green and Energy Retrofit Assessment (GERA) project was not tasked with estimating water savings, and little data were available with which to do so. Water savings, however, have become an important national objective and were a component of the ARRA-supported HUD investment program. Further, in the year-one interim evaluation report, an estimate was made based on the preliminary savings model. The Bright Power/SAHF report provides a rough estimate for GRP, and some UEL water savings data were made available for the competitive grants program. To obtain a number for the formula grants program, it was assumed that all ECMs that were planned for those units were carried out. From these sources and assumptions, a very rough estimate of total water savings in public housing from ARRA-funded measures could be made. The separate components and the total savings are shown in table 3-5.

Table 3-5. Water Savings

Program	Savings (ccf)
Competitive grant	296,193
Formula grant	687,575
Green Retrofit Program for Multifamily Housing	188,502
Total water savings[a]	1,172,270

ccf =hundred cubic feet.

[a] *According to the Environmental Protection Agency, a U.S. family on average uses between 300 and 400 gallons of water per day. A ccf contains 748 gallons. If we assume 350 gallons per family per day over 365 days, the amount of water saved by the U.S. Department of Housing and Urban Development's green retrofits would supply 7,000 U.S. families for a year.*

Comparison of the Water Savings Estimate With the Year-One Interim Evaluation Report Estimate

In the year-one interim evaluation report, estimated water savings were 591,000 hundred cubic feet, but that estimate was based on early RAMPS data and excluded units in which retrofits had not yet been completed. Also, it did not include estimates from GRP. Although the estimate is inexact, it still represents a more complete accounting of water savings from ARRA-funded grants than provided in the year-one interim evaluation report.

ENVIRONMENTAL IMPROVEMENTS

Reductions in kilowatt-hours consumed translate into various emission reductions. Table 3-6 shows estimated reductions in carbon dioxide, sulfur dioxide, and nitrogen oxide from the energy retrofit programs examined. The numbers are rounded to the nearest thousand.

Table 3-6. Annual Emission Reductions

Greenhouse Gases	Annual Reduction (pounds/year)
Carbon dioxide	384,600,000
Sulfur dioxide	1,431,000
Nitrogen oxide	481,000

The carbon dioxide reduction translates to about 175,000 metric tons (2,200 pounds per metric ton). According to the Environmental Protection Agency, the average U.S. passenger vehicle emits about 4.7 metric tons of carbon dioxide per year.[27] Thus, the estimated reduction in carbon dioxide from HUD's housing retrofit program is sufficient to offset average annual emissions from about 37,400 U.S. automobiles per year.

HUD's ARRA-funded energy-efficiency retrofit program may have resulted in other environmental benefits; for example, cleaner, better-quality indoor air and reductions in pollution involving noncriteria pollutants. These benefits were not measured within the GERA project, however, and, hence, are not discussed further in this report.

[27] *https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle-0.*

CHAPTER 4

SITE VISITS

The assessment team carried out a set of 20 visits to individual sites at which HUD had invested American Recovery and Reinvestment Act (ARRA) funds.[28] These visits were an important component of the review project, as they were aimed at gaining insights into what was done, how well it was done, and what results were achieved. Within HUD, the decision was made that all 20 sites would be chosen from the competitive grant program. The assessment team then made efforts to include sites of differing sizes, climate zones, and Energy Conservation Measures (ECMs). The site visit process was as follows.

- Communicate with the public housing authority (PHA) for each property selected for site inspection.
- Interview PHA management and/or maintenance staff most familiar with the ARRA retrofits.
- Collect and review available documentation relative to energy retrofits, including construction documents, engineering information, installer-contractor information, manufacturer product data, operations and maintenance manuals, commissioning documents, receipts, preretrofit and postretrofit energy (utility) consumption data, and preretrofit and postretrofit energy audit reports (as applicable).
- Inspect the subject properties using a Building Performance Institute Building Analyst, the inspection to include access to representative resident units (10 percent interior unit inspections) and to all common areas, mechanical spaces, rooftops, and exterior facades.
- Review to eliminate ECMs or Water Conservation Measures (WCMs) that may have been installed at the same time as ARRA-funded retrofit installations, thus requiring normalization of energy reduction calculations.
- Analyze preretrofit and postretrofit consumption data to include weather normalization.
- Prepare individual site reports, inclusive of photos and exhibits, which detail the results of the onsite physical evaluations, and prepare a final summary findings report.

PROPERTIES VISITED

Table 4-1 shows the properties included in the 20 site visits. All properties except one are Category 4 Option 2, and they are spread throughout the United States.

Table 4-1. Properties Selected for Site Visits

PHA Name	PHA Code	Project Name and Location	No. of Units	Grant Type	Property Type	HVAC Utility	DHW Utility
H.C. Anne Arundel County	MD018	Pinewood Village 7900 Benesch Circle Glen Burnie, MD 21060	95	Option 2	Midrise	Gas	Gas
Harrisburg H.A.	PA008	W. Howard Day Homes 1300 Community Drive Harrisburg, PA 17103	218	Option 2	Townhouse	Gas	Gas

(continued)

AMP = Asset Management Project. DHW = domestic hot water. H.A. = Housing Authority. H.C. = Housing Commission. HVAC = heating, ventilation, and air-conditioning

[28] *The comprehensive site visit report submitted to HUD as part of GERA accompanies this study as appendix E.*

Table 4-1. Properties Selected for Site Visits *(continued)*

PHA Name	PHA Code	Project Name and Location	No. of Units	Grant Type	Property Type	HVAC Utility	DHW Utility
Morganton H.A.	NC049	Providence Place 644 1st Street Morganton, NC 28655	150	Option 2	Duplex	Electric	Electric
Chicago H.A.	IL002	Ralph J. Pomeroy Apartments 5850 N. Kenmore Avenue Chicago, Illinois 60660	105	Option 1	Highrise	Gas	Gas
H.A. of Baltimore City	MD002	Brooklyn Homes 4140 10th Street Baltimore, MD 21218	486	Option 2	Townhouse	Gas	Gas
H.A. of the City of Augusta	GA001	Oak Pointe Apartments 703 East Boundary August, GA 30901	250	Option 2	Duplex	Gas	Gas
H.A. City of Columbus	GA004	EJ Knight (Newton D. Baker Village) 3610 Youman Street Columbus, GA 31903	40	Option 2	Duplex	Gas	Gas
New Bedford H.A.	MA007	Westlawn 197 Liberty Street New Bedford, MA 02740	200	Option 2	Townhouse	Electric	Electric
Charlotte H.A.	NC003	Charlottetown 1000 Baxter Street Charlotte, NC 28204	161	Option 2	Highrise	Electric	Electric
Cuyahoga Metro H.A.	OH003	King Kennedy 2501 East 59th Street Cleveland, OH 44104	186	Option 2	Midrise	Gas	Gas
H.A. of Charleston	SC001	Parkdale Townhomes 2360 Applebee Way Charleston, SC 29414	16	Option 2	Townhouse	Electric	Electric
H.A. of the City of Austin	TX001	North Loop 2300 West North Loop Blvd Austin, TX 78756	130	Option 2	Midrise	Gas	Gas
King County H.A.	WA002	Boulevard Manor 12039 Roseberg Avenue South Burien, WA 98168	70	Option 2	Midrise	Electric	Electric
H.A. City of Little Rock	AR004	Powell Towers 1010 Wolfe Street Little Rock, AR 72202	169	Option 2	Highrise	Gas	Gas
H.A. of Covington	KY002	City Heights 2500 Todd Court Covington, KY 41011	366	Option 2	Garden	Gas	Gas
Hamtramck H.C.	MI004	Colonel Hamtramck Homes 12025 Dequindre Street Hamtramck, MI 48212	300	Option 2	Townhouse	Gas	Gas
H.A. of Wichita Falls	TX022	Wichita Falls Apts (AMP 4) 501 Webster Street Wichita Falls, TX 76306	122	Option 2	Townhouse	Gas to Electric	Gas to Electric

(continued)

AMP = Asset Management Project. DHW = domestic hot water. H.A. = Housing Authority. H.C. = Housing Commission. HVAC = heating, ventilation, and air-conditioning

Table 4-1. Properties Selected for Site Visits *(continued)*

PHA Name	PHA Code	Project Name and Location	No. of Units	Grant Type	Property Type	HVAC Utility	DHW Utility
H.A. City of Deerfield Beach	FL081	Palms at Deerfield 425 NW 1st Terrace Deerfield Beach, FL 33441	100	Option 2	Midrise	Electric	Electric
H.A. of the City of Jennings	LA118	Bangle Drive Apts (Unnamed) 300 Bangle Drive Jennings, LA 70546	12	Option 2	Duplex	Gas	Gas
East Tawas H.C.	MI102	Bay Park Tower 304 West Bay Street East Tawas, MI 48730	41	Option 2	Midrise	Gas	Gas

AMP = Asset Management Project. DHW = domestic hot water. H.A. = Housing Authority. H.C. = Housing Commission. HVAC = heating, ventilation, and air-conditioning.

ENERGY SAVINGS RESULTS

In analyzing energy savings, the preretrofit and postretrofit utility data obtained from each of the sites was key. Although sites were required to maintain such data, some did not. In all, complete preretrofit and postretrofit utility data were available for only 12 of the 20 sites, so that adjustments such as interpolation were necessary to conduct the analysis. Some sites, however, were able to provide preretrofit and postretrofit water utility consumption data in addition to energy consumption data, and these data were used in calculating savings at each of the 20 locations.

