Better Buildings Neighborhood Program Southeast Consortium Impact Evaluation

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Southeast Energy Efficiency Alliance
50 Hurt Plaza SE
Atlanta, GA 30303

The Cadmus Group, Inc.

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Prepared by:
Eric Rambo
Holly Farah
Natalie Bodington
Carol Mulholland

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Glossary

Avoided Costs	Costs avoided by the implementation of an energy-efficiency measure, program, or practice. These costs generally include generation or distribution costs.
Claimed Savings	Energy savings as reported by the administrator or implementer, before being verified by the evaluation team. Claimed savings may also be referred to as ex ante or pre-evaluation savings.
Deemed Savings	An estimate of energy, demand, or gas savings for a single unit of an installed energy-efficient measure. Deemed savings are developed from data sources and analytical methods that are widely considered acceptable for the measure and purpose. Deemed savings may be obtained from a statewide database, Technical Reference Manual (TRM) or prior evaluations and may be updated based on new evaluation findings.
Ex Ante Savings	Ex ante savings (also called claimed savings) are the pre-evaluation values recorded and tracked for the program, from the Latin for "beforehand."
Ex Post Savings	Ex post savings are the values reported by an evaluator after the energy impact evaluation has been completed, from the Latin for "from something done afterward."
Freeridership	Participants who would have adopted the energy-efficient measure in the program's absence in the same time period.
Gross Evaluated Savings	The total of the claimed or ex ante savings adjusted to reflect findings of the analysis conducted by the evaluator (engineering methods, billing analysis, etc.). The gross evaluated savings has not been adjusted for freeridership or spillover.
Lifecycle Savings	Energy savings, expressed as either evaluated gross or evaluated net, that are produced as a result of a set of measures installed in the current program cycle over each measure's estimated useful life.
Measure (noun)	An action or product, whose installation and operation at a customer's premised results in a reduction in the customer's on-site energy use compared to what would have happened otherwise.
Net Savings	Savings "net" of what would have occurred in the program's absence – these are the impacts attributable to the program. The net savings are typically calculated by applying a net-to-gross ratio to the gross evaluated savings.

Net-to-Gross (NTG)	An adjustment made to gross evaluated savings using estimates of freeridership and spillover, typically in the form of a NTG ratio. The objective is to remove freeridership from the gross savings, and add any spillover attributed to the program.
Realization Rate	A realization rate is the ratio of evaluated to claimed savings by measure type, facility type, and project stream.
Spillover	Spillover occurs when customers purchase energy-efficient measures or adopt energy-efficient building practices influenced by a program, even though the customers do not receive incentives for the purchases.

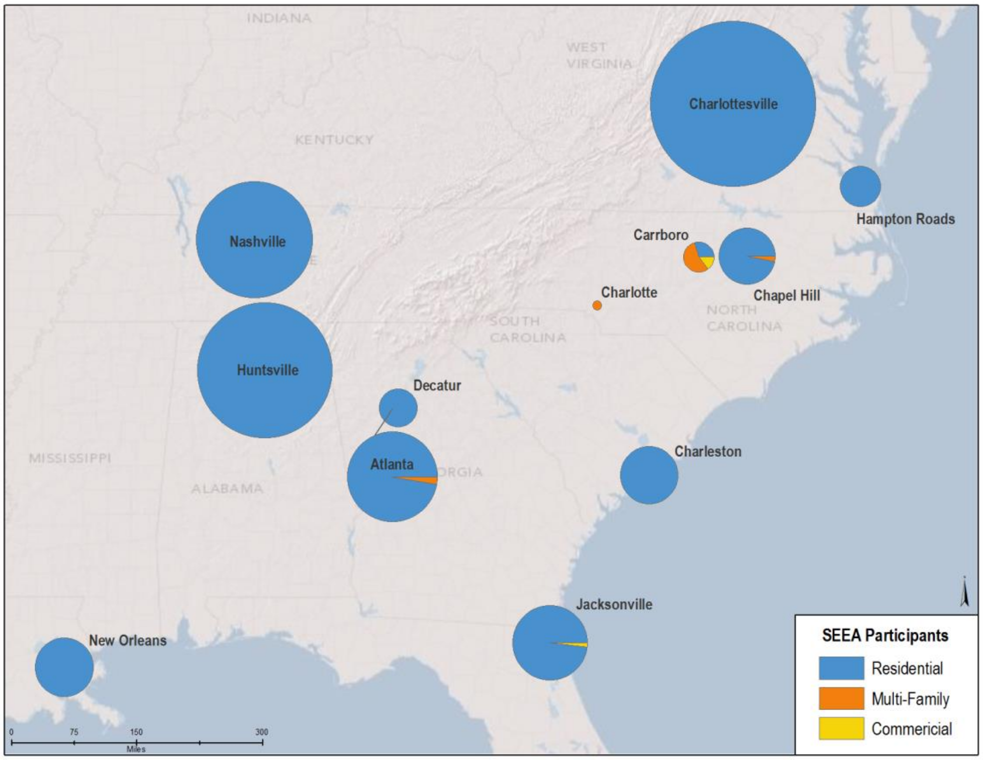
Introduction

The Southeast Energy Efficiency Alliance (SEEA) hired Cadmus to evaluate its portfolio of 13 programs in the Southeast Consortium Better Buildings Neighborhood Program (BBNP). SEEA received seed funding from the U.S. Department of Energy's (DOE's) BBNP in 2010 and contracted with program partners in 13 communities across eight states and the U.S. Virgin Islands to serve as subgrantees. These subgrantees launched local programs intended to dramatically increase the effectiveness of building retrofits. Each program launched following completion of contracts with SEEA, on dates ranging from June 6, 2010 through January 25, 2011. In this report, Cadmus presents its analyses of the energy savings and cost-effectiveness of the programs since their launch through November 25, 2013.

Program leaders in each city designed and implemented a program based on the community's unique market, experience with energy-efficiency programs, and relationship with other SEEA cities offering local BBNPs; thus, no two programs were alike. The programs targeted one or more customer sectors including residential single-family homeowners, multifamily buildings, and commercial buildings. Most programs included a building audit and incentives for installation of energy-efficiency measures, but some offered grants for selected projects instead. The measures promoted by the programs varied.

Figure 1 illustrates program participation by jurisdiction, with the size of the bubble representing the number of participants and the colors differentiating between residential, multifamily, and commercial customers.

Figure 1. Distribution of SEEA BBNP Participation across the Southeast*



*The figure does not include the U.S. Virgin Islands, a small program targeting commercial buildings.

Table 1 – Table 3 show the distribution of participation in the local programs across each of the jurisdictions for residential, multifamily, and commercial program participants, respectively.

Table 1. Summary of SEEA BBNPs Residential Participation

Climate Zone	City	State	# of Program Participants	% of Total Program Participants
2	Jacksonville	FL	206	6%
	New Orleans	LA	171	5%
3	Atlanta	GA	310	9%
	Charleston	SC	127	4%
	Decatur	GA	54	2%
	Huntsville	AL	735	21%
4	Carrboro	NC	18	1%
	Chapel Hill	NC	161	5%
	Charlottesville	VA	1,215	34%
	Hampton Roads	VA	62	2%
	Nashville	TN	510	14%
TOTAL			**3,569**	**100%**

Table 2. Summary of SEEA BBNPs Multifamily Participation

Climate Zone	City	State	# of Program Participants	% of Total Program Participants
3	Atlanta	GA	9	8%
	Charlotte	NC	9	8%
4	Carrboro	NC	93	78%
	Chapel Hill	NC	9	8%
TOTAL			**120**	**100%**

Table 3. Summary of SEEA BBNPs Commercial Participation

Climate Zone	City	State	# of Program Participants	% of Total Program Participants
1	U.S. Virgin Islands		2	10%
2	Jacksonville	FL	4	19%
4	Carrboro	NC	5	24%
	Charlottesville	VA	12	57%
TOTAL			**21**	**100%**

Overall Findings

In total, the SEEA BBNP subgrantees achieved 8,443,469 kWh savings in the single-family residential sector with an average realization rate of 65.9%, and 303,330 therms savings with an average realization rate of 73.9 %. The residential single-family homes sector contributed the majority of all program savings and was the only sector for which Cadmus could calculate *ex post* savings values. We awarded multifamily and commercial programs 100% realization rates due to insufficient supporting data and documentation, with 2,141,288 kWh and 11,134 therms saved through multifamily programs and 1,955,326 kWh and 34,688 therms saved through commercial programs. Table 5 – Table 7 show the contribution of each subgrantee by sector: residential single-family and multifamily and commercial.

Table 5. Summary of SEEA BBNPs Residential Single-Family *Ex Ante* and *Ex Post* Energy Savings

Table 4 shows each sector's contribution to overall savings

Table 4. Summary of SEEA BBNPs Overall Savings Contribution by Sector

	Electricity			Gas		
City	Realization Rate	Total Annual Ex Ante Savings (kWh)	Total Annual Ex Post Savings (kWh)	Realization Rate	Total Annual Ex Ante Savings (Therms)	Total Annual Ex Post Savings (Therms)
Residential	65.9%	12,812,459	8,443,469	73.9%	410,269	303,330
Multifamily	100.0%	2,141,288	n/a	100.0%	11,134	n/a
Commercial	100.0%	1,955,326	n/a	100.0%	34,688	n/a
OVERALL	**n/a**	**16,909,073**	**n/a**	**n/a**	**456,091**	**n/a**

Cadmus applied realization rates of 100% to multifamily and commercial programs, as the data initially provided were not sufficient to independently evaluate savings for these programs based on the program database received on 25 July, 2013. In addition, the contribution of these sectors to overall savings was relatively low.

However, the new program database received on November 25, 2013 shows that the energy savings increased in a significant way for multifamily sector specially in cities of New Orleans, Charlotte and Carrboro by 829,900, 388,013 and 228,387 kilowatt-hours respectively. For commercial sector too, the new database reports a considerable increase in energy savings in cities of Charlotte (+120,341 kWh), Charlottesville (+38,834 kWh) and New Orleans (+25,900 kWh). This significant energy savings increase could potentially prompt performing an impact evaluation for the multifamily and commercial sectors once SEEA program closes its activities to ensure a better estimate of the realized energy savings resulted from the program.

Table 5 – Table 7 show the contribution of each subgrantee by sector: residential single-family and multifamily and commercial.