In about one-half of the cases, energy audits were available (because they were required to be kept by competitive grantees), but only one of these audits qualified as American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Level II. The audits nonetheless helped to indicate the scope of the retrofits undertaken.

Raw savings amounts were normalized for weather and for other monies spent on energy projects by the PHAs at the same time as the ARRA-funded projects were being carried out. At 12 of the 20 sites visited, other such monies were involved. Table 4-2 provides normalized results for all 20 site visit properties. The table indicates that savings reached as high as $818 per unit per year, achieved at Ralph J. Pomeroy Apartments, which were nearly 50 percent of annual utility costs. In two other cases, savings of nearly 40 percent were achieved, and, in three others, savings of about 30 percent were achieved. Significant utility savings clearly were achieved at many of the 20 sites.

Table 4-2. Energy and Water Savings Results at the 20 Sites

Project Name	Cost per Gallon ($)	Estimated Annual Water Savings ($)	Cost per kWh ($)	Estimated Annual Electric Savings ($)	Cost per Therm ($)	Estimated Annual Gas Savings ($)	Estimated Annual Total Savings ($)	Annual Expense/ Unit Reduction ($)	Annual Expense/ Unit Reduction (%)
Pinewood Village	NA	NA	0.15	(24,761)[a]	1.22	11,225	(13,536)[a]	NA	– 9
W. Howard Day Homes	0.0084	(18,531)[a]	0.13	(42,209)[a]	1.16	213,318	152,578	700	38

(continued)

AMP = Asset Management Project. DHW = domestic hot water. H.A. = Housing Authority. H.C. = Housing Commission. HVAC = heating, ventilation, and air-conditioning

Table 4-2. Energy and Water Savings Results at the 20 Sites *(continued)*

Project Name	Cost per Gallon ($)	Estimated Annual Water Savings ($)	Cost per kWh ($)	Estimated Annual Electric Savings ($)	Cost per Therm ($)	Estimated Annual Gas Savings ($)	Estimated Annual Total Savings ($)	Annual Expense/ Unit Reduction ($)	Annual Expense/ Unit Reduction (%)
Providence Place	NA	NA	0.10	54,905	NA	NA	54,905	366	30
Ralph J. Pomeroy Apartments	NA	NA	0.11	46,654	0.83	39,206	85,860[b]	818	49
Brooklyn Homes	0.0084	187,622	0.15	86,241	1.16	111,374	385,237	793	26
Oak Pointe Apartments	NA	NA	0.10	990	1.47	11,749	12,739[b]	51	8
EJ Knight (Newton Baker Village Gardens)	0.0084	2,904	0.10	6,612	1.47	10,700	20,216	505	39
Westlawn	NA	NA	0.15	17,938	NA	NA	17,938	90	11
Charlottetown Terrace	0.0084	17,841	0.10	40,993	NA	NA	58,834	365	25
King Kennedy	NA	NA	NA	NA	0.99	17,074	17,074[b]	92	17
Parkdale Townhomes	NA	NA	0.10	393	NA	NA	393[b]	25	2
North Loop	NA	NA	0.12	36,476	1.06	3,281	39,757	306	18
Boulevard Manor	0.0084	2,241	0.08	5,838	NA	NA	8,079	115	16
Powell Towers	0.0084	21,675	0.09	(15,614)[a]	1.05	7,870	13,931	82	5
City Heights	NA	NA	NA	NA	1.02	39,078	39,078	107	13
Colonel Hamtramck Homes	NA	NA	0.11	98,709	1.62	5,109	103,818	346	32
Wichita Falls Apartments (AMP 4)	0.0084	27,211	0.12	(38,541)[a]	1.02	52,424	41,093	337	16
Palms at Deerfield	NA	NA	0.11	2,244	NA	NA	2,244[b]	22	9
Bangle Drive Apartments (Unnamed)	0.0084	76	0.09	836	1.05	2,109	3,021	252	28
Bay Park Tower	NA	NA	0.13	2,814.66	1.09	1,803.74	4,618.40	113	8

kWh = kilowatt-hour. NA = not applicable.

[a] *Numbers in parentheses represent increases in consumption.*

[b] *Data gaps that imply underestimates of actual savings.*

The results indicate that all but one site experienced energy savings. The exception occurred as a result of adding heat pumps that cost more in electricity than the savings from reduced use of natural gas. The heat pumps, however, presumably provided added comfort to residents. Annual utility expenses elsewhere were reduced by up to $818 per unit per year. On average, each unit at the 20 sites saved $288 on utilities per year. Further, the savings numbers likely understate actual savings because not all Asset Management Projects involved in the site visits were able to provide preretrofit and postretrofit water consumption data.

PAYBACK ANALYSIS

Payback analysis requires matching utility savings with the incremental costs of energy-efficient equipment (green upgrade) relative to code minimum equipment (traditional replacement). Due to data limitations, however, the calculation of simple paybacks could not be done at some of the sites. These data limitations included—

- Inconsistent preretrofit and postretrofit energy consumption data.
- The absence of an ASHRAE Level II energy audit.
- Incomplete data regarding preretrofit systems, including their energy consumption and remaining useful life.
- Inadequate retrofit construction cost segregation, especially in instances of non-ECM construction work.

To overcome the problem of a lack of segregated cost data, the green incremental cost increase at each property was inferred by using values derived during an earlier component of the Green and Energy Retrofit Assessment (GERA) study, namely the Catalog of Cost-Effective Energy Conservation Measures (appendix G). Based on the ECMs installed at each property and the green percentage cost increase taken from that catalog, the imputed incremental cost of the PHA green investments was determined.

Within the sample set of 20 properties, the retrofit construction at each was reviewed to determine if only ECMs and WCMs were implemented or whether these properties also included nongreen upgrades, such as civil engineering work, building reconfiguration, gut rehabilitation, and replacement of interior finishes. Those properties where only ECMs and WCMs were addressed during the retrofit, and where sufficient preretrofit and postretrofit utility data were supplied, were further isolated to derive simple payback calculations. As presented in table 4-3, simple payback consists of the incremental cost of the upgrades divided by annual utility savings.

Table 4-3. Simple Payback Calculations

Project Name	Total Retrofit Amount, ARRA+ Leverage ($)	ECM and WCM Incremental Cost Increase (%)	ECM and WCM Incremental Cost Increase ($)	Adjusted Annual Utility Savings ($)	Payback (Incremental/ Savings) in Years
Providence Place	702,850	45.9	322,608	54,905	5.9
Brooklyn Homes	5,768,917	33.4	1,928,650	385,237	5.0
Oak Pointe Apartments	245,000	39.2	96,040	12,739	7.5
EJ Knight (Newton D. Baker Village Gardens)	550,000	31.8	175,038	20,216	8.7
City Heights	240,500	39.2	94,276	39,078	2.4
Wichita Falls Apartments (AMP 4)	322,076	33.0	106,178	41,093	2.6
Bay Park Tower	205,000	31.2	63,892	4,618	13.8

AMP = Asset Management Project. ARRA = American Recovery and Reinvestment Act. ECM = Energy Conservation Measure. WCM = Water Conservation Measure.

The table breaks out the amount funded by moderate rehabilitation competitive grants from the total funds expended on the seven projects listed. Utility savings are adjusted as well. According to the table, three of the seven projects had paybacks of 5 years or less, another three had paybacks of 5 to 10 years, and one had a payback of nearly 14 years. Taken as a group, these paybacks show relatively attractive returns to HUD's energy and water efficiency projects at these properties.

CONCLUSIONS DRAWN FROM THE SITE VISITS

The following principal conclusions were drawn from the 20 site visits.

- Availability of data and recordkeeping—To draw meaningful conclusions about energy and water savings at HUD public housing sites, these sites must obtain and retain at least a year's worth of preretrofit and postretrofit utility data. In fact, only 60 percent of the sample set (12 of 20) were able to provide data not requiring considerable adjustment and cleaning to be usable. Although the assessment team interpolated data points and made estimates based on analogous properties to analyze all 20 sites, this approach was not preferable.
- Quality of preretrofit studies—Within the 20-property sample set, preretrofit energy audits were provided for only 50 percent and postretrofit energy audits for only 45 percent. Of the provided energy audits, only one (from North Loop) qualified as a preretrofit ASHRAE Level II Energy Audit, which discussed the incremental costs of recommended upgrades and retrofits and which provided simple payback and investment ratios. Others were typically either ASHRAE Level I walkthrough energy audits or Energy Performance Contract energy audits, focused entirely on the systems proposed for retrofit.
- Retrofit planning—Inspected sites exhibited planning ranging from minimal to comprehensive. Many of the sites undertook relatively simple retrofits, replacing energy-using equipment with more efficient versions. In such cases, only a minimal amount of retrofit planning would be expected. Of the assessed properties, however, 60 percent included leveraged funds in addition to the ARRA funds. Of the sample set, 4 properties (Baltimore, Charlotte, Chicago, and Hamtramck) had obtained significant leveraged funds to augment the ARRA retrofits. In these cases, substantial advanced planning was involved in the retrofit process.
- Quality of installation—Overall, the quality of installation was judged good to excellent at all 20 properties; however, the sites were found to have (a) instances of code-minimum energy-efficiency equipment being installed instead of best available efficiency; (b) deviations from the ARRA grant proposal language; and (c) installation of non-ECM or non-WCM items, such as interior finishes, accessibility improvements, and electrical infrastructure.
- Financial metrics—Simple paybacks are difficult to provide for the sample set based on information provided during the assessment, most notably a lack of segregated costs by ECM type. In the absence of segregated construction costs and incremental green upgrade costs, however, green increment cost percentages derived under an earlier part of the GERA study were applied to build an imputed incremental cost for each PHA investment. This approach provided a conservative incremental cost, which in select scenarios could be used to derive simple payback. The average annual utility cost reduction per unit within the sample set of properties also was calculated and came to $288 per unit per year.
- Value proposition—Not all benefits from the ARRA-funded retrofits involve energy savings. For example, many of these properties used ARRA funds to meet the immediate capital needs of their properties, preserving public housing stock or transforming substandard or even vacant housing into viable living communities. The investments also generated construction-related jobs and income, with multiplier effects in nearby communities, at a time of high unemployment. Finally, many of these properties recapitalized building components and systems which placed them on a more stable footing to seek conversion of Section 9 to Section 8 under HUD's Rental Assistance Demonstration, a program to expand sources of financing for the improvement of certain public housing properties.

CHAPTER 5

CASE STUDIES

The assessment of HUD's American Recovery and Reinvestment Act (ARRA)-funded energy-efficiency and green investment program included seven case studies from among the 20 sites that were visited. The purpose of the case studies was to go into greater depth concerning what was done and what lessons were learned from individual ARRA-funded energy-efficiency projects at Asset Management Projects around the country. The cases were selected subjectively based on where data and personnel were available and where the site inspection revealed positive lessons learned by the public housing authorities (PHAs). These studies were compiled into seven reports, one covering each case study, which are included in appendix F.

The seven case studies are summarized in the following sections. In six of the seven, the grant applied to a moderate rehabilitation project, and in one (Ralph J. Pomeroy Apartments) the grant was for substantial reconstruction. Each case (listed alphabetically by property name) presents lessons learned by the local PHA and conclusions drawn from the site review.

BANGLE DRIVE: JENNINGS, LOUISIANA

Bangle Drive is a 40-unit, duplex-style project housing an elderly population in Jennings, Louisiana, just off Interstate 10 between the cities of Lake Charles and Lafayette. Only 6 of the 20 buildings (12 of the 40 units) were included in the retrofit due to the limited funding available.

Table 5-1. Bangle Drive Project Profile

Characteristic	Site Details
Public housing authority	Housing Authority of the City of Jennings (JHA)
ARRA investment	$498,000 moderate rehabilitation grant
Per unit	$41,500
Retrofit installation period	6 months from 7/2010 to 1/2011
Number of units	12 retrofitted (40 total)
Unit configuration	All one bedroom
Year units constructed	1982
Building type	Six one-story duplex buildings retrofitted
Occupancy	Elderly
Payment of utilities	Gas and electricity by resident; water by owner

ARRA = American Recovery and Reinvestment Act.

The following retrofit investments were made at the Bangle Drive property.

- Heating, ventilation, and air-conditioning (HVAC) upgrade.
- Low flow toilets and faucets.
- Energy-efficient windows.
- Interior lighting fixtures.

- Insulation.
- Energy-efficient doors.
- Refrigerators.
- ENERGY STAR exhaust fans.
- Tankless water heaters.
- Energy-efficient storm doors.

Energy, Water, and Money Savings From the Retrofits

Savings data for all the case study retrofits reviewed in this chapter are contained in chapter 4, table 4-2. They are summarized for each in this chapter. All results have been normalized for weather.

Bangle Drive savings—

Electricity:	9,291 kilowatt-hours per year (13.1 percent).
Natural gas:	2009 therms per year (49.3 percent).
Water:	9,049,000 gallons per year (34.7 percent).
Utility savings per unit retrofitted:	$252 per year.

PHA Assessment of Lessons Learned

- If the overall budget can cover the increased upfront cost of tankless water heaters, they have a reasonable payback period.
- Double pane windows work very well but are expensive. If these windows are purchased, investment should be made in security screens to protect the windows.
- It is difficult to obtain adequate energy consumption data on resident-paid utilities. If possible, obtain the data directly from the utility company.
- To avoid substandard work, hire an architect and a general contractor who have experience with energy-efficient retrofits.
- It may be necessary to relocate the residents during the rehabilitation. The most straightforward way to cover residents' out-of-pocket moving expenses is to offer them a lump sum payment.

Conclusions From the Bangle Drive Case Study

- The Housing Authority of the City of Jennings (JHA) was positioned to benefit from ARRA grant funding as they were developing a building rehabilitation program with the architect at the time. Some of the retrofit components exceeded what the PHA would have been able to complete within its own capital budget.
- The utility savings for individual residents have been substantial and provide justification to upgrade the balance of the Bangle Drive buildings.
- The execution of this project by a smaller-capacity PHA was exceptional. JHA engaged in a detailed and extensive retrofit planning process with all parties, kept residents apprised throughout the planning and installation processes, and maintained strong project management oversight.

BOULEVARD MANOR: BURIEN, WASHINGTON

Boulevard Manor is a four-story, 70-unit project housing an elderly and disabled population in Burien, Washington, a suburb of the city of Seattle.

Table 5-2. Boulevard Manor Project Profile

Characteristic	Site Details
Public housing authority	King County Housing Authority (KCHA)
ARRA investment	$1,467,312 moderate rehabilitation grant
Per unit	$20,962
Other funding	Moving to Work: $777,516 Central Office Cost Center: $117,923 DOE ARRA SERC: $414,613 Seattle City Light (utility): $143,638 Total project investment: $2,921,020
Retrofit installation period	15 months from 2/2011 to 5/2012
Number of units	70
Unit configuration	All one bedroom
Year units constructed	1969
Building type	One four-story elevator building
Occupancy	Elderly/disabled
Payment of utilities	Electricity by resident; water by owner

ARRA = American Recovery and Reinvestment Act. DOE = U.S. Department of Energy. SERC = Sustainable Energy Resources for Consumers.

The following retrofits were installed at this property.

- HVAC upgrade.
- Low-flow toilets and faucets.
- Energy-efficient windows.
- Insulation.
- Exterior lighting fixtures.
- Building envelope.
- Bathroom exhaust fans.

Energy, Water, and Money Savings From the Retrofits

Boulevard Manor savings—

Electricity: 126,387 kilowatt-hours per year (27.2 percent).
Natural gas: (not applicable).
Water: 267,784 gallons per year (16.4 percent).

Utility savings per unit retrofitted: $115 per year.

PHA Assessment of Lessons Learned

- Careful preplanning of retrofit projects tends to result in well-executed projects. Therefore, one of the most important stages in the retrofit is the planning stage. Ample time should be devoted to developing a plan, including time going through the TREAT (building energy software) model (or some other) to select the best scope of work. The planning process involves running different scenarios and considering many alternatives. For Boulevard Manor, the planning stage took 9 months.
- A PHA with an asset management staff can offer substantial assistance to retrofit projects. Such staff should be engaged during the planning stage, specifically by asking them to describe and justify improvements they think the project needs.
- Tried and true approaches to retrofits, in general, are superior to untried. Therefore, for sustainable HVAC and energy components, use what is known to work. Do not overexperiment.
- Outside consultants can offer excellent knowledge and expertise. Inhouse experts, however, tend to know the residents and the PHA, and so may provide even better service if they are sufficiently knowledgeable about the investments in question.

Conclusions From the Boulevard Manor Case Study

- The ARRA grant funding provided the King County Housing Authority (KCHA) with an opportunity to undertake a necessary facelift to its 40-year-old building at Boulevard Manor. Adding air-conditioning, even in the Pacific Northwest, will lead to increased utility usage and must be viewed in the context of resident comfort. Even with that, the KCHA staff expressed satisfaction with the utility savings achieved to date and they see potential for greater savings as more resident training is completed.
- The PHA's execution of this project was exceptional. KCHA engaged in a detailed and extensive retrofit planning process with its staff and contractors and maintained excellent project management oversight.

BROOKLYN HOMES: BALTIMORE, MARYLAND

Brooklyn Homes consists of 486 units in 80 two-story buildings housing a multifamily population in downtown Baltimore, Maryland.

Table 5-3. Brooklyn Homes Project Profile

Characteristic	Site Details
Public housing authority	Housing of Baltimore City (HABC)
ARRA investment	$2,602,023 moderate rehabilitation grant
Per unit	$5,354
Other funding	Energy Performance Contract: $2,082,066 Weatherization program grant: $1,084,828 Total project investment: $5,768,917
Retrofit installation period	35 months from 7/2009 to 6/2012
Number of units	486
Unit configuration	44 one-bedroom, 304 two-bedroom, 138 three-bedroom units
Year units constructed	1942

(continued)

ARRA = American Recovery and Reinvestment Act.

Table 5-3. Brooklyn Homes Project Profile *(continued)*

Characteristic	Site Details
Building type	One 11-story elevator building
Occupancy	Multifamily
Payment of utilities	Electricity, gas, and water by owner

The following retrofits were installed at the Brooklyn Homes property.

- HVAC upgrade.
- Programmable thermostats.
- ENERGY STAR appliances.
- Low flow toilets and faucets.
- Energy-efficient windows.
- Domestic water heaters.

Energy, Water, and Money Savings From the Retrofits

Brooklyn Homes savings—

Electricity: 574,937 kilowatt-hours per year (15.4 percent).
Natural gas: 96,012 therms per year (23.1 percent).
Water: 22,416,064 gallons per year (43.3 percent).