Table 5. Summary of SEEA BBNPs Residential Single-Family *Ex Ante* and *Ex Post* Energy Savings

City	Electricity				Gas			
	Ex Ante Savings (kWh)	*Ex Ante* Percent of Total	*Ex Post* Savings (kWh)	*Ex Post* Percent of Total	*Ex Ante* Savings (Therms)	*Ex Ante* Percent of Total	*Ex Post* Savings (Therms)	*Ex Post* Percent of Total
Jacksonville	1,077,669	8%	729,226	9%	0	0%	0	0%
New Orleans	777,864	6%	921,613	11%	21,856	5%	20,720	7%
Atlanta	1,273,674	10%	197,092	2%	136,980	33%	78,946	26%
Charleston	573,104	4%	387,802	5%	9,002	2%	6,661	2%
Decatur	250,012	2%	62,409	1%	17,866	4%	16,158	5%
Huntsville	2,824,148	22%	2,148,094	25%	29,206	7%	19,859	7%
Carrboro	33,803	0%	25,711	0%	1,796	0%	1,221	0%
Chapel Hill	530,072	4%	403,181	5%	29,362	7%	19,966	7%
Charlottesville	3,649,047	28%	2,139,399	25%	154,068	38%	132,283	44%
Hampton Roads	159,262	1%	163,425	2%	10,068	2%	7,450	2%
Nashville	1,663,805	13%	1,265,517	15%	66	0%	66	0%
OVERALL	**12,812,459**	**100%**	**8,443,469**	**100%**	**410,269**	**100%**	**303,330**	**100%**

Table 6. Summary of SEEA BBNPs Multifamily *Ex Ante* Energy Savings

City	Electricity		Gas	
	Ex Ante Savings (kWh)	*Ex Ante* Percent of Total	*Ex Ante* Savings (Therms)	*Ex Ante* Percent of Total
New Orleans	829,900	39%	5,557	50%
Atlanta	30,714	1%	1,160	10%
Charlotte	963,921	45%	3,867	35%
Carrboro	303,965	14%	550	5%
Chapel Hill	12,788	1%	0	0%
OVERALL	**2,141,288**	**100%**	**11,134**	**100%**

Table 7. Summary of SEEA BBNPs Commercial *Ex Ante* Energy Savings

City	Electricity		Gas	
	Ex Ante Savings (kWh)	*Ex Ante* Percent of Total	*Ex Ante* Savings (Therms)	*Ex Ante* Percent of Total
U.S. Virgin Islands	155,845	8%	0	0%
Jacksonville	1,528,488	78%	0	0%
New Orleans	25,900	1%	0	0%
Charlotte	120,341	6%	194	1%
Carrboro	8,240	0%	823	2%
Charlottesville	116,512	6%	33,672	97%
OVERALL	**1,955,326**	**100%**	**34,688**	**100%**

Cadmus found a wide range of realization rates across the 11 programs targeting residential single-family homes, ranging from a low of 15.5% to a high of 118.5%. Table 8 shows the realization rates along with the annual *ex ante* savings recorded in the SEEA BBNP database and the *ex post* savings resulting from Cadmus analyses.

Table 8. Summary of SEEA BBNPs Residential Single-Family *Ex Ante* and *Ex Post* Energy Savings

	Electricity (kWh)			Gas (Therms)		
City	Realization Rate	Total Annual Ex Ante Savings (kWh)	Total Annual Ex Post Savings (kWh)	Realization Rate	Total Annual Ex Ante Savings (Therms)	Total Annual Ex Post Savings (Therms)
Jacksonville	67.7%	1,077,669	729,226	n/a	0	0
New Orleans	118.5%	777,864	921,613	94.8%	21,856	20,720
Atlanta	15.5%	1,273,674	197,092	57.6%	136,980	78,946
Charleston	67.7%	573,104	387,802	74.0%	9,002	6,661
Decatur	25.0%	250,012	62,409	90.4%	17,866	16,158
Huntsville	76.1%	2,824,148	2,148,094	68.0%	29,206	19,859
Carrboro	76.1%	33,803	25,711	68.0%	1,796	1,221
Chapel Hill	76.1%	530,072	403,181	68.0%	29,362	19,966
Charlottesville	58.6%	3,649,047	2,139,399	85.9%	154,068	132,283
Hampton Roads	102.6%	159,262	163,425	74.0%	10,068	7,450
Nashville	76.1%	1,663,805	1,265,517	100.0%	66	66
OVERALL	**65.9%**	**12,812,459**	**8,443,469**	**73.9%**	**410,269**	**303,330**

Using the results from its residential analysis shown in Table 8, Cadmus calculated the average electric savings per household for both the *ex ante* and *ex post* savings, both in kWh and as a percent of consumption. The results, shown in Table 9, demonstrate the sizable differences in the reported and evaluated savings, which contribute to overall realization rate of 66% for residential single-family electric savings.

Table 9. Summary of SEEA BBNPs Residential Single-Family Percent Electric Savings

	Ex Ante kWh		Ex Post kWh		
City	Average Savings per Household	Percent Savings*	Average Savings per Household	Percent Savings**	Realization Rate
Jacksonville	5,231	25.3%	3,540	16.4%	67.7%
New Orleans	4,603	34.9%	5,453	35.5%	118.5%
Atlanta	4,149	24.1%	642	6.6%	15.5%
Charleston	4,513	24.4%	3,054	15.8%	67.7%
Decatur	4,630	23.9%	1,156	9.1%	25.0%
Huntsville	3,842	19.2%	2,923	13.0%	76.1%
Carrboro	1,878	13.3%	1,428	9.0%	76.1%
Chapel Hill	3,355	16.7%	2,552	11.3%	76.1%
Charlottesville	3,162	16.7%	1,854	5.0%	58.6%
Hampton Roads	2,569	21.8%	2,636	16.2%	102.6%
Nashville	3,262	19.6%	2,481	13.3%	76.1%
OVERALL	**3,661**	**20.1%**	**2,412**	**13.5%**	**65.9%**

* Cadmus calculated the percent savings per city from the average percent savings per household for each city reported in the tracking database.

** *Ex post* consumption per household was extrapolated from billing data for Jacksonville, Decatur, Huntsville, Charlottesville, and Hampton Roads. Due to lack of sufficient data for the remaining cities, Cadmus used alternative approaches to estimate *ex post* consumption. Cadmus assumed the same ratio between *ex ante* and *ex post* consumption for Carrboro, Chapel Hill, and Nashville as for Huntsville, as these four cities were considered due to similarities in weather and/or ex ante percentage of savings. Similarly, the *ex ante* to *ex post* ratio for Jacksonville was applied to Charleston. *Ex post* consumption for Atlanta and New Orleans was extrapolated from the models used to evaluate electric savings in these cities. A scale factor derived from the ratio of the *ex ante* percent savings for the sites modeled and the citywide *ex ante* percent savings was applied to each city's *ex post* percent savings.

Cost-Effectiveness Results

Cadmus analyzed the costs and benefits of the SEEA BBNPs using the Societal Cost Test (SCT). The SCT uses the benefit and cost methodologies described in the California Standard Practice Manual[1] for assessing DSM program cost-effectiveness. The test examines the programs' net benefit to society overall. For this analysis, we included benefits such as avoided energy costs, avoided capacity costs, and line losses in the test. We also included a 10% adjustment to reflect non-quantified benefits such as environmental externalities and other societal benefits. For the costs, we considered the overall project costs to both the programs and customers.

A benefit/cost ratio greater than one indicates that a program is cost-effective (i.e., the present value of the benefits are greater than the present value of the costs). As shown in Table 10, according to the SCT, the SEEA BBNPs were not cost-effective across the evaluation period. Over the span of the programs, we observed an overall benefit/cost ratio of 0.73, with ratios ranging between 0.41 and 1.66 annually.

Table 10. 2010-2013 SEEA BBNPs Cost-Effectiveness

Year	Benefits (PV)	Costs (PV)	Net Benefits	B/C Ratio
2010	$156,438	$268,086	-$111,648	0.58
2011	$3,515,872	$8,673,608	-$5,157,737	0.41
2012	$5,428,242	$12,213,168	-$6,784,926	0.44
2013	$11,797,728	$7,127,472	$4,670,256	1.66
2010-2013	**$19,399,309**	**$26,629,971**	**-$7,230,662**	**0.73**

Several factors may contribute to the program being less cost-effective especially throughout 2010-2012:

- The program's primary objective was to create jobs, not to be cost-effective. This assessment does not include the beneficial economic impacts from job creation.
- The avoided costs for energy saved in the Southeast are low.
- Realization rates were poor in several cities with significant program participation.
- Most of the energy savings came from installing HVAC measures such as insulation, windows, and air sealing. Lighting and cooling measures tended to be more cost-effective due to the coincidence of their energy savings with higher avoided energy-cost hours.

However, in the year 2013 benefit/cost ratio increased significantly due to program activities in cities such as Charlotte, New Orleans and Charlottesville while the increase in cost was low relative to the

[1] The California Standard Practice Manual of 2001 sets out a standardized procedure for evaluations of program cost-effectiveness. http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF.

2010-2012 program years. The majority of the energy savings resulted from these activities were reflected in the new database received on November 25, 2013.

The tracking database did not record energy savings and costs by specific measure, but rather by project. More specific measure-level data may have allowed for a more granular approach to the cost-effectiveness inputs such as realization rates and temporal occurrence of energy savings.

Methodology

The objective of Cadmus' impact evaluation was to determine the gross energy savings by fuel type and to assess cost-effectiveness of the programs' achieved savings.

SEEA and Cadmus originally planned to rely primarily on billing analysis to verify program savings. SEEA intended to collect 12 months pre- and post-billing data for participants in the BBNPs. Although SEEA designed the program to accomplish this and obtained customer authorization, not all of the utilities were willing to provide the data. SEEA attempted to obtain consistent data from each program in a master tracking database, but the different program models and tools used for capturing and reporting data resulted in incomplete or missing data for a number of the programs.

After identifying significant limitations in the data available in a mid-program database and billing data review, Cadmus worked with SEEA to collect additional data and developed an approach to determine savings for each program based on the specific data available. Cadmus used several approaches to assess program performance including tracking database reviews, billing analysis, technical desk reviews, whole-house energy modeling, and engineering analysis. Table 11 shows the approach or approaches employed in the evaluation for each city.

- **Tracking Database Reviews.** Cadmus conducted database reviews for all of the programs to assess data available for participants, project location, and measure installation. Data for each participant included the expected *ex ante* measure savings, installation dates, and percentage of savings. For commercial and multifamily programs, the tracking database review was the analysis approach employed by Cadmus.
- **Billing analysis.** This analysis involved the comparison of customer billing data with metered energy use before and after the installation of energy-efficiency measures. For the electric analysis, the average number of days used in the analysis ranged from 256 to 339. The analysis required a minimum of four months. We normalized the data for comparison by matching each billing period with the respective daily heating and cooling degree days for the weather station nearest to the participant's ZIP code. Cadmus used two regression models to estimate savings and then selected the model that provided the smallest error around the savings estimates. Please see the Billing Analysis section of this report for a detailed description of our methodology and analysis.
- **Technical Desk Reviews.** Cadmus conducted technical desk reviews when sufficient billing data was not available but when SEEA provided data files from simulation models or other project documentation for a sufficient sample of participant homes. For a representative sample of participants, Cadmus reviewed whole-house simulation model files and compared building parameters and assumptions to data in the SEEA database and available program documentation. To verify building parameters for modeling, we collected data, when available, on the following key components:

- The envelope leakage (infiltration) and duct leakage through documented test-in and test-out results
- Building footprint dimensions, orientation, and square footage of living space
- Envelope characteristics
- HVAC system types and efficiency ratings
- Envelope insulation materials and thicknesses (R-values)
- Lighting

We reviewed the available documents to assess the reasonability of the input and output values. In some cases, we used satellite mapping techniques to corroborate each home's orientation[2] and percentage of glazing on each side of the home. This step served as an initial check to evaluate potential reasons for discrepancies between *ex ante* and *ex post* savings.