Utility savings per unit: $793 per year.

PHA Assessment of Lessons Learned

- Residents can remove and replace newly installed compact fluorescent bulbs with incandescent bulbs, so the Housing Authority of Baltimore City (HABC) advises replacing the fixtures also. If the retrofit were being performed today, light-emitting diode (commonly known as LED) lighting probably would be a better choice.
- To obtain consistently high-quality equipment, including appliances, manufacturers should be thoroughly vetted beforehand.
- The use of resident ambassadors as part of a retrofit program structure helps a great deal in encouraging resident buy-in and engagement.
- Residents often need coaching to comply with project requirements. Therefore, hands-on resident education and training sessions should be conducted, particularly if a major change, such as a new billing system, is being implemented.
- To keep residents and other stakeholders properly informed, hold biweekly meetings throughout the retrofit process.
- To increase the chances that a retrofit project will go smoothly, it is usually best to use known and trusted contractors.
- It is more work, but in the end it is more cost effective to perform the general contracting role in house.
- To make sure that the information being given is unbiased, it is best to review Energy Performance Contract (EPC)-estimated utility savings with an independent third party contractor.

Conclusions From the Brooklyn Homes Case Study

- HABC was in an ideal position when the ARRA grant funding became available. They were already in the process of assessing Energy Conservation Measures (ECMs) and Water Conservation Measures at five of their oldest sites that were most in need of repair (including Brooklyn Homes).
- The ARRA grant allowed for HABC to reduce the long-term obligation that would have to be repaid, thereby reducing the strain on future operating budgets.
- HABC completed submetering of electric, gas, and water with a substantial portion of the funds, enabling them to bill residents for excessive consumption. This use of funds was unique among the projects inspected. The retrofit modernized this 67-year-old project and significantly reduced operating expenses, putting it on a more solid financial foundation for the future.
- The execution of this project by a large-capacity PHA was exceptional. HABC engaged in a detailed and extensive retrofit planning process with all parties, kept residents apprised throughout the planning and installation processes, completed the unique retrofit of resident submetering, and maintained good project management oversight throughout. This retrofit also stands out as one that was part of a much larger five-site retrofit undertaken simultaneously by the PHA.

CHARLOTTETOWN TERRACE: CHARLOTTE, NORTH CAROLINA

Charlottetown Terrace is an 11-story, 161-unit project housing an elderly and disabled population in downtown Charlotte, North Carolina.

Table 5-4. Charlottetown Terrace Project Profile

Characteristic	Site Details
Public housing authority	Charlotte Housing Authority (CHHA)
ARRA investment	$6,200,000 moderate rehabilitation grant
Per unit	$38,509
Other funding	Moving to Work loan: $5,200,000 CHHA land sales proceeds: $460,000 Charlotte Housing Trust Fund: $1,000,000 Total project investment: $12,860,000
Retrofit installation period	13 months from 10/2010 to 11/2011
Number of units	161
Unit configuration	129 studio, 31 one-bedroom, 1 two-bedroom units
Year units constructed	1977
Building type	One 11-story elevator building
Occupancy	Elderly/disabled
Payment of utilities	Electricity, gas, and water by owner

ARRA = American Recovery and Reinvestment Act.

The following retrofits were installed at the Charlottetown Terrace property.

- HVAC upgrade.
- ENERGY STAR appliances.
- Low flow toilets and faucets.
- Energy management system.
- Energy-efficient windows.
- Interior lighting fixtures.
- Exterior lighting fixtures.

Energy, Water, and Money Savings From the Retrofits

Charlottetown Terrace savings—

Electricity:	(106,785) kilowatt-hours per year (-5.4 percent).
Natural gas:	516,719 therms per year (25.9 percent).
Water:	2,131,495 gallons per year (49.1 percent).
Utility savings per unit:	$365 per year.

PHA Assessment of Lessons Learned

- Sustainable rehabilitation of this scale (nearly $80,000 per unit) can be cost effective. Given code updates and increasingly widespread behavioral changes, such pursuit is increasingly economically viable.
- To achieve truly substantial energy savings, consider LEED standards and get a LEED consultant on board early.
- Ongoing training of both residents and maintenance staff contributes to protecting the investment and to meeting the PHA's energy savings goals.
- To head off resistance, it is useful to engage residents to be ambassadors for the retrofit program during training, especially for compliance with new policies like a smoking prohibition.
- To encourage buy-in, get residents involved early on and keep them involved through the life of the retrofit.
- Understand the resident population, what they want, and how they will use any new space.
- Coordination between the PHA development staff and the property or asset management staff during the design phase is critical for smooth operation after the retrofit is completed.
- Purchase costly new equipment early to avoid unanticipated price increases.
- The PHA has to commit to a Section 3 hiring effort, and the construction team must be aware of it. The Charlotte Housing Authority (CHHA) has a designated staff person for Section 3 hiring, and as a result 68 percent of new hires were Section 3.
    - Relocation is traumatic for residents and therefore it is helpful to—
    - Assess mental and physical capacity of residents before moving them, so as to provide support as needed.
    - Hire professional moving contractors with good references to lessen the burden.
    - Follow up and contact the residents often while they are away from home.

    - Follow up and contact them when they are back at home.
    - Recognize that residents want to return to same units, but the PHA cannot always deliver. Therefore, do not guarantee that residents can return to the same unit.
    - Ensure the relocation unit is bedbug free; new units must also be bedbug free.
    - Incorporate inspections and treatments into the project schedule, as they are time consuming.
- To assure a smooth project process, communication across all disciplines is critical. This communication should occur before planning, during planning, during construction, and after construction.
    - The opportunity to provide input at the point when the development team can make changes is critical.
    - If communication is consistently maintained, stakeholders likely will develop an ownership mentality and will care about the outcome.
    - Communication can be enhanced by putting together a residents handbook and using it to educate residents.

Conclusions From the Charlottetown Terrace Case Study

- CHHA used the availability of the ARRA grant to double the size of a major retrofit that was in the planning and design phases. They were able to address the substantial needs of a 33-year-old building and did so in such an energy-efficient, sustainable, and environmentally friendly way as to achieve LEED Gold certification.
- The result is a showcase property where water usage has dropped in half and electricity usage is down nearly one-fourth. Annual expense savings of $365.43 per unit are substantial and set the project on a firm financial footing for the future.
- The execution of this project by a PHA that engaged in a LEED Gold certification retrofit was exceptional. CHHA kept residents apprised throughout the planning and installation processes and took much care in its resident relocation plans.

NORTH LOOP: AUSTIN, TEXAS

North Loop is a five-story, 130-unit project housing an elderly and disabled population in downtown Austin, Texas.

Table 5-5. North Loop Project Profile

Characteristic	Site Details
Public housing authority	Housing Authority of the City of Austin (HACA)
ARRA investment	$3,364,680 moderate rehabilitation grant
Per unit	$25,882
Retrofit installation period	21 months from 8/2010 to 5/2012
Number of units	130
Unit configuration	122 one-bedroom, 8 two-bedroom units
Year units constructed	1975
Building type	One five-story elevator building
Occupancy	Elderly/disabled
Payment of utilities	Electricity, gas, and water by owner

ARRA = American Recovery and Reinvestment Act.

The following retrofits were performed at North Loop.

- HVAC upgrade.
- ENERGY STAR appliances.
- Photovoltaic (PV) panels.
- Energy-efficient windows.
- Interior lighting fixtures.
- Solar thermal hot water.
- Domestic water heaters.

Energy, Water, and Money Savings From the Retrofits

North Loop savings—

Electricity:	303,964 kilowatt-hours per year (19.3 percent).
Natural gas:	3,095 therms per year (10.5 percent).
Water:	(not applicable).
Utility savings per unit:	$306 per year.

PHA Assessment of Lessons Learned

- In putting together a project budget, make sure that rebate programs with local utility companies are fully understood and incorporated.
- Consider specific ECMs in light of the resident population; for example, occupancy sensors may be inappropriate for elderly and disabled populations.
- To avoid undue risk, sign a maintenance contract for the initial years of a new, unique mechanical system's life.
- Maximize the grant funds and the capital funds available to the project by selecting capital repair items that could easily be replaced with green, energy-efficient components.
- Make the replacements that will make the most significant reduction to utility usage; traditional HVAC upgrades may accomplish more and be more cost effective than a new technology, such as a solar PV system.
- Engage the residents and the maintenance team during the planning stage to ensure that the retrofits are practical and are desired.
- To assure a smooth project process, work with the existing resident council assuming one exists. If not, recommend that the residents form one to assist the PHA with decisionmaking and onsite communications.
- Residents need repeated, hands-on training in how to use new in-unit technology. Followup, not merely a one-time education, is therefore needed.

Conclusions From the North Loop Case Study

- The ARRA grant funding provided the Housing Authority of the City of Austin (HACA) with an opportunity to make necessary capital improvements and to fulfill an Authority desire to install a PV panel system to provide electricity and another panel system to provide hot water. Although the electrical system is providing savings, but HACA staff generally recommends not pursuing the PV panels for electricity. This recommendation is based partly on performance; the PV panels have not carried the electrical load projected and apparently are more affected by Austin's cloudy days than was anticipated.
- HACA staff also stated a preference for using funds to generate savings for residents rather than investing in improvements that would serve mainly to reduce the PHA's operating costs. Another PHA might perceive the situation differently given their organizational directives and opportunities concerning individual projects.
- The PHA's experiences in the challenging retrofit planning process, the individual resident notifications (rather than the more common meetings of all residents), and the ways in which the PHA added to resident comfort and property features in adding the solar PV panels were all noteworthy.

RALPH J. POMEROY APARTMENTS: CHICAGO, ILLINOIS

The Ralph J. Pomeroy Apartments (hereafter, Pomeroy Apartments) is a nine-story, 105-unit project housing an elderly and disabled population in uptown Chicago, Illinois.

Table 5-6. Ralph J. Pomeroy Apartments Project Profile

Characteristic	Site Details
Public housing authority	Chicago Housing Authority (CHA)
ARRA investment	$18,301,170 substantial rehabilitation grant
Per unit	$174,296
Other funding	LIHTC equity: $11,408,236 Energy Investment Tax Credit equity: $83,313 CHA seller financing: $6,300,000 CHA seller financing accrued interest: $368,794 DCEO Energy Efficient Affordable Housing Construction grant: $397,142 Total project investment: $36,858,655 (after bond redemption: $33,437,850)
Retrofit installation period	15 months from 7/2010 to 10/2011
Number of units	105
Unit configuration	All one bedroom
Year units constructed	1923
Building type	One nine-story elevator building
Occupancy	Elderly and disabled
Payment of utilities	Electricity by owner and residents; gas and water by owner

ARRA = American Recovery and Reinvestment Act. DCEO = Illinois Department of Commerce and Economic Opportunity. LIHTC = low-income housing tax credit.

The following retrofits were performed at the Pomeroy Apartments.

- HVAC upgrade.
- Programmable thermostats.
- ENERGY STAR appliances.
- Low-flow toilets and faucets.
- PV panels.
- Energy management system.
- Energy-efficient windows.
- Indoor lighting fixtures.
- Insulation.
- Solar thermal hot water.
- Domestic water heaters.
- Exterior lighting fixtures.
- Roof.
- Stormwater management.
- Geothermal system.

Energy, Water, and Money Savings From the Retrofits

Pomeroy Apartments savings—

Electricity:	424,130 kilowatt-hours per year (42.0 percent).
Natural gas:	47,236 therms per year (62.6 percent).
Water:	(insufficient data to estimate).
Utility savings per unit:	$818 per year.

PHA Assessment of Lessons Learned

- In a significant rehabilitation project, one contract for demolition and a separate one for rebuilding enables an owner to anticipate all building needs and any potential change orders.
- To be sure a wide range of options are considered, do not limit the project at the outset in terms of what might be achievable. Put everything, including the newest technology, on a wish list.
- If this project is any indication, a master temperature control system can contribute immensely to payback.
- In a region with extensive heating needs, consider a geothermal system. Such systems are expensive but provide energy savings year round. If done at project inception, they can be cost effective.
- LEED provides a helpful guideline in terms of components to consider but may not be economically attractive because of the costs of commissioning, certification, design, and documentation. Instead, it may be more worthwhile to simply employ greening best practices in design and operation, generating the same payback without the third party certification costs.
- To improve acceptability, make a positive case for aspects that might traditionally be considered drawbacks, such as a smoking ban and a lack of parking.

- With the installation of less familiar new technology, consider a warranty and also the accessibility and quality of the service provider. Purchasing an extended warranty may be worthwhile. If possible, execute maintenance contracts to avoid responsibility for equipment that requires special skills to maintain.
- Ensure equipment is correctly sized to the estimated need.

Conclusions From the Pomeroy Apartments Case Study

- The Chicago Housing Authority (CHA) saw the availability of ARRA grant funding as an opportunity to leverage federal funding and reopen an 86-year-old building as a showcase, LEED Platinum-certified building for public housing residents. The ARRA funds leveraged approximately $18.6 million dollars for a final (after bond redemption) project cost per unit of approximately $320,000. This total supported a complete gut rehabilitation and redevelopment as a sustainable, environmentally friendly, energy-efficient building with gas and electric utility costs at half those of comparable properties.
- The execution of this gut rehabilitation by the local PHA was exceptional. CHA engaged in a detailed and extensive retrofit planning process with all the parties, maximized opportunities to reduce operating expenses through energy efficiency and sustainable components, achieved LEED Platinum certification, and maintained overall project management oversight in house.

WESTLAWN: NEW BEDFORD, MASSACHUSETTS

Westlawn consists of 50 two-story apartment buildings containing 200 units of multifamily housing (plus two buildings housing the property management and maintenance offices) in downtown New Bedford in southeastern Massachusetts.

Table 5-7. Westlawn Project Profile

Characteristic	Site Details
Public housing authority	New Bedford Housing Authority (NBHA)
ARRA investment	$986,406 moderate rehabilitation grant
Per unit	$4,932
Retrofit installation period	22 months from 10/2010 to 8/2012
Number of units	200
Unit configuration	12 one-bedroom, 108 two-bedroom, 60 three-bedroom, 20 four-bedroom units
Year units constructed	1954
Building type	50 two-story buildings with apartments (plus two buildings housing property management and maintenance)
Occupancy	Multifamily
Payment of utilities	Electricity, gas, and water by owner

ARRA = American Recovery and Reinvestment Act.

The following retrofits were performed at the Westlawn.

- PV panels.

Energy, Water, and Money Savings From the Retrofits

Westlawn savings—

Electricity:	119,586 kilowatt-hours per year.
Natural gas:	(not applicable).
Water:	(not applicable).
Utility savings per unit:	$90 per year.

PHA Assessment of Lessons Learned

- Solar PV is maintenance free—do it if it is affordable.
- Some solar companies will perform the full design and installation. The New Bedford Housing Authority (NBHA), however, had a professional engineer who could hold the general contractor accountable at each step along the way. This approach led to a very good experience and is probably a superior approach when the requisite skills are on board.
- Establish field check-ins with all project stakeholders at least weekly during construction.

Conclusions From the Westlawn Case Study

- NBHA approached the opportunity for ARRA grant funds with an eye toward where they could have a significant effect on utility savings in future years. With an EPC in place, traditional ECMs would require a sharing of the utility savings and coordination with the EPC provider. Adding an alternative energy source—in this case solar PV panels—was an excellent solution and also provided funds that were otherwise unavailable to generate savings for years to come.
- The execution of this project by a PHA who had to manage the constraints imposed by an existing EPC was exceptional. NBHA engaged in a detailed and extensive retrofit planning process with all the parties, kept residents apprised throughout the planning and installation, took steps to minimize the disruption to their home life, and maintained good project management oversight.

OVERALL LESSONS LEARNED

A number of common themes emerge from the conclusions drawn by the various PHAs cited in the seven case studies completed by the assessment team and summarized in this chapter. These themes include the following.

- Plan a project carefully. HUD's Capital Needs Assessment electronic tool (or CNA-e) can help choose among alternative green building investments. The results from this type of tool are useful for making initial retrofits and also for selecting components for future replacement. Some funding sources may provide their own tool to facilitate the planning process.
- Communicate frequently with stakeholders, especially residents and maintenance staff. Superior communication helps to secure buy-in from affected parties.
- Form a resident council or resident ambassadors with whom to communicate. Keep them fully informed about progress in the project.
- Bear in mind the needs and challenges posed by the type of residents being dealt with. Moving is traumatic for many, particularly elderly or disabled residents, and has to be handled carefully.
- Use known and trusted contractors. If possible, do the general contracting in house, which will save money and provide more control over the process.
- As needed, include resident training regarding new energy saving equipment. This process may have to be ongoing, not merely a one-time occurrence.

CHAPTER 6

ENERGY SAVINGS MODEL AND TOOL

ENERGY SAVINGS MODEL

In Task 2 of this project, the assessment team assembled a preliminary Energy Savings Model (ESM), which it used to provide HUD an estimate of the energy consumption savings achieved through its American Recovery and Reinvestment Act (ARRA)-funded formula and competitive grants programs. In addition, a catalog of top energy savings measures was provided that examined the costs, benefits, and cost effectiveness of each.[29]

As explained in chapter 2, the preliminary ESM was based on conventional estimates of Energy Conservation Measure (ECM) savings published in the open literature, information from the Green Retrofit Program (GRP) for Multifamily Housing, feedback from people who had installed these ECMs in the past, and expert judgment from people who had analyzed the effects of similar measures. In the preliminary ESM, expected savings from a given ECM were the same no matter where in the country it was installed or in what type of housing it was installed. The percentage savings were applied to a base energy consumption estimate based on baseline consumption data from GRP. To reflect different energy consumption values in different climates, the baseline consumption was based on the average consumption in each census region.[30]

At the time, energy savings retrofits funded under ARRA were still getting started or under way, so actual energy consumption data showing preretrofit and postretrofit consumption were not yet available. As these data since have been collected, it has been possible to conduct more sophisticated analyses of the factors that most influence the energy savings from each ECM. Thus, it has been possible to validate the preliminary ESM and, in particular, to isolate weather- and building-specific factors so as to more accurately predict any given ECM's energy-saving potential.

The main purpose of the model validation is to provide HUD with a more accurate estimate of the savings actually achieved through its ARRA-funded investments in energy efficiency. To this end, intensive effort was made to use actual consumption data to the maximum extent possible.