- **Whole-house Energy Modeling.** Cadmus used whole-house energy modeling to assess the reported savings when sufficient billing or simulation data was not available but program tracking data was complete enough to populate required model inputs. Cadmus used the REM/*Rate*[3] model, calibrating it to actual annual consumption data.
- **Engineering Analysis.** We used engineering analysis to estimate savings for measures not incorporated into the models or to evaluate the applicability of data from other program locations when little or no data other than the program tracking data was available. Cadmus applied engineering formulas to estimate savings for additional measures. When data was not available, Cadmus compared weather and participant profiles to other program locations for similarities.

2 With respect to the four cardinal points (north, south, east, and west).

3 REM/*Rate* is a whole-house simulation tool developed by Architectural Energy Corporation for energy analysis.

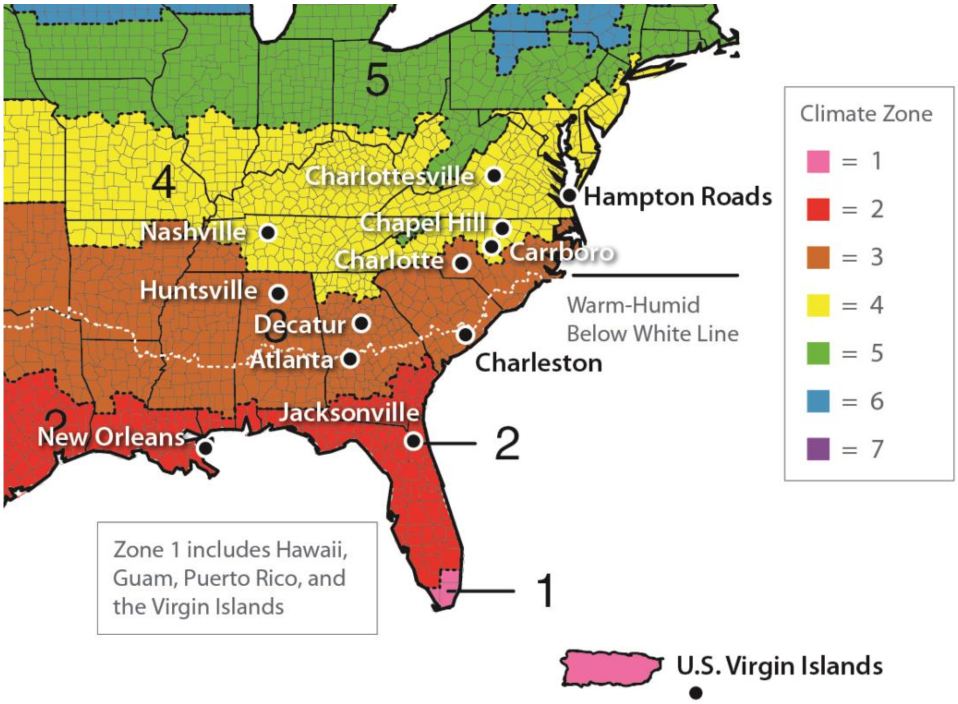
Table 11. Analytical Methods Used to Determine Energy Savings

Subgrantee	Tracking Database Review	Billing Analysis	Technical Desk Review	Whole-House Energy Modeling	Engineering Analysis
Atlanta	√		√	√	√
Carrboro	√				√
Chapel Hill	√				√
Charleston	√				√
Charlotte	√				
Charlottesville	√	√	√	√	
Decatur	√	√	√	√	
Hampton Roads	√	√			
Huntsville	√	√			
Jacksonville	√	√			
Nashville	√				V
New Orleans	√	√	√	√	
U.S. Virgin Islands	√				

Weather-sensitive measures represented the majority of measure types promoted by the residential single-family programs. These measures also contributed more to the overall energy savings for the BBNPs than the non-weather-sensitive measures. Using the U.S. Department of Energy climate zone map to determine which zone each program operated in, Cadmus evaluated each program using data specific to each zone in whole-house energy modeling and billing analysis.

Figure 2 shows the geographic latitudes each climate zone covers, along with the SEEA BBNPs cities in each zone.

Figure 2. SEEA BBNP Jurisdictions by Climate Zone



Reported Savings

For each program, Cadmus obtained the *ex ante,* or claimed savings for each project from SEEA's program tracking database or through data requests to program managers. Cadmus used the methodology most appropriate for the data available to calculate the *ex post*, or evaluated savings. The ratio of the evaluated gross savings to the claimed savings provides an overall realization rate for the program savings. Cadmus did not adjust the savings claimed for multifamily and commercial projects, awarding them a realization rate of 100%. The quality of data provided for these projects was insufficient for evaluation. In total, the multifamily and commercial projects located in Atlanta, Carrboro, Chapel Hill, Charlotte, Charlottesville, Jacksonville, and the U.S. Virgin Islands accounted for 24.2% of total *ex ante* kWh savings.

Program Findings

Cadmus evaluated energy savings by sector and by climate zone for each program. As described in the overall discussion of our methodology, Cadmus selected different approaches for each program based on the data available for evaluation. In this section we discuss the available data, the selected evaluation approach, program-specific methodology (where applicable), and our findings for each program. Table 12 shows the climate zone and targeted sectors for each program.

Table 12. SEEA BBNPs Climate Zone and Sectors by City

Climate Zone	Program City	Sector Targeted		
		Single-Family	Multifamily	Commercial
1	U.S. Virgin Islands			√
2	Jacksonville	√		√
2	New Orleans	√	√	√
3	Atlanta	√	√	
3	Charleston	√		
3	Charlotte		√	√
3	Decatur	√		
3	Huntsville	√		
4	Carrboro	√	√	√
4	Chapel Hill	√	√	
4	Charlottesville	√		√
4	Hampton Roads	√		
4	Nashville	√		

U.S. Virgin Islands (Climate Zone 1)

Commercial Participants

Although a SEEA BBNP for the commercial sector was active in the U.S. Virgin Islands, Cadmus did not receive sufficient data to analyze savings under this program. We did not receive billing data, building parameters, or project documentation to support an evaluation of the two buildings participating in the U.S. Virgin Islands' commercial program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the U.S. Virgin Islands' commercial program. Table 13 lists the *ex ante* savings calculated for the program.

Table 13. U.S. Virgin Islands SEEA BBNPs Commercial Gross Savings Summary

	Ex Ante Gross Savings	
	kWh	Therms
Annual	155,845	-

Total Program Savings

Table 14 shows the total gross savings for the U.S. Virgin Islands. The gross savings represent savings from the commercial program in the U.S. Virgin Islands.

Table 14. U.S. Virgin Islands SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross Savings		*Ex Post* Gross Savings	
	kWh	Therms	kWh	Therms
Annual	155,845	-	155,845	-

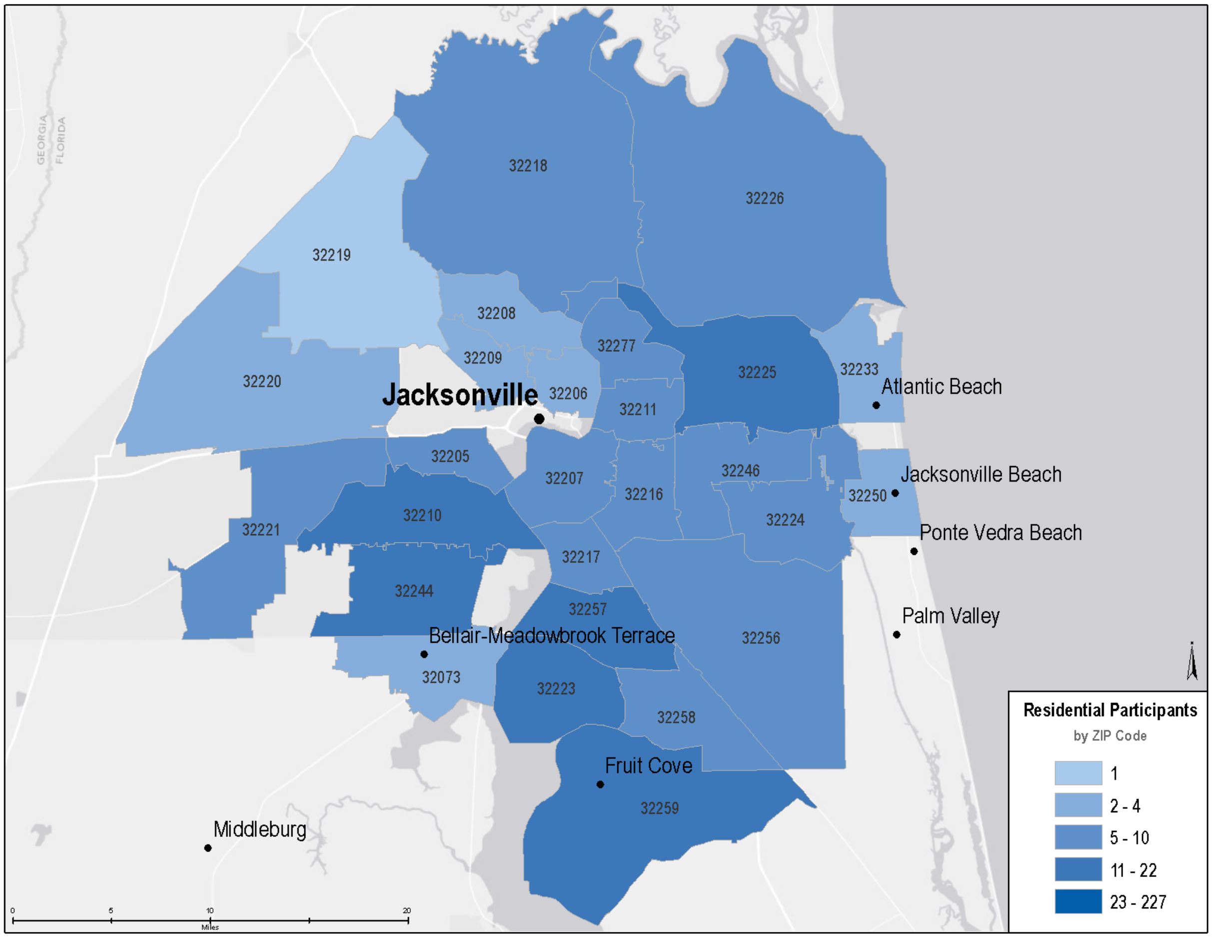
Jacksonville, Florida (Climate Zone 2)

Residential Single-Family Participants

JEA, the Jacksonville municipal utility, managed the SEEA BBNP within their ShopSmart and InvestSmart with JEA portfolios. JEA offered home energy audit and residential energy upgrade incentives for lighting, heating and cooling system repair or replacement, duct sealing, insulation, window tint or solar screen, and water heater measures. JEA also offered business energy audits and energy upgrade incentives for a number of measures including lighting retrofits; heating, cooling, and air handling; duct sealing; insulation and windows; refrigeration solutions; and appliances.

Figure 3 shows the geographical distribution for the SEEA BBNP residential participants in Jacksonville, Florida. This program had 206 participants during the evaluation timeframe. SEEA funding was discontinued in April 2012, but JEA still maintains many of the BBNP services as part of their energy-efficiency program portfolio.

Figure 3. SEEA BBNP Residential Participants of Jacksonville, Florida



Under the SEEA BBNP, installation of new heat pumps and attic insulation were the most common actions taken by participants. Table 15 shows measure categories, types, and units installed under the BBNP in the City of Jacksonville, along with the percentage of households receiving each measure type.

Table 15. Measures Installed under SEEA BBNP in Jacksonville

City: Jacksonville			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	85	41%
	Floor/Foundation Insulation	6	3%
	Windows Installed/Replaced	18	9%
	Air Sealing	30	15%
	Radiant Barrier or Vapor Barrier	3	1%
	Shade Screen Addition	3	1%
Lighting and Appliances	Lighting CFLs	4	2%
HVAC	Air Conditioner	5	2%
	Heat Pump	119	58%
	Duct Sealing	76	37%
	Duct Insulation	2	1%
	Programmable Thermostat	6	3%
	HVAC tune up	29	14%
Domestic Hot Water	Water Equipment Insulation	1	0%
	Water Heater	36	17%

Data Available for Impact Evaluation

Cadmus reviewed the data available to support the impact evaluation and found:

- Sufficient electric billing history (meter data) was available for 94 of the households participating in SEEA BBNP in Jacksonville.
- JEA did not report any gas savings and no gas billing history (meter data) was available for households participating in the SEEA BBNP in Jacksonville.
- Site-level project documentation was not available for households participating in the SEEA BBNP in Jacksonville.
- In Cadmus' review of the program tracking database provided by SEEA in November 2013, the team found that electric savings associated with installed program measures were reported for all 206 participants. Measure-level savings were not available for these households.

Cadmus reviewed the SEEA BBNP tracking database, noting missing values or presumed data entry errors. All households reported electric savings either in kilowatt hours or as a percentage of household electricity consumption.

Based on the November 2013 SEEA tracking database, Cadmus found 1,077,669 kWh savings were reported by JEA for the installation of program measures in Jacksonville households.

Evaluation Approach

For the impact evaluation of the SEEA BBNP in Jacksonville, Cadmus reviewed the household energy savings reported in the program database. To evaluate *ex ante* energy savings, Cadmus also performed billing analysis for a sample of 94 participant homes, based on the available billing data. The Billing Analysis section describes the applied methodology in detail.

Energy Savings Impact Findings (Residential Single-Family Homes)

Table 16 shows the overall claimed gross and evaluated gross energy impacts (kWh and therms) for the SEEA BBNP in Jacksonville. We used savings documented within the SEEA BBNP tracking database to arrive at *ex ante* savings, and *ex post* values derive from the billing analysis conducted with 46% of the 206 participating households. The program realized *ex post* evaluated gross energy savings of 729,226 kWh.

Table 16. Jacksonville SEEA BBNPs Residential Single-Family Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	1,077,669	-	729,226	-
Lifetime	-	-	11,449,000	-

* All of the records included savings as kilowatt hours and therms, not as a percentage of consumption. E*x ante* numbers represent all reported savings for Jacksonville residential participants.

As shown in Table 17, evaluation findings for the SEEA BBNP in Jacksonville resulted in a 67.7% realization rate for electricity. The Jacksonville residential BBNP did not report gas savings, so Cadmus did not calculate a gas savings realization rate for this program.

Table 17. Jacksonville SEEA BBNPs Residential Single-Family Realization Rate

Realization Rate	
Electric	Gas
67.7%	n/a

Commercial Participants

Although a SEEA BBNP for the commercial sector was active in Jacksonville, Cadmus did not receive sufficient data to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project details and supporting documentation to support an evaluation of the Jacksonville commercial program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the Jacksonville commercial program. Table 18 lists the *ex ante* savings calculated for the program.

Table 18. Jacksonville SEEA BBNPs Commercial Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	1,528,488	-	1,528,488	-
Lifetime	-	-	13,446,000	-

Total Program Savings

Table 19 shows total gross savings for Jacksonville. These combine savings from the residential single-family and commercial programs in Jacksonville.

Table 19. Jacksonville SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	2,606,157	-	2,257,714	-
Lifetime	-	-	24,894,000	-

New Orleans, Louisiana (Climate Zone 2)

Residential Single-Family Participants

The City of New Orleans hired Global Green, a national nonprofit, to manage the NOLA Wise program (the local name for the SEEA BBNP) in the parish of Orleans (within the New Orleans metro area). The program focuses on funneling homeowners into the Entergy-New Orleans whole-home rebate program, ENERGY SMART®, by providing enhanced marketing, certified contractors, and affordable financing. Global green partnered with a local bank and leveraged other federal funds to create an affordable financing option to drive energy-efficient retrofits under the NOLA Wise program. Program participants had access to financing and utility rebates for HVAC equipment, building shell, lighting, and domestic hot water measure categories. Figure 4 shows the geographical distribution of residential participants in the NOLA Wise program. The program had 171 participants during the evaluation timeframe, and program operations continue.

Figure 4. SEEA BBNP Residential Participants of New Orleans, Louisiana

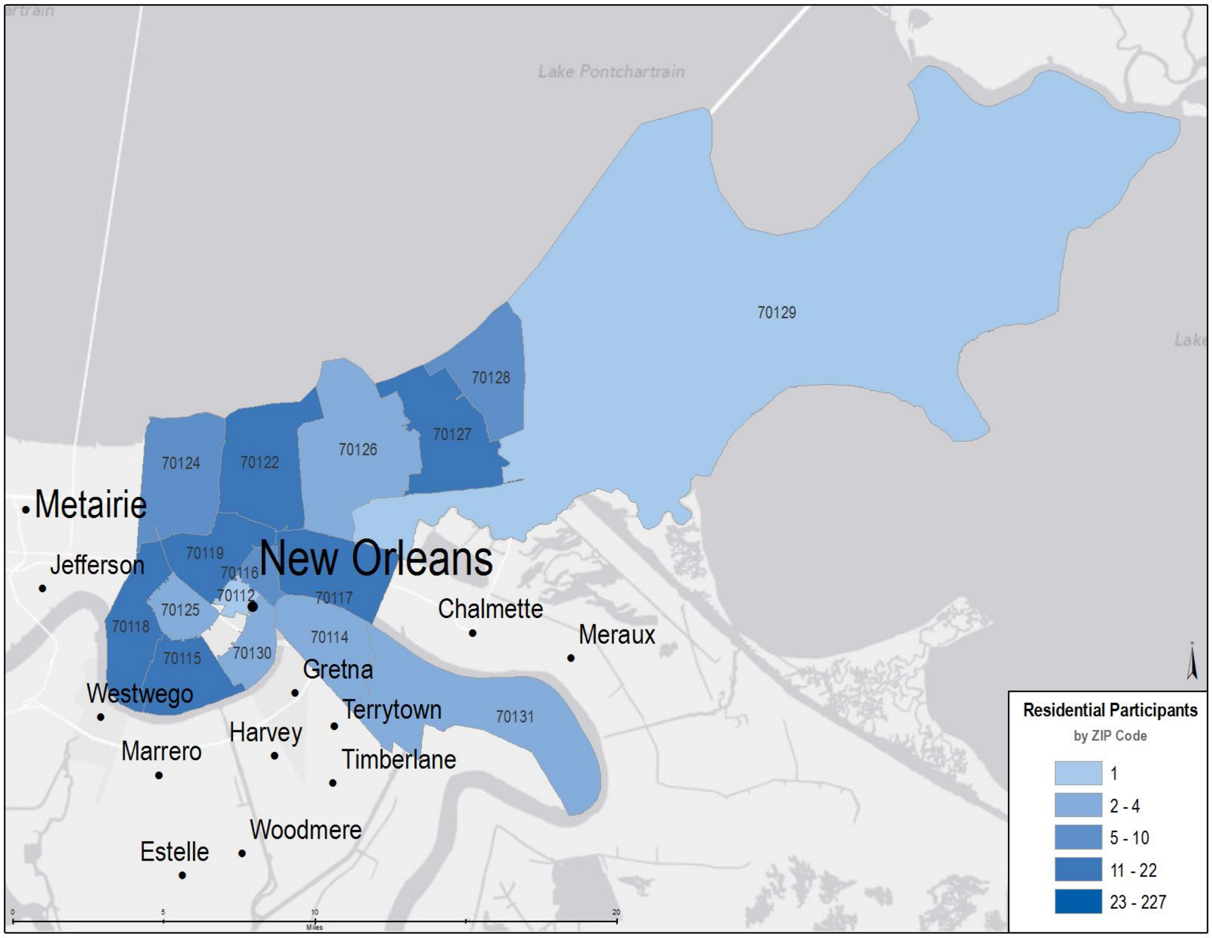


Table 20 shows the measure categories, types, and units installed through the program in the City of New Orleans, along with percentage of households receiving each measure type.

Table 20. Measures Installed under SEEA BBNP Program in New Orleans

City: New Orleans			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	83	64%
	Wall Insulation	2	2%
	Floor/Foundation Insulation	58	45%
	Windows Installed/Replaced	14	11%
	Air Sealing	142	110%
	Radiant Barrier or Vapor Barrier	57	44%
	Shade Screen Addition	12	9%
Lighting and Appliances	Lighting CFLs	72	56%
HVAC	Air Conditioner	10	8%
	Furnace	8	6%
	Heat Pump	13	10%
	Duct Sealing	120	93%
	Duct Insulation	5	4%
	Programmable Thermostat	74	57%
	HVAC tune up	72	56%
Domestic Hot Water	Water Equipment Insulation	70	54%
	Low Flow Faucet Aerator/Shower Head	12	9%
	Water Heater	6	5%

Data Available for Impact Evaluation

Cadmus reviewed the REM/Rate models, billing data, and SEEA BBNP tracking database, noting missing values or presumed data entry errors. We found:

- The SEEA program database presented electric savings values and the percentage of household electricity consumption saved for all households.
  - The tracking database included 171 records for New Orleans. Of these records, 170 included electric savings and 115 included natural gas savings associated with installed program measures.
  - One household record was missing the percentage of household electricity consumption saved due to program measure installation.
  - Records for three households were missing gas savings values, and records for seven households were missing the percentage of gas consumption saved.
  - Records for three households were missing for both gas savings values and the percentage of gas consumption saved.
  - None of the households had measure-level savings available.
- Sufficient electric billing history (meter data) was not available for most of the households participating in the NOLA Wise program. Useable data was only available for nine participants, who we found were not representative of the population.

- Gas billing history (meter data) was unavailable for households participating in the NOLA Wise program.
- REM/*Rate* models were available for a sample of 30 NOLA WISA participants (nine participants with billing data and 21 randomly-selected participants). For each participant in the sample, Cadmus also received a folder containing one or more of the following project files:
  - ENERGY SMART assessment and rebate form
  - Building leakage curve
  - Building leakage test report
  - Household economic summary
  - Emissions report
  - Energy cost and feature report
  - Images of existing conditions
  - Improvement analysis
  - Diagram with building dimensions
  - Work scope and test-in report

Evaluation Approach

For the impact evaluation of the SEEA BBNP in New Orleans (NOLA Wise program), Cadmus reviewed the reported household energy savings in the SEEA tracking database. Due to lack of sufficient billing data, Cadmus could only evaluate nine program participants using the PRISM savings estimation models. However, because the percentage of verified annual savings (27% compared to 10% average *ex ante* savings) was much higher than average, we determined that the nine households were not a representative sample of the entire population in New Orleans. Similarly, the pre-usage for the model analysis subgroup was statistically different than the population—showing that the analysis group was not a representative group. As an alternative approach, Cadmus conducted technical desk-reviews of whole-house energy simulations for a sample of 11 participant homes, which were chosen based on availability of REM/*Rate*[4] simulation files and site-level data and documentation. Table 21 outlines the available sources of data for the New Orleans savings analysis.