Data Limitations

The original plan was to use consumption data from a statistical sample of all grantees, gathered by survey. After internal consultation, however, HUD determined that most formula grantees, who comprise the vast majority of grantees, would probably not be able to provide consumption data. It was decided to use Utility Expense Level (UEL) data instead, despite various limitations. One limitation is that data are provided for only the meters that are subject to the UEL calculation—in some cases, only for common areas, in others for common areas and select units, and in yet others for the entire property. Another limitation is that misreporting of consumption information is common in the UEL data. To be specific, in many cases, data appear to be reported in incorrect units. Therefore, intensive data cleaning was undertaken, which led to the removal of some observations.

Various measurement errors also affected the model. For example, in some instances, air-conditioners were installed where they had not been used before. Grantees reported these new air-conditioners as "Air Conditioner

[29] *The catalog is included as appendix G.*

[30] *Census region was used as a proxy for climate zone because information was available only on the states in which retrofits took place.*

Replaced with More Efficient Model" in the Recovery Act Management and Performance System (RAMPS). These air-conditioners may well have been more efficient than standard versions, but the data showed an increase in energy consumption, not a decrease, leading to the inference that the air-conditioners had been added to properties rather than replacing less efficient versions. In addition, no information was available on other actions at each property that may have affected energy consumption, such as other retrofits taking place.

Another problem was that the UEL data indicated that installing light-emitting diode (LED) exit lighting achieved very large reductions in utility consumption, though such installation by itself should have shown only small gains. Because only one category for LED lighting was among the ECMs, it is possible that all new LED lighting was categorized in the data as exit lighting, no matter where or how much was done, resulting in the apparent large consumption reductions from LED exit lighting.

Judgment Required

In sum, judgment was required as to whether the validated energy saving estimates or the original estimates in the preliminary ESM were the more accurate. Best estimates were selected based on the following criteria.

- Use the validated results if plausible because they are based on actual UEL data and take account of more factors.
- If uncertain, choose the more conservative number so as not to provide overly optimistic projections of ECM energy savings. Thus, when large differences in projected savings exist between the preliminary ESM and validation models, lean toward the more conservative of the two.
- Use judgment to rule out anomalous findings from the validation model when the findings probably were caused by faulty data.

Main Findings

Given this approach, the major results from validating the preliminary ESM were—

- Electricity.
    - The estimates provided by the preliminary ESM are often somewhat larger than the estimates from the validation model (for example, for installing new heating, ventilation, and air-conditioning equipment). In some cases, however, the estimates from the validated model were the larger of the two.
    - Solar panels show the largest savings and were much larger in the validation model than the preliminary ESM. Most grantees that installed solar panels were competitive grantees, and therefore survey data from competitive grantees were used. These data showed 65 percent electricity savings.
    - Air-conditioning and refrigerators were estimated by the preliminary ESM to provide small savings; however, in the validation model, they showed increases in consumption, most likely due to the installation of units where none had existed before or to the installation of larger units. The example also underlines a point made elsewhere in this report—namely, that services beyond energy savings often are included with the replacement of appliances and other equipment, and the measurement of energy savings can be misleading without accounting for these other services.
- Natural gas.
    - The estimates provided by the preliminary ESM, in general, are larger than the estimates from the validation model for natural gas.

- Boiler temperature controls and replacement heating plants showed the largest gas savings in the validation model.
- Heating plant and boiler replacements showed smaller savings in the validation model than predicted by the preliminary ESM. This finding may be because the savings depend on how efficient the replacements are relative to the old units. An earlier analysis (discussed in chapter 2) also had indicated the preliminary ESM was overpredicting savings from these replacements. The validated savings estimates for these ECMs are the smaller figures the validation model found—9.3 and 0.4 percent, respectively.

Estimates of Individual ECM Energy Savings

Tables 6-1 and 6-2 show best estimates of overall electricity and natural gas consumption savings from each ECM. These numbers are shown in the columns labeled "Validated." For purposes of this analysis, it was assumed that energy consumption is evenly split between electricity and natural gas at public housing properties. This proportionate split was determined through analysis of the validation data, wherein the average split between the two forms of consumption in British thermal unit (or BTU) terms was about 50 percent. Also, comments are offered if the results were different from what might have been expected.

The updated model was used to estimate the overall energy savings from HUD's formula and competitive grant programs. As was reported in chapter 3, estimated savings from the two summed to about 272,000,000 kilowatt-hours via this approach, which was slightly less than the savings of 279,000,000 kilowatt-hours derived from the preliminary ESM. The validated model pertained to a greater number of completed ECMs, which would have increased the overall estimate, but that model contains more conservative individual ECM estimates (including increases in consumption when these estimates were statistically associated with certain ECMs), which reduced it by slightly more. The updated model is further described in appendix I.

Table 6-1. Validated Electricity Consumption Savings From ECMs[a]

ECM	AMPs	Savings (%)			Validated	Comments
		Preliminary ESM	Validation Model			
ECM 34 Solar photovoltaic panels	33	11.2	20.5	±5.4	65.3	Both preliminary ESM and validation model estimate are potentially too low, due to lack of net metering at AMPs that use solar PV. Therefore, we use the mean savings from the competitive grant survey.[b]
ECM 22 LED exit signs	50	0.2	20.2	±10.3	0.2	The validation model savings estimate is likely too high; it may be measuring effects of other changes happening at the same time.
ECM 05 Clothes washers replaced	35	2.2	10.4	±6.8	2.2	
ECM 21 Install programmable thermostats	213	0.1	5.8	±3.1	0.1	
ECM 25 Outdoor and common areas light controls	99	0.2	5.7	±5.8	0.2	
ECM 13 Energy-efficient storm doors	252	0.0	4.7	±2.7	0.0	
ECM 01 Air sealing	130	0.5	3.1	±3.7	0.5	
ECM 11 Dishwashers replaced	119	0.2	3.0	±4.5	0.2	
ECM 19 HVAC pump motors replaced	71	2.0	1.9	±4.9	1.9	
ECM 26 Outdoor and common areas light fixtures replaced	202	1.0	1.7	±2.6	1.0	
ECM 33 Replacement windows	618	0.4	0.2	±1.6	0.4	
ECM 27 Radiator controls installed	40	.	0.2	±5.5	0.2	
ECM 09 Constant air regulating dampers	42	0.0	0.0	±6.2	0.0	

(continued)

AC = air-conditioning. AMP = Asset Management Project. ECM = Energy Conservation Measure. ESM = Energy Savings Model. HVAC = heating, ventilation, and air-conditioning. LED = light-emitting diode. RAMPS = Recovery Act Management and Performance System.

[a] *Tables 6-1 and 6-2 exclude certain ECMs that did not involve energy savings at all, were duplicative, or for which the information was insufficient to provide an estimate.*

[b] *Competition Evaluation Report, Task 16, HUD Green and Energy Retrofit Assessment.*

Notes: Negative numbers connote increases in consumption. Cells with a "." Indicate that there was no or not enough data to generate an estimate.

Table 6-1. Validated Electricity Consumption Savings From ECMs[a] *(continued)*

ECM	AMPs	Savings (%)			Validated	Comments
		Preliminary ESM	Validation Model			
ECM 32 Replace inefficient hot water heaters	326	0.0	- 0.1	±2.7	0.0	
ECM 18 Replace inefficient heating plants	345	0.0	0.4	±2.2	0.0	
ECM 02 Attic or roof insulation	272	0.0	- 0.8	±2.7	0.0	
ECM 29 Refrigerators replaced	483	3.8	- 1.5	±2.1	- 1.5	Consumption may increase if new refrigerators are larger than replaced units.
ECM 30 Replace central air-conditioners	316	12.0	- 1.5	±2.9	- 1.5	AC units installed in units without AC will cause increases in electricity consumption.
ECM 14 Energy-efficient storm windows	116	0.1	- 2.5	±3.5	0.1	
ECM 08 Compact fluorescent lighting and fixtures	318	2.4	- 2.9	±2.3	2.4	Increase unlikely from compact fluorescent lights.
ECM 16 ENERGY STAR-qualified replacement exterior doors	257	0.0	- 4.3	±2.6	0.0	
ECM 15 Energy-efficient window film	56	0.5	- 4.8	±6.0	0.5	
ECM 36 Spot ventilation	68	- 0.5	- 4.9	±5.9	- 0.5	
ECM 38 Window air-conditioners replaced	24	4.8	- 8.4	±13.5	- 8.4	AC units installed in units without AC will cause increases in electricity consumption.
ECM 03 Advanced utility metering	.	1.0	.		1.0	No data in RAMPS on advanced utility metering.

AC = air-conditioning. AMP = Asset Management Project. ECM = Energy Conservation Measure. ESM = Energy Savings Model. HVAC = heating, ventilation, and air-conditioning. LED = light-emitting diode. RAMPS = Recovery Act Management and Performance System.

[a] *Tables 6-1 and 6-2 exclude certain ECMs that did not involve energy savings at all, were duplicative, or for which the information was insufficient to provide an estimate.*

[b] *Competition Evaluation Report, Task 16, HUD Green and Energy Retrofit Assessment.*

Notes: Negative numbers connote increases in consumption. Cells with a "." Indicate that there was no or not enough data to generate an estimate.