[4] REM/*Rate* is software designed by Architectural Energy Corporation that calculates hearing, cooling, hot water, lighting and appliance energy loads. Global Green used REM/*Rate* whole-house simulation package software to estimate energy savings for lighting, domestic water heating and weather-sensitive measure types offered through the program.

Table 21. The SEEA BBNP Impact Evaluation Activities for the City of New Orleans

Activity	Completed Sample Size (n)
SEEA program tracking database review	171
Engineering assessment of energy savings using technical desk reviews, REM/*Rate* modeling software and calibrating the model results to actual consumption data	11
Billing analysis (electric)*	9

*Results of billing analysis not used in final analysis.

Cadmus summarized the data and measure types reported in the SEEA program tracking database, which provided energy savings at a household-level. Cadmus generated *ex ante* energy (kWh and therms) savings estimates for program measures using REM/*Rate* to account for the interactive effects of the weather-sensitive measures. Program measure categories included HVAC equipment; building envelope (including envelope insulation, air sealing, and duct sealing); lighting; and domestic water heating.

To validate tracked energy savings for the NOLA Wise program, we primarily relied on:

- **Technical Desk-Review.** Cadmus performed a technical desk-review of all available 11 whole-house REM/*Rate* simulation files. Our reviewed was based on the assumptions for the building parameters and characteristics as well as the measure descriptions previously used by the implementer/contractor.
- **Whole-house Energy Modeling.** We assessed the reported savings by comparing the reported savings to the savings simulated using REM/*Rate.*
- **Model Calibration.** To estimate the evaluated home's *ex post* energy savings, we calibrated the energy savings generated by our revised REM/*Rate* models to the home's actual annual consumption from provided billing data and adjusted the savings proportionately.

Technical Desk-Review

Cadmus performed technical desk-reviews for 11 homes in the NOLA Wise program. We used satellite mapping techniques to corroborate each home's orientation[5] and the approximate square footage of glazing (window and glass door area) on each side of the house, when possible. Cadmus modified REM/*Rate* models for the sampled homes based on data collected through the technical desk-review. Based on a review of the provided documentation, 10 of the 11 REM/*Rate* simulation files required adjustments to either the post-retrofit or pre-retrofit baseline models. In several cases, the provided simulation files used REM/*Rate* default values from the "simplified inputs" mode, which Camus modified in the following areas:

- Year the home was built

[5] With respect to the four cardinal points (north, south, east and west).

- Percentage of fixtures occupied by compact fluorescent lamps (CFLs), both pre- and post-retrofit
- Ceiling or attic characteristics including pre-retrofit insulation R-value, existence of a knee wall, and the exterior square footage of the attic
- Pre- and post-retrofit duct leakage, which Cadmus set to the REM/*Rate* defaults "leaky, uninsulated" and "RESNET/HERS default," respectively, when test documentation was not available but duct sealing improvements were indicated by the tracking system.
- Furnace size and efficiency
- House size (square footage) and total volume of the conditioned air
- Window orientation
- Pre-retrofit R-values of floor and foundation insulation
- Foundation type
- Residence type (from single-family home to duplex)

The models did not reflect the following measures noted in the tracking database:

- Tank insulation
- Radiant barrier
- HVAC tune-up measures, which were implemented by assuming a 90% performance adjustment factor for the pre-retrofit model and a 100% performance adjustment factor for the post-retrofit model.

Whole-House Energy Modeling

To verify measures assigned to the sampled home models, Cadmus used the installed measures tracked in the SEEA BBNP database. Through a technical desk-review, we identified building parameters in addition to detailed descriptions of the installed measures.

We developed two REM/*Rate* building models for each home:

- The first model simulated the existing (or pre-measure) home's annual energy use
- The second model simulated the home's energy use after installation of the measures.

Thus, the pre-calibration energy savings equal the difference in annual energy use between the as-built (pre-measure installation) home and the upgraded home.

For the impact evaluation, Cadmus reviewed all of the available project documentation to gather pre- and post-measure installation data for the 11 homes randomly selected and compared the data against data in the SEEA BBNP program tracking database. For example, Cadmus used test-in and test-out measurements provided in NOLA Wise Home Energy Assessment Reports to assess duct leakage and envelope leakage.

Cadmus selected 11 households for which electric consumption data (meter data) were available to calibrate the models. We also ensured that these 11 sampled participant homes were representative of the of house size ranges across the full New Orleans census.

Table 22 shows the percentage of various house size categories in the BBNP (NOLA Wise) participant population versus the sample population.

Table 22. Square Footage of SEEA BBNP Households in the New Orleans

House Size Category	Percentage of Households in the New Orleans BBNP Population	Percentage of Households in the Sample Population
0-1,000	16%	9%
1,000-2,200	60%	55%
2,200-3,500	19%	27%
3,500 and bigger	5%	9%

Energy Savings Impact Findings (Residential Single-Family Homes)

Electricity

Cadmus found that there was discrepancy between the energy savings generated by the *ex ante* REM/*Rate* models and the energy savings reported in the SEEA tracking database. Table 23 shows the variance between the *ex ante* model and *ex post* calibrated model energy savings (kWh) results compared to the energy savings reported by the SEEA tracking database for the evaluated homes.

Table 23. *Ex Ante* Model and *Ex Post* Calibrated Model Energy Savings (kWh) versus Energy Savings Reported in the SEEA Tracking Database for the Evaluated Homes

Project ID	Home Square Footage	*Ex Ante* Model versus SEEA Database	Calibrated *Ex Post* Model versus SEEA Database
1	900	101.6%	147.1%
2	1,188	99.8%	68.8%
3	1,275	112.1%	332.3%
4	1,281	102.1%	80.6%
5	1,450	109.6%	134.5%
6	1,600	100.0%	34.9%
7	1,781	99.1%	67.5%
8	2,270	99.2%	53.9%
9	2,300	96.9%	144.4%
10	2,373	121.5%	154.2%
11	4,241	96.5%	132.8%

Regarding the estimates from the SEEA database and the *ex post* calibrated REM/*Rate* models, Figure 5 shows *ex ante* versus ex post percentage of electric energy-savings estimates.

Figure 5. Percentage of *Ex Post* and *Ex Ante* Electric Savings by Household, New Orleans

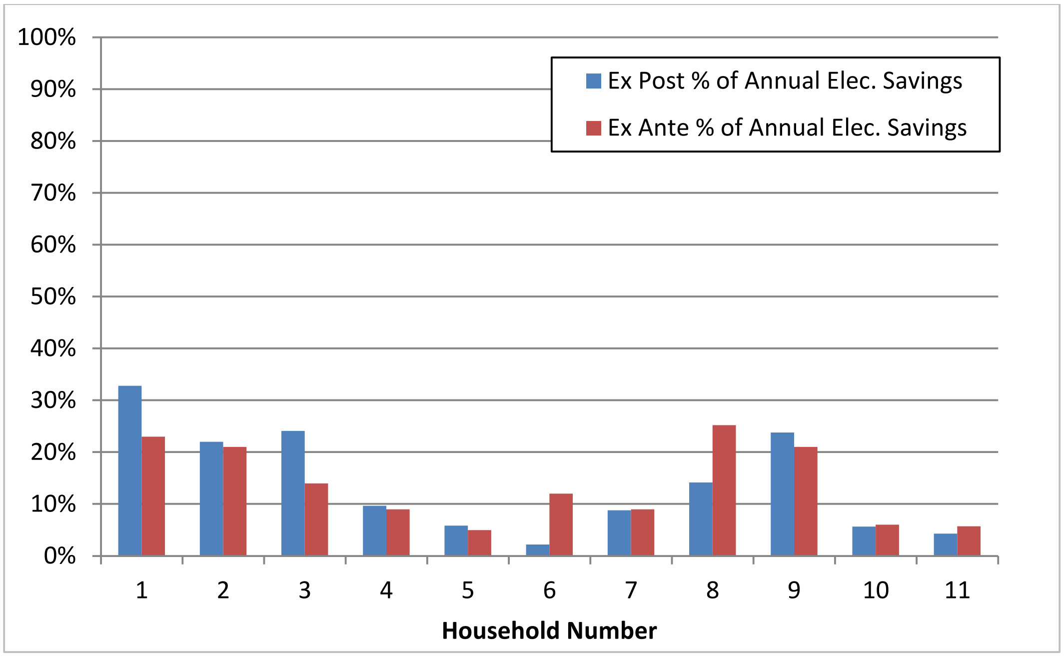
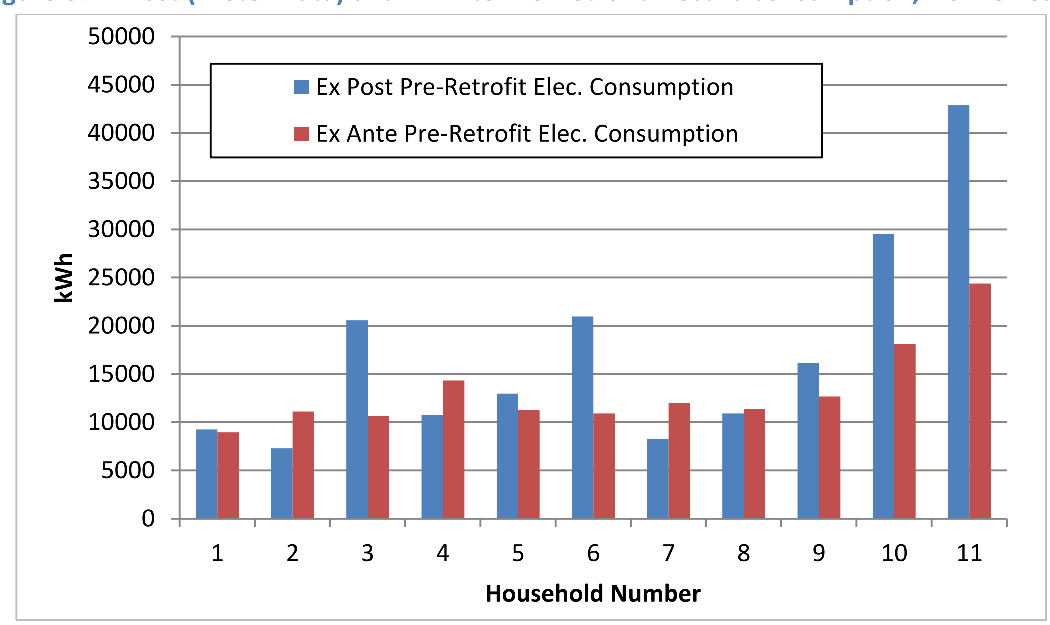


Figure 6 shows *ex ante* versus the *ex post* pre-retrofit electric consumption. In this case, the *ex post* pre-retrofit consumption is equal to the actual electric consumption indicated by the evaluated homes' billing data (meter).

Figure 6. *Ex Post* (Meter Data) and *Ex Ante* Pre-Retrofit Electric Consumption, New Orleans



The Energy Use Index (EUI) of a home is typically expected to decrease gradually as the house size increases, due largely to appliance and other usage patterns that do not scale with home size. Figure 7 and Figure 8 show *ex post* and *ex ante* EUI by square footage, respectively.

Figure 7. *Ex Post* Electric Utilization Index by Square Footage, New Orleans

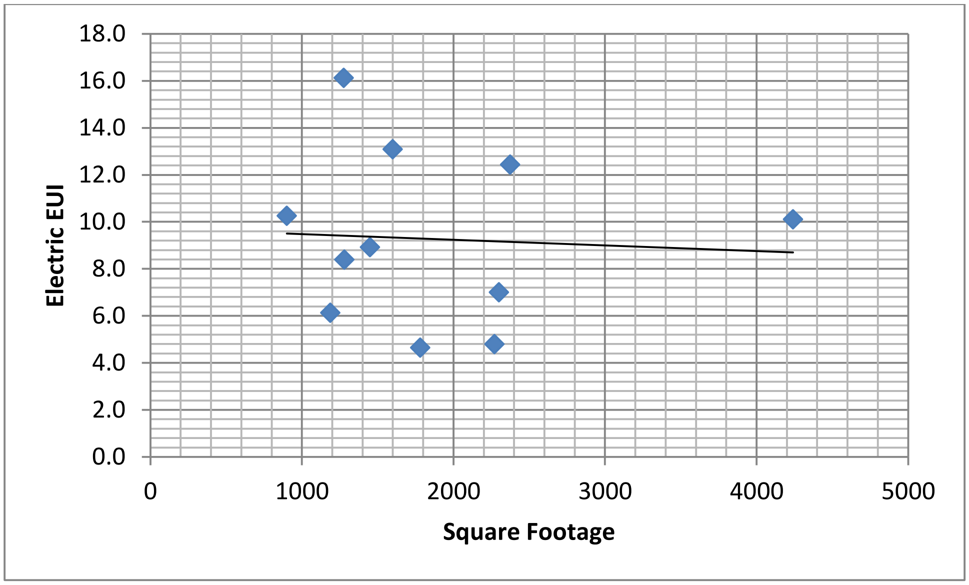
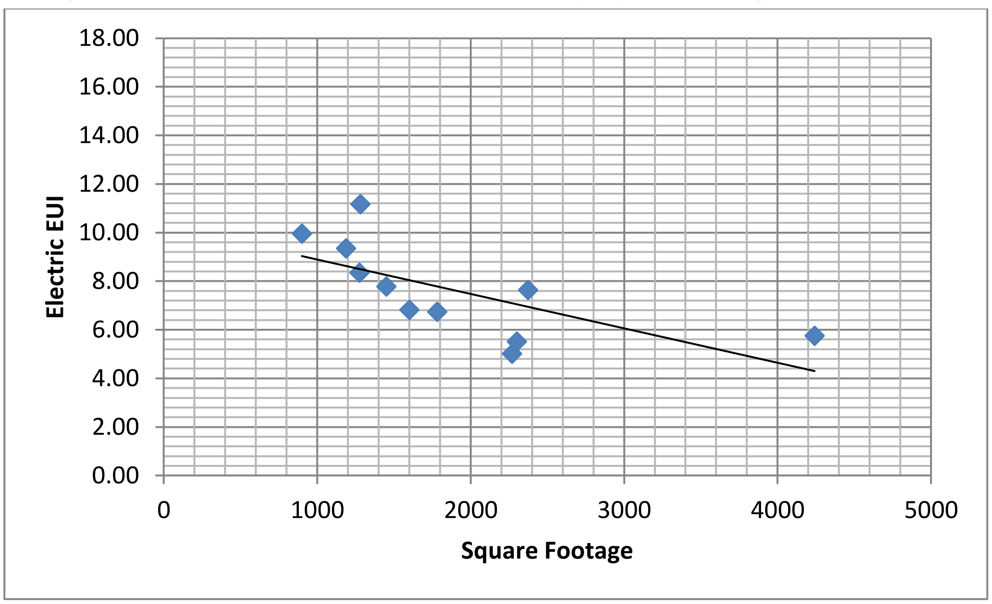


Figure 8. *Ex Ante* Electric Utilization Index by Square Footage, New Orleans



Gas

As shown in Figure 10, pre-retrofit gas consumption (therms) closely aligns between *ex ante* and *ex post*.

Figure 9. *Ex Post* and *Ex Ante* Pre-Retrofit Gas Consumption, New Orleans

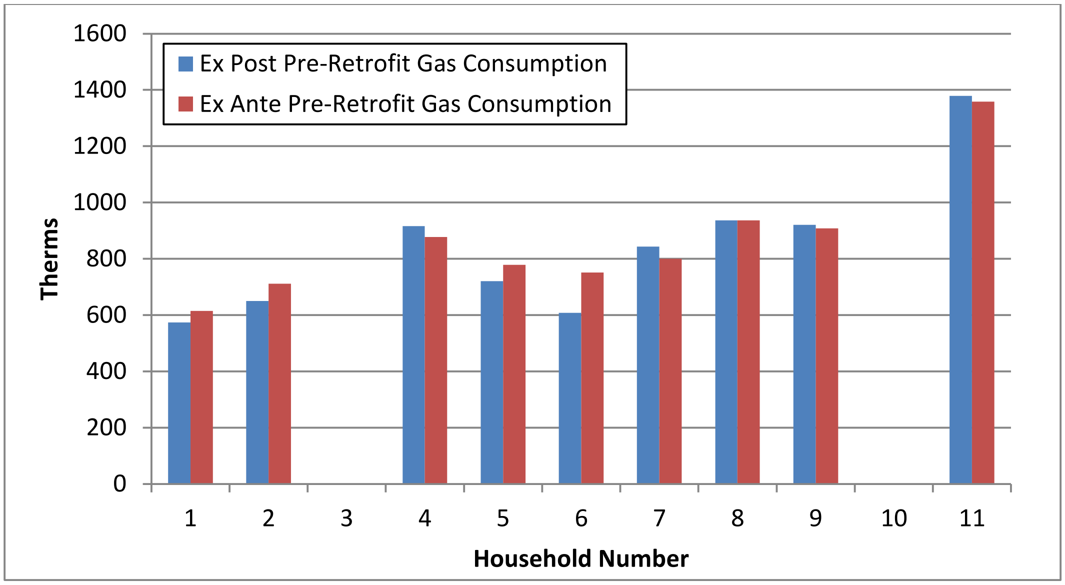
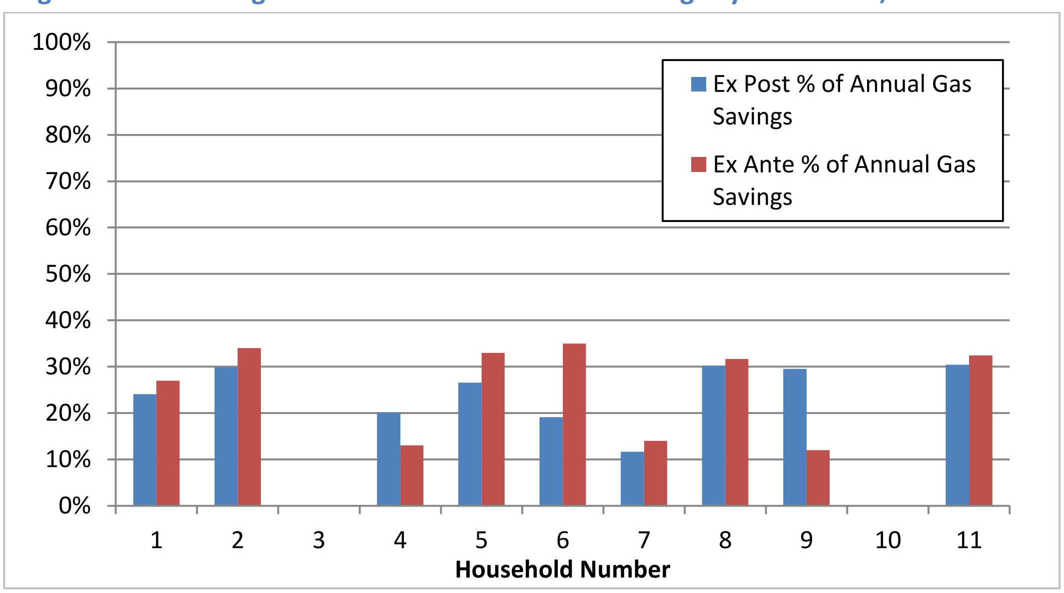


Figure 10 compares the annual percentage of *ex ante* gas savings with the *ex post* savings.

Figure 10. Percentage of *Ex Post* and *Ex Ante* Gas Savings by Household, New Orleans



Cadmus observed the following differences between *ex ante* and *ex post* gas savings values:

- **Home 4:** Cadmus calculated a higher percentage of gas savings for home 4 than was found in the SEEA tracking database. The *ex ante* simulation REM/*Rate* files for this site did not reflect the installation of frame floor insulation, which we found in both the tracking database and the provided site-level documentation. Moreover, investigation of the site using satellite imaging tools revealed that the home was a unit in a duplex rather than a free-standing, single-family home.

- **Home 6:** We calculated a lower percentage of gas savings for home 6 than was found in the tracking database. The *ex ante* REM/*Rate* files for this site reflected air sealing improvements, which were not specified in the tracking database. Therefore, Cadmus deemed this an invalid savings source. Moreover, the post-retrofit floor insulation levels specified in the *ex ante* REM/*Rate* files were higher than those cited in the tracking database. Thus, we lowered the floor insulation levels. Cadmus also calculated reduced savings due to attic insulation. We considered the pre-retrofit attic insulation levels in the simulation files to be unrealistically low. Additionally, the post-retrofit insulation R-value in the files did not match the value calculated by Cadmus, which was based on the standard accepted R-value for the material specified in the provided documentation, and the insulation thickness specified in the tracking database.
- **Home 9:** We calculated a higher percentage of gas savings for home 9 than was found in the tracking database. The *ex ante* REM/*Rate* files for this site reflected air sealing improvements not specified in the tracking database. Therefore, we deemed this an invalid savings source. However, the tracking database listed improvements to the furnace and ductwork, which Cadmus included in the model. We did not find these improvements in the *ex ante* simulation files. We also used substantially different characteristics for the home envelope than we observed in the simulation files. The square footage of the home shown in the provided REM/*Rate* files was significantly lower than what we found both in the tracking database and through use of satellite imaging software; the files also specified a one-story home, while satellite views showed it to be two stories. We updated the home square footage, volume, and number of stories to match the tracking system. The simulation files also erroneously applied all glazing to only the north and east walls, which we corrected.

Table 24 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the NOLA Wise program in New Orleans. Cadmus based the analysis on savings documented within the SEEA program database.

Table 24. New Orleans SEEA BBNPs Residential Single-Family Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	777,864	21,856	921,613	20,720
Lifetime	-	-	13,814,000	324,550

* In New Orleans, three records reported missing gas savings. The above *ex ante* numbers for gas do not include savings for these projects.