Table 6-2. Validated Natural Gas Consumption Savings From ECMs[a]

ECM	AMPs	Preliminary ESM	Validation Model		Validated	Comments
ECM 04 Boiler temperature controls	43	6.0	12.6	±9.1	6.0	
ECM 18 Replace inefficient heating plants	235	40.0	- 9.3	±3.0	9.3	Magnitude of the savings depends on how inefficient the replaced heating plants are.
ECM 19 HVAC pump motors replaced	46	0.0	6.0	±6.5	0.0	
ECM 21 Install programmable thermostats	133	1.9	5.8	±4.3	1.9	
ECM 16 ENERGY STAR-qualified replacement exterior doors	162	0.8	5.0	±3.6	- 0.8	
ECM 36 Spot ventilation	43	- 0.5	4.0	±8.9	- 0.5	
ECM 33 Replacement windows	401	4.6	2.7	±2.0	2.7	
ECM 35 Solar thermal hot water system installations	7	10.0	2.2	±13.6	2.2	
ECM 13 Energy-efficient storm doors	161	0.6	1.8	±3.5	0.6	
ECM 32 Replace inefficient hot water heaters	205	12.0	0.4	±3.8	0.4	Magnitude of the savings depends on how inefficient the replaced water heaters are.
ECM 01 Air sealing	85	0.5	0.4	±4.5	0.4	
ECM 27 Radiator controls installed	33	5.0	- 0.6	±6.7	- 0.6	Radiator controls enable residents to use potentially more heat than they previously would have used.
ECM 02 Attic or roof insulation	177	2.2	- 0.7	±3.5	2.2	Increases unlikely from insulated attics and roofs.
ECM 12 Domestic hot water tanks insulated	91	2.0	- 1.7	±4.1	2.0	Increases unlikely from insulated hot water tanks.
ECM 14 Energy-efficient storm windows	66	2.9	- 4.6	±5.4	2.9	
ECM 09 Constant air regulating dampers	29	3.0	- 6.6	±9.1	3.0	
ECM 15 Energy-efficient window film	36	0.5	8.8	±8.6	0.5	

(continued)

AMP = Asset Management Project. ECM = Energy Conservation Measure. ESM = Energy Savings Model. HVAC = heating, ventilation, and air-conditioning.

[a] *Tables 6-1 and 6-2 exclude certain ECMs that did not involve energy savings at all, were duplicative, or for which the information was insufficient to provide an estimate.*

Notes: Negative numbers connote increases in consumption. Cells with a "." Indicate that there was no or not enough data to generate an estimate.

Table 6-2. Validated Natural Gas Consumption Savings From ECMs[a] *(continued)*

ECM	AMPs	Preliminary ESM	Validation Model		Validated	Comments
ECM 10 Conversions to electronic ignition	91	1.0	- 9.2	±5.1	1.0	
ECM 06 Clothes washing machines converted to cold rinse	3	0.6	.	.	0.6	
ECM 07 Cogeneration/ micro combined systems	2	- 0.2	.	.	- 0.2	

AMP = Asset Management Project. ECM = Energy Conservation Measure. ESM = Energy Savings Model. HVAC = heating, ventilation, and air-conditioning.

[a] *Tables 6-1 and 6-2 exclude certain ECMs that did not involve energy savings at all, were duplicative, or for which the information was insufficient to provide an estimate.*

Notes: Negative numbers connote increases in consumption. Cells with a "." Indicate that there was no or not enough data to generate an estimate.

ENERGY SAVINGS TOOL

The validated model and the preliminary ESM were used to develop an energy savings tool for future HUD use.[31] The tool is forward looking and aimed at predicting savings from the added energy efficiency from an ECM. Thus, for example, the tool is structured to examine the savings from installing energy-efficient air-conditioners rather than standard versions but takes account of location, average weather (heating degree days and cooling degree days), type of unit involved, and building type. Thus, it makes use of information gained from the ESM but does not simply repeat the validated estimates shown in Tables 6-1 and 6-2.

Use of the Tool

The tool allows for a user to input characteristics of an ECM, its location, the type of building under consideration, and relevant prices and costs to forecast energy savings and net monetary benefits from a particular investment. The tool's purpose thus is to enable HUD to make practical use of the analyses that underlie the final version of the model. Because the tool cannot take account of all local circumstances, judgment is required in the use of its forecasts, but it should prove useful in a variety of circumstances.

For a particular ECM, the tool estimates the physical savings that will be obtained from an energy-efficient version versus a standard version, taking account of certain local conditions, such as weather and building type. In such a comparison, prices of the different versions and local energy prices are inputted, and the tool calculates the incremental cost of the efficient version and the dollar savings that will be obtained. An appropriate discount rate and equipment lifetime also are inputted, and the model uses the information to calculate a Net Present Value (NPV) from the investment. The number of units affected also is input, and the NPV from one unit is multiplied by whatever number of units is contemplated to give an overall NPV from investment in that particular ECM.

In specific terms, the energy savings tool requires a public housing authority (PHA) that is considering an investment in one or more ECMs to provide the following inputs.

[31] *The tool and a guide to its use are included in appendix J.*

- Identification number of PHA. The tool automatically locates the PHA geographically and therefore sets the weather parameters for the investment.
- Housing type. Whether the units are low rise, high rise, duplex, and so on. The underlying ESM discriminates between these types of housing.
- Numbers of units of each bedroom type (studio, one bedroom, two bedroom, and so on.). The model discriminates between these bedroom types.
- Discount rate. The default rate is 3 percent, but the tool user can change it to reflect local capital market conditions.
- Electricity cost (per kilowatt-hour).
- Natural gas cost (per therm).
- Specific ECMs under consideration.
- Cost of an energy-efficient version of the ECM, in many cases an ENERGY STAR version.
- Cost of a traditional replacement component. The difference between the cost of the energy-efficient and traditional versions is the per-unit green energy investment increment.
- The number of each of the ECMs to be installed.
- The estimated useful life of the ECM in years.

The tool will automatically calculate the total investment in each ECM from the quantities and prices provided, and then estimate the total annual electricity and natural gas savings from implementing that ECM, plus the NPV of the investment.

Water Savings

Although the Green and Energy Retrofit Assessment project did not cover estimation of water savings, an aggregate estimate was compiled and provided in chapter 3, and water savings are included in the energy savings investment tool. Thus, the tool provides NPV calculations for 36 different ECMs included in the initial RAMPS data set, including those pertaining only to water.

The tool is constructed so that it can handle several ECM investments simultaneously, including investments in water savings. Therefore, an entire investment program's NPV can be obtained. This aggregation can occur at a particular property, at a set of properties in a particular locality (AMP or PHA level), or even at the national level.

The tool is meant to be simple to utilize so that local PHAs can easily apply it to contemplated energy-efficiency investments. Also, a guidance document for use of the tool has been developed to explain its operation and what input data are needed to obtain the desired output information. The guidance document is included in appendix J.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The purpose of the Green and Energy Retrofit Assessment (GERA) was to assess the relative success of HUD's American Recovery and Reinvestment Act (ARRA)-supported green housing investments in saving energy and in improving the energy efficiency of the nation's public and assisted housing stock. The basic approach was to model energy savings potential on an Energy Conservation Measure (ECM)-by-ECM basis, gather data with which to validate the model and modify it as needed, and provide HUD and public housing authorities (PHAs) information and tools to guide future energy savings investments.

As described in the foregoing chapters, the GERA study was able to accomplish these tasks.

- A preliminary Energy Savings Model (ESM) was developed, which was applied to green investment data obtained from the Recovery Act Management and Performance System, providing HUD with an initial rough estimate of energy savings from its ARRA-sponsored investments.
- Data were obtained via survey and other means to validate this initial ESM. The survey was modified from its initial design to include only recipients of competitive grants but still provided a worthwhile data sample. In addition, Utility Expense Level (UEL) data were utilized to statistically test and validate the preliminary savings model.
- The revised model provided updated estimates of energy (and water) savings from HUD's green investments. The aggregate energy estimates did not differ materially from the earlier, rough estimates.
- Site visits and case studies supported the statistical modeling by providing indepth reviews at specific locations. These studies were conducted over a variety of climate zones, building types, and PHA sizes. In general, the site visits and case studies indicated that local PHAs were able to oversee worthwhile green investment programs while considering resident concerns.
- A catalog showing the cost effectiveness of the various ECMs was constructed for purposes of guiding future HUD investments. In addition, a tool was developed that can be used to assess both energy and water savings investments under a variety of assumptions. The catalog and tool provide HUD with means to assess the expected results of green investments in the nation's public and assisted housing stock and to discern which of these investments likely will be cost effective.
- Overall, HUD's ARRA-supported green investment programs were able to accomplish a good deal. The accomplishments included rapid turnaround of monies provided through ARRA, a geographically extensive investment program, substantial energy and water savings, resulting environmental improvements, and revitalization of the nation's public and assisted housing stock.

RECOMMENDATIONS

In the course of conducting the GERA study, a number of observations were made that may assist HUD in its future green investment activities. These observations cover such areas as defining program success, data collection, energy audits, the energy savings review process, the calculation of energy savings, and other areas. The observations are categorized and then briefly described and discussed in the following subsections. They are presented as recommendations for consideration in formulating and implementing future investment programs of this type.

Data Collection

- To assist with data collection, grant recipients need to understand the purposes of a HUD investment program. For example, if the intent of a grant program is to earn at least a minimum return on the capital invested, that should be stated up front, in the Notice of Funding Availability (NOFA), and should be included as a selection criterion for grant award. The site visits revealed that few competitive grant recipients understood that return on investment (ROI) was a consideration in HUD's green building investment strategy.
- Recipients should be informed up front, within the NOFA, about the data and measurements that will be used to evaluate program success. For example, the objectives of ARRA included putting people to work and generating income to revive local economies. The metrics for the GERA study, however, included few of the results of economic stimulation, and grant recipients were not asked to compile such data (for example, how fast they were able to put their grant to work, how many contractors they hired, how many people the contractors employed).
- Include within the terms of the NOFA all data to be collected, and hold recipients to that requirement as part of the grant reporting and final closeout process. Doing so has two main benefits.
    - It will define data collection for grant management purposes within the NOFA, which will avoid a separate Paperwork Reduction Act (PRA) clearance process.
    - It will ease the burden on both PHAs and on HUD, enabling PHAs to provide the desired data as they become available.
- If a survey requiring PRA approval by the Office of Management and Budget is required, start very early on in the evaluation. The PRA process is time consuming and requires a good deal of preparation and lead time.
- Be specific with grantees about the data they are required to collect. Competitive grantees were required to keep 1 year of preretrofit and 1 year of postretrofit utility bills as a requirement of their grants; however, it was not made clear within the NOFA what utility bills were included. For example, the NOFA did not mention whether tenant-paid utility bills were required to be kept. Most competitive grantees therefore had data available only for utility usage in common areas.
- Consider including data collection expenditures as an allowable use of grant funds. Green Retrofit Program (GRP) for Multifamily Housing recipients were able to use grant funds to pay for a baseline utility preretrofit and a 1-year postretrofit utility study from an outside contractor. As a result, nearly all GRP grantees were able to provide HUD with preretrofit and postretrofit data that could be used to estimate actual savings.
- Retrofits implemented sometimes turned out to be different in scope from what was planned; for example, because of unavailability of the preferred component, later revelation that the preferred component would not work at this project (due to lack of space, for example), or unanticipated cost increases when the work was later bid out (thus imposing a need to reduce scope to stay within budget). HUD should understand that retrofits initially planned and reported sometimes are not what actually occur.
- Store data collected as part of a data collection system on HUD servers and maintain at least a minimum level of support for the system until final data have been collected.
- Archive all grant application materials, such as energy audits, by completing an evaluation. Audit information, in particular, is needed to compare the actual savings experienced with what was initially estimated in the audits.

Energy Audits

- Energy retrofits require a pragmatic approach that must include preretrofit energy use analysis. This analysis should include property benchmarking and also a project-specific, whole-building energy audit that follows the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Level II protocol and is procured by the building owner, not by an energy performance contractor.
- ASHRAE Level II energy audits also can help overcome the temptation to invest in popular technologies, such as solar photovoltaic panels, that may not be cost effective in a particular location. Saving-to-investment ratios should guide federally subsidized energy retrofits and will help sort out which investments are worthwhile and which are not.

Calculating Energy Savings

- Unless both efficient and traditional components are competitively bid out, the true incremental cost of an efficient component cannot be calculated. Segregating efficient equipment costs is imperative to calculating ROI or even simple payback values.
- It is impossible as a practical matter to measure savings from each of multiple ECMs at a particular property. Actual savings can be measured only in the aggregate (that is, at the level of the utility bill).
- Utility savings are affected by resident behavior, and no two units will produce the same results. Having an understanding of the resident type (for example, elderly or family), however, can shed light on this aspect of utility savings.
- Accurate, comprehensive measurement of utility savings in public housing is challenging. By anticipating the challenges, steps can be taken to try to meet them head on or find ways around them. The challenges include—
    - Obtaining tenant-paid utilities (need tenant-by-tenant permission) for a full year before and after retrofits.
    - Making adjustments to preretrofit and postretrofit data for weather with only 1 year's data for each.
    - Identifying the portion of the retrofit cost that represents the green premium.
    - Accurately estimating the utility consumption of in-place equipment. Manufacturer information is usually available, but actual usage varies by the age of the equipment, quality of installation, quality of maintenance, how tenants use the equipment, and so on.
    - Accurately ascertaining preretrofit and postretrofit building occupancy levels to make appropriate adjustments to energy quantities consumed.

Providing More Timely Program Evaluation

- Best practice in program evaluation is to design the evaluation at the same time as the program. One of the major delays to the GERA project was a required change in the evaluation design to involve data collection from a full census of competitive grantees rather than a statistical sample of both formula and competitive grantees. The delays might have been avoided had the initial evaluation design more thoroughly assessed the feasibility of collecting retrofit-related data from formula grantees.
- Defining success at program inception helps to guide measurement and data collection, sets priorities for program execution, and enables quicker assessment of program progress and accomplishments.
- Shortcomings in timeliness and quality of data were major reasons for the long timeframe of the GERA project. Because no energy consumption data were available directly from formula grantees, the major

source of data used to validate the preliminary ESM was UEL data collected via Form HUD-52722. Because Form HUD-52722 data are collected only once each year, on a July 1-to-June 30 annual schedule, however, the need to collect 12 months of postretrofit UEL data, which did not always coincide with the July 1-to-June 30 schedule, lengthened the review process.

- Case studies and site inspections could be done as each site's retrofit is executed; waiting until the whole program is completed is not necessary.

Other Insights

- GRP limited eligibility to retrofits that exceeded local code minimum efficiency, whereas the public housing programs did not. As a result, opportunities were missed in the public housing program because some PHAs selected or were provided code-minimum equipment when more efficient versions were available that would have yielded attractive returns on investment. Contractors should be informed that green (better than code) is a goal to which they will be held accountable.
- No cookie-cutter cutter property exists with a standard set of retrofits. The type and age of construction, maintenance provided, and particulars of the resident population all shape the most beneficial retrofits for a particular project. Each project must be inspected and evaluated and have a tailored retrofit plan.
- Nonfinancial parameters matter regarding energy-efficiency investments. For example, the replacement of existing components that were installed improperly or do not function as designed may yield substantial benefits to residents' quality of life.
- Property inspections and case study interviews lead the assessment team to the conclusion that a resident satisfaction rating for the ARRA-supported retrofits would be high. Although difficult to quantify, this factor should not be overlooked and might even be something that could be systematically assessed (for example, through surveys).
- Opportunities to save utilities that are paid by tenants may be missed unless tenant-paid utilities are emphasized in the program design. Missed opportunities can occur because building owners have an economic interest in prioritizing savings in utilities paid by themselves as opposed to savings accruing to tenants.
- Whenever heating, ventilation, and air-conditioning (HVAC) retrofits are planned, it is best practice to require a professional engineering assessment to identify appropriate unit sizes. In practice, HVAC units often are oversized, leading to spending more than is necessary and obtaining a component that will operate at less than optimum efficiency.
- Energy retrofit planning should be a collaborative team effort that includes the general contractor, architect (if one is engaged), residents, property management, maintenance staff, and the owner and should include a mini charrette. Comprehensive planning leads to greater control over the retrofit process, inclusion of the evaluation of alternatives, specification of appropriate equipment, installation quality, and postrehabilitation performance.

Suggestions From the Public Housing Authorities

The PHAs implemented HUD's formula, competitive, and GRP energy-related grant programs. Their suggestions emanate from their participation in the contracting process, dealing with tenants, overseeing the retrofits, and so on.

Planning

- Plan a green building project carefully and include all the property stakeholders (residents, property management, and maintenance staff).

- Engage the professionals required for the project that is envisioned, spend the time necessary to thoroughly evaluate alternatives, and work up a plan that is feasible given the resources available.
- HUD's Capital Needs Assessment electronic tool (or CNA-e) can help choose among alternative green building investments. The results from this type of tool are useful for making initial retrofits and also for selecting components for future replacement. Some funding sources may provide their own tool to facilitate the planning process.
- Look into multiple sources of public or private funds. If necessary, gear the project toward the availability of such funding sources, which often encourage green energy investment.

Working With Contractors

- Tension exists between a public and transparent bidding process and using known contractors. Using known and trusted contractors, who know the property, saves time and stress but must be balanced with cost.
- If the capability exists, consider doing the general contracting in house. Doing so will save money and provide more control over the process. General contractors, however, provide a vital service, bringing their expertise and organizational ability to the project. If that expertise does not exist among the participant staff, engage a general contractor.

Working With Residents

- Communicate frequently with residents. Superior communication will help to secure buy-in from them.
- Form a resident council with whom to communicate. Keep them fully informed as to what is happening in the project, and look for feedback to avoid unnecessary challenges as the project proceeds.
- Engage resident ambassador(s) who will be champions of the retrofits and help communicate the benefits to their fellow residents.
- Bear in mind the needs and challenges posed by the resident population. Moving is always traumatic, particularly for many elderly or disabled public housing residents. Whether the retrofits are completed with residents in place or relocated for a period of time, such plans must be crafted carefully and with extensive resident input.
- As needed, include resident training regarding new energy saving equipment. This process may have to be ongoing, not merely a one-time occurrence. Make this training a part of the property's new resident orientation process.

Working With Maintenance Staff

- Bring maintenance staff in during the planning stages of a project. They likely will have responsibility for maintaining new energy-efficient equipment and will want to know what is being planned and when. Experience has shown that some claims from equipment manufacturers have not been borne out in practice, and the maintenance staff can provide that input as the component decisions are made.
- Communicate frequently with maintenance staff as a project proceeds. Such communication will help to secure buy-in from them.
- Make sure maintenance staff have adequate knowledge of new energy-efficient equipment to maintain it as necessary. Arrange for training if needed, and plan for how the next generation of maintenance staff will obtain the necessary training.

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