As shown in Table 25**Error! Reference source not found.**, the evaluation findings for the SEEA BBNP in New Orleans resulted in a realization rate of 118.5% for electricity and 94.8% for gas.

Table 25. New Orleans SEEA BBNPs Residential Single-Family Realization Rate

Realization Rate	
Electric	Gas
118.5%	94.8%

Multifamily Participants

Although the SEEA BBNP was active in the multifamily sector, Cadmus did not receive sufficient data to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project documentation to support an evaluation of the multifamily program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the New Orleans multifamily program. Table 26 lists the *ex ante* savings calculated for the program.

Table 26. New Orleans SEEA BBNPs Multifamily Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	829,900	5,557	829,900	5,557
Lifetime	-	-	13,766,000	12,587,935

Commercial Participants

Although a SEEA BBNP for the commercial sector was active in New Orleans, Cadmus did not receive sufficient data to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project details and supporting documentation to support an evaluation of the Jacksonville commercial program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the New Orleans commercial program. Table 27 lists the *ex ante* savings calculated for the program.

Table 27. New Orleans SEEA BBNPs Commercial Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	25,900	-	25,900	-
Lifetime	-	-	399,000	-

Total Program Savings

Table 28Table 45 lists the total gross savings for the SEEA BBNP in New Orleans. These combine savings from both the residential single-family, multifamily, and commercial programs in New Orleans.

Table 28. New Orleans SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	**Therms**	**kWh**	**Therms**
Annual	1,633,664	27,413	1,777,413	26,277
Lifetime	-	-	27,979,000	12,912,485

Atlanta, Georgia (Climate Zone 3)

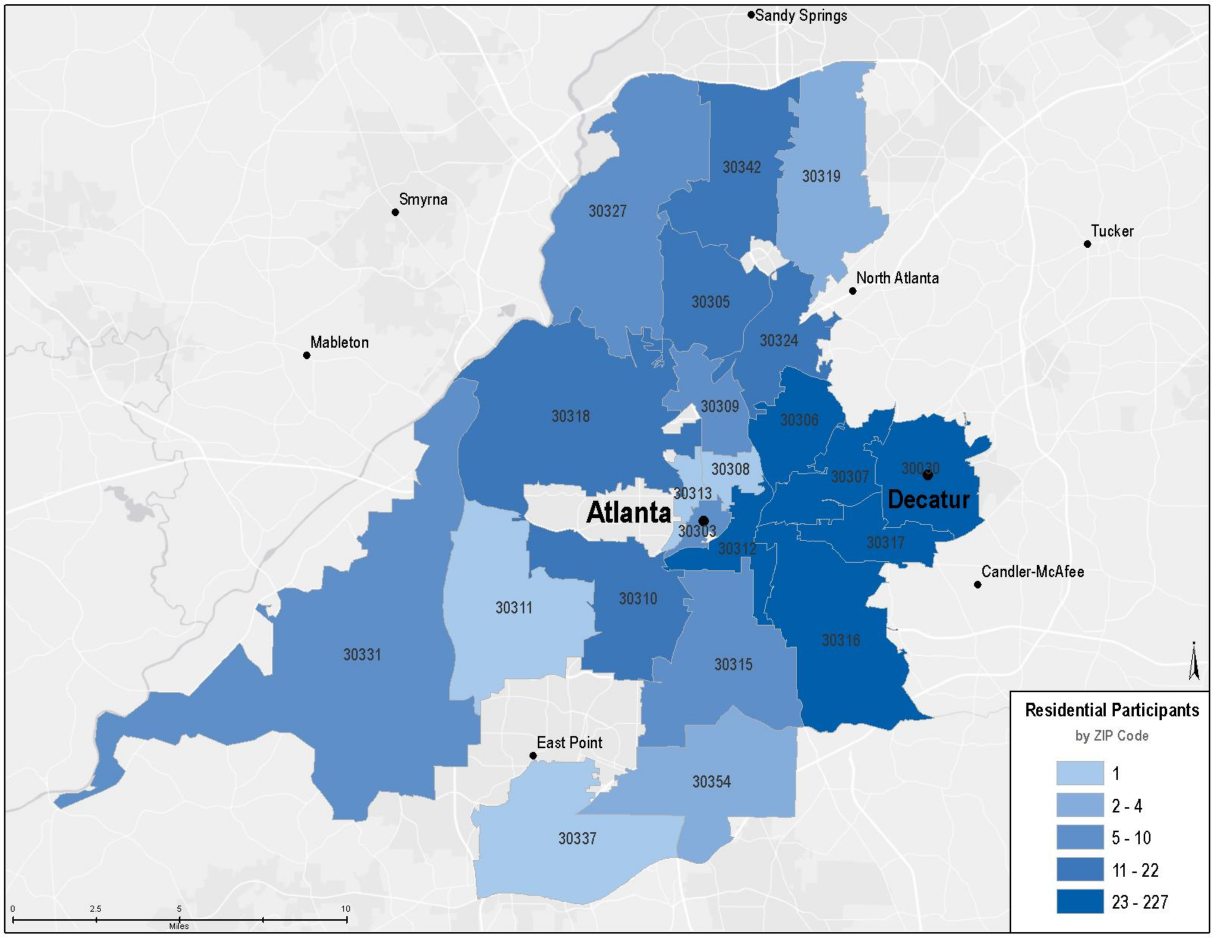
The Mayor's Office of Sustainability managed the SEEA BBNP program in Atlanta, known as the Sustainable Home Initiative for the New Economy (SHINE). The program's residential weatherization rebate services ran from May 2010 through December 2012, followed by a service offered to multifamily property owners. The first iteration of SHINE offered single-family and multifamily homeowners in the City of Atlanta a 25% rebate for the installed cost of qualifying, whole-home energy upgrades, up to $2,000. Improvements included duct and air sealing, insulation improvements, caulking, weather stripping, and window replacements. The SHINE Silver program marked the second phase of the program, offering up to a $1,500 rebate for the purchase and installation of an ENERGY STAR®-certified, high-efficiency hot water heater. The second phase of the program provided a minimum energy savings of 15% in addition to the traditional SHINE rebate opportunities. SHINE utilized the Beacon[6] tool, a whole-building (custom) method, to estimate energy savings on a household basis for the installed measures.

Residential Single-Family Participants

The SEEA BBNP had 310 participants in the residential program, which closed in December 2012. Figure 11 shows the geographical distribution of SEEA's residential customers in Atlanta, Georgia.

6 Beacon is a proprietary tool developed by ICF. The Mayor's office used it to estimate energy savings on a household basis for weather-sensitive measures.

Figure 11. SEEA Residential Participants of Atlanta, Georgia



Participants in the SHINE program most commonly installed attic insulation, conducted air and duct sealing, and added floor or foundation insulation. Table 29 lists the measure categories, types, and units installed through SHINE, along with the percentage of households receiving each measure type.

Table 29. Measures Installed under SEEA BBNP Program in Atlanta

City: Atlanta			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	257	87%
	Wall Insulation	53	18%
	Floor/Foundation Insulation	176	59%
	Windows Installed/Replaced	7	2%
	Air Sealing	276	93%
	Radiant Barrier or Vapor Barrier	12	4%
Lighting and Appliances	Lighting CFLs	25	8%
HVAC	Air Conditioner	32	11%
	Furnace	33	11%
	Heat Pump	11	4%
	Duct Sealing	169	57%
	Duct Insulation	27	9%
	Programmable Thermostat	42	14%
	HVAC tune up	21	7%
Domestic Hot Water	Water Equipment Insulation	28	9%
	Low Flow Faucet Aerator/Shower Head	1	0%
	Water Heater	32	11%

Data Available for Impact Evaluation

Cadmus reviewed the program database as well as project files for a group of participant homes. The documentation included:

- Beacon pre-installation and post-installation home energy audit reports
- Home Performance with ENERGY STAR® customer completion and rebate forms
- Home Energy Saver Reports
- SHINE City approval and period of approval forms

The participants in the SHINE program did not have electric or gas billing data available.

Cadmus reviewed the SEEA program tracking database (received in November 2013) for missing savings values, data discrepancies, savings duplicates, or data entry errors. We reviewed energy savings data in the tracking database and found:

- The tracking database had records for 310 participant households in Atlanta. Of these records, the database reported electric and gas energy savings for 307 and 271 households, respectively.
- The database did not include measure-level savings for any of the households.
- Records for six households were missing electric savings values.
- Records for nine households were missing the percentage of household electricity consumption saved due to program measure installations.

- Records for six household were missing both electric savings values and the percentages of electric consumption saved.

Evaluation Approach

Billing history (meter data) was not available for city of Atlanta. Consequently, Cadmus could not use a billing analysis approach to verify energy savings due to measures installed under the program. To estimate *ex post* energy savings, we used REM/*Rate* whole-house modeling software package to model a sample of 10 Atlanta homes for which program administrators provided documentation. From these models, we extrapolated savings at measure-level and based on the size (square footage) of the participant's home. Selected projects spanned a representative range of square footage, but otherwise we chose them randomly.

While documentation occasionally included measures not shown in the SEEA tracking database, we only included measures reported by tracking database in our models. For a group of measures less frequently installed, Cadmus employed engineering formulas and end-use energy consumptions, generated by REM/*Rate* modeling software, to evaluate associated energy savings.

To validate tracked energy savings for SEEA BBNP implemented in Atlanta, Cadmus relied primarily on the following:

- **Tracking Database Review.** Cadmus reviewed the data and measure types reported in the program tracking database, which provided energy savings at a household level.
- **Technical Desk-Review.** We collected pre- and post-measure installation building data through all of the available project documentation and satellite imaging for a random sample of 10 households participating in the program. Cadmus performed a technical desk-review of homes based on the assumptions related to the building parameters and characteristics and the measure descriptions previously used by the implementer/contractor.
- **Whole-House Energy Modeling.** We performed energy simulation, based on data collected through the technical desk-review and using the REM/*Rate* simulation software package.
- **Engineering Formulas.** We employed engineering formulas to estimate savings associated with measures not incorporated into the models.

Cadmus developed two REM/*Rate* building models for each home:

- The first model simulated the existing (or pre-measure) home's annual energy use.
- The second model simulated the home's energy use after installation of the measures.

Thus, the energy savings equaled the difference in annual energy use between the as-built (pre-measure installation) home and the upgraded home.

While we randomly selected the households, we also ensured that the 10 sampled participant homes were representative of the of house size ranges across the full Atlanta census. Table 30 shows square footage of each Atlanta evaluated home.

Table 30. Square Footage of Atlanta Evaluated Households

Household Number	Square Footage
1	1,490
2	1,530
3	1,550
4	1,720
5	2,120
6	2,500
7	2,888
8	3,054
9	4,084
10	5,341

Table 31 shows percentage of various house size categories in the Atlanta population versus the sample population.

Table 31. Square Footage of SEEA BBNP Households in Atlanta

House Size Category	Percentage of Households in the Atlanta Population	Percentage of Households in the Sample Population
0-1,000	2%	0%
1,000-2,200	48%	50%
2,200-3,500	35%	30%
≥3,500	15%	20%

Extrapolation of Measure Level Savings

For the SEEA BBNP in Atlanta, Cadmus assessed the contribution of measure groups using a combination of the REM/*Rate* modeling and engineering algorithms for non-modeled measures. In this section we discuss both the approach and findings for the following groups:

- Building envelope measures (modeling)
- Lighting measures (engineering algorithms)
- HVAC measures (engineering algorithms)
  - Air conditioning
  - Heat pumps
  - Radiant barriers
  - Solar water heaters
- Domestic hot water measures (engineering algorithms)
  - Electric water heaters
  - Solar water heaters

Building Envelope Measures

Cadmus estimated the energy savings associated with the following building envelope measure types using REM/*Rate*'s Savings per Component report for the 10 evaluated homes:

- Attic insulation
- Floor/foundation insulation
- Wall insulation
- Air infiltration
- Duct sealing
- Windows installed/replaced

Due to similarities in EUI, and therefore energy savings in houses within the same size categories, Cadmus stratified the SHINE program participants by four major square footage categories:

- 0 to 1,000
- 1,000 to 2,200
- 2,200 to 3,500
- ≥3,500

We then estimated the average energy savings per square foot (SF) (kWh/SF or therms/SF) for each category.

For the six building envelope measures, if the tracking system indicated a household installed the relevant measure, we awarded the household the appropriate energy savings per square foot, depending upon the stratification group of the square footage range. If square footage was not reported, we assumed the home had the average square footage of all Atlanta homes. (We based average square footage of Atlanta homes square footage reported in the database or found in project documentation.)

Table 32 shows average energy savings (kWh) per measure type per house size (SF) for each house size category in the Atlanta population.

Table 32. Energy Savings (kWh) per House Size (SF) in Atlanta

	Average kWh Savings per House Area (SF)					
Size Category	Attic Insulation	Floor/ Foundation Insulation	Wall Insulation	Air Sealing	Duct Sealing/ Insulation	Windows Installed/ Replaced
0-1,000	0.0166	0.0103	-0.0009	0.0041	0.1024	0.5107
1,000-2,200	0.0166	0.0103	-0.0009	0.0041	0.1024	0.5107
2,200-3,500	0.1013	0.0220	-0.0009	0.2331	0.2736	0.6035
≥ 3,500	-0.0119	-0.0075	-0.0009	0.0752	0.0969	0.1430

Lighting Measures

For many Atlanta households receiving lighting measures, the SEEA tracking database did not report the existing lamp wattages, installed lamp wattages, or quantity of installed lamps. Cadmus reviewed the provided documentation for several households with lighting measures installed, and formulated the following approach:

- Where the tracking database indicated a quantity of installed CFLs greater than one, we calculated the savings using the reported quantity y. A value of “1” in the tracking database denoted that only CFLs were installed and did not indicate of the number of lamps installed.
- Where the tracking database indicated a quantity of “1” installed CFL and the measure quantity was missing, we assumed the household installed the average number of lamps per lighting measure type in Atlanta.
- As the data did not include information on the wattages of either of the existing or replacement lamps, Cadmus assumed replacements of 40 watt (W) incandescent bulbs with 15W CFLs. The team further assumed usage rates of 2.15 hours of use per day, with a 90% in-service rate.

We used the following engineering formula to estimate lighting energy savings:

$$\Delta kWh_{CFL} = \left(\frac{40W - 15W}{1000}\right) \times \left(365 days \times 2.15 \, {}^{hrs}/_{day}\right) \times (\# \, of bulbs) \times 90\%$$

Weather-Sensitive Measures

For the weather-sensitive measures, we estimated the consumption per load type factored in the engineering formulas by calculating the average consumption per load type per square footage of the modeled homes. As a result, the estimated total consumption per load type for each household was a product of the average consumption per load type per square footage multiplied by the home’s size (SF).

For households with no record of square footage either in the SEEA tracking database or available project documentation, Cadmus assumed the missing home size is the average home size of all participants’ homes in Atlanta.

$$(Estimated\ Consumption\ [kWh])_{per\ load\ type} = \left(Estimated\ Consumption\ per\ Sq.Ft. \left[\frac{kWh}{ft^2}\right]\right)_{per\ load\ type} \times Home\ Size\ [ft^2]$$

Table 33 shows pre-retrofit electricity and gas energy consumption per house square footage.

Table 33. Pre-Retrofit Energy Consumption per House Size (SF) in Atlanta

Size Category	Number of Modeled Homes	Pre-Retrofit Consumption per House Area (SF)	
		Electric Consumption (kWh/SF)	Gas Consumption (Therms/SF)
0-1,000	0	6.31	0.58
1,000-2,200	5	6.31	0.58
2,200-3,500	3	6.84	0.35
≥3,500	2	4.39	0.48

Table 34 shows post-retrofit electricity and gas energy consumption per house square footage per load type.

Table 34. Post-Retrofit Energy Consumption (kWh) per House Size (SF) per Load Type in Atlanta

Size Category	Number of Modeled Homes	Post-Retrofit Consumption per House Area (SF)				
		Heating (kWh)	Cooling (kWh)	Water Heating (kWh)	Heating (Therms)	Water Heating (Therms)
0-1,000	0	0.28	1.65	1.22	0.36	0.05
1,000-2,200	5	0.28	1.65	1.22	0.36	0.05
2,200-3,500	3	1.81	1.30	0.45	0.20	0.04
≥3,500	2	0.16	1.47	0.45	0.23	0.02

HVAC Measure Category

Air Conditioning

Cadmus awarded energy savings associated with air conditioning measures based on the efficiency (Seasonal Energy Efficiency Ratio [SEER]) of the installed unit and the average annual electric cooling consumption based on modeling 10 evaluated homes. We calculated an average electric cooling consumption per square footage for the 10 models per house size categories (kWh/SF). We then multiplied this value by the square footage of each participant's home to estimate its annual cooling consumption.

The tracking database provided SEER values for six of the 29 air conditioner measures installed under the SHINE program. Where we could determine a given project's SEER, we used it to calculate savings. For the remaining records, we used the average SEER for air conditioner measures installed in Atlanta to calculate savings. Cadmus assumed a baseline efficiency of 9 SEER.

We employed the following engineering formula to estimate energy savings:

$$\Delta kWh_{AC} \;=\; 3.412 \times \left(\frac{1}{9SEER} - \frac{1}{SEER\ Installed}\right) \times (Estimated\ Cooling\ Consumption\ [kWh])$$

Heat Pumps

Cadmus awarded heat pump savings based on the efficiency (SEER and Heating Seasonal Performance Factor [HSPF]) of the installed unit and the estimated electric heating and cooling consumption for each household. The tracking database did not report the unit's capacity for the 11 heat pump measures installed under the SHINE program. In order to calculate the annual heating and cooling consumption, we estimated electric heating and cooling consumption for the 10 models previously described and calculated an average value per square foot for each size category. We then multiplied this value by the square footage of each home to estimate annual heating and cooling consumption.

$$(Estimated\ Consumption\ [kWh])_{seasonal} = \left(Estimated\ Consumption\ per\ Sq.Ft.\left[\frac{kWh}{ft^2}\right]\right)_{seasonal} \times Area\ of\ Conditioned\ Space\ [ft^2]$$

The tracking database did not provide SEER values for the 11 heat pump measures installed under the SHINE program, but provided HSPF values for four heat pumps. If available, we used an HSPF value specific to the house to calculate savings. For the remaining records, we used the average HSPF for heat pump measures installed in Atlanta to calculate savings. Cadmus used the average heat pump HSPF (8.6 HSPF) for all heat pumps installed under the SHINE program. For all heat pumps, we assumed a baseline efficiency of 7.6 HSPF and 13 SEER.

Cadmus used the following engineering formula to estimate energy savings:

$$\Delta kWh_{HP} = 3.412 \times \left[\left(\frac{1}{7.6HSPF} - \frac{1}{HSPF\ Installed}\right) \times (Estimated\ Heating\ Consumption\ [kWh])\right] + 3.412 \times \left[\left(\frac{1}{13SEER} - \frac{1}{SEER\ Installed}\right) \times (Estimated\ Cooling\ Consumption\ [kWh])\right]$$

Radiant Barriers

Cadmus estimated energy savings associated with radiant barriers installed under the program utilizing REM/*Rate* whole-house modeling after the radiant barrier was added to the 10 evaluated homes. Cadmus awarded a deemed savings of 271 kWh, an average savings value for all of the 10 modeled homes, to each home that installed this measure type under the SHINE program.

Domestic Hot Water Measures

Electric Water Heaters

Cadmus calculated saving for electric water heaters based on the efficiency (energy factor [EF]) of the installed unit and the assumed electric water heating consumption for each relevant project. Cadmus extrapolated electric water heating consumption post-retrofit (where relevant) for the models previously discussed and found an average value per square foot for each size category. If data were not available for a given size category, we used the value taken from the closest category with relevant data. We then multiplied this value by the square footage of each home to determine its assumed water heating electric consumption.

The tracking database reported EF values for all of the seven energy-efficient electric water heater measures installed under the SHINE program. Therefore, we calculated the savings c using a project-specific EF. For all electric water heaters, we estimated a baseline efficiency of 0.86 EF.

Cadmus used the following engineering formulas to estimate energy savings:

$$\Delta kWh_{WH} = \left(\frac{1}{0.86EF} - \frac{1}{EFee}\right) \times (Estimated\ Water\ Heating\ Consumption\ [kWh])$$

Solar Water Heaters

We estimated energy savings associated with solar water heaters installed under the program using the System Advisor Model [7] (SAM), developed by National Renewable Energy Laboratory. Cadmus awarded each of the five homes deemed savings of 648 kWh based on the energy savings reported by the model.

Energy Savings Impact Findings (Residential Single-Family Homes)

In addition to the measure-level analysis described above, Cadmus reviewed the gas and electric savings and consumption for the ten whole-house models. The results are described in the following sections.

Electricity

Since most of the modeled homes used natural gas heating systems,[8] the changes in electric energy use due to installation of envelope measures typically resulted from changes in air conditioning use, air handler fan operations during heating, and increased use of whole-home mechanical ventilation.

As shown in Figure 12, the percentage of electric energy savings varied between *ex ante* and *ex post* savings.

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7 National Renewable Energy Laboratory. “System Advisor Model (SAM).” Last modified April 5, 2010. Accessed November 8, 2013. https://sam.nrel.gov/.

8 One home had an air-source heat pump.

Due to the addition of whole-home mechanical ventilation systems and other potential interactive modeling effects, one model result showed negative electric savings. The team expects that the negative savings for Home 9 are likely due to interactive effects from the heat transfer to air conditioning ducts in the attic, and reduced heat transfer between the house and the attic. In Atlanta's climate zone, the seasonal average temperature is lower than the set point of most homes. Consequently, when a home is tightened, the cooling effect of ambient temperatures reduces over a season, producing an affect that can override energy savings associated with time outside of that window, thus resulting in negative cooling savings. Additionally, buffering the conditioned space of a home from an attic through adding envelope insulation contributes to negative cooling savings through increasing attic temperatures, increasing the heat transferred from the attic to the ducts. The reduction in heat transfer from the attic to the conditioned space due to insulation is less than the increase from the attic to the ducts. .

Regarding the estimates from the SEEA database and the REM/*Rate* models, Figure 12 shows the *ex ante* versus *ex post* percentage of electric energy-savings estimates.

Figure 12. Percentage of *Ex Post* and *Ex Ante* Electric Savings by Household, Atlanta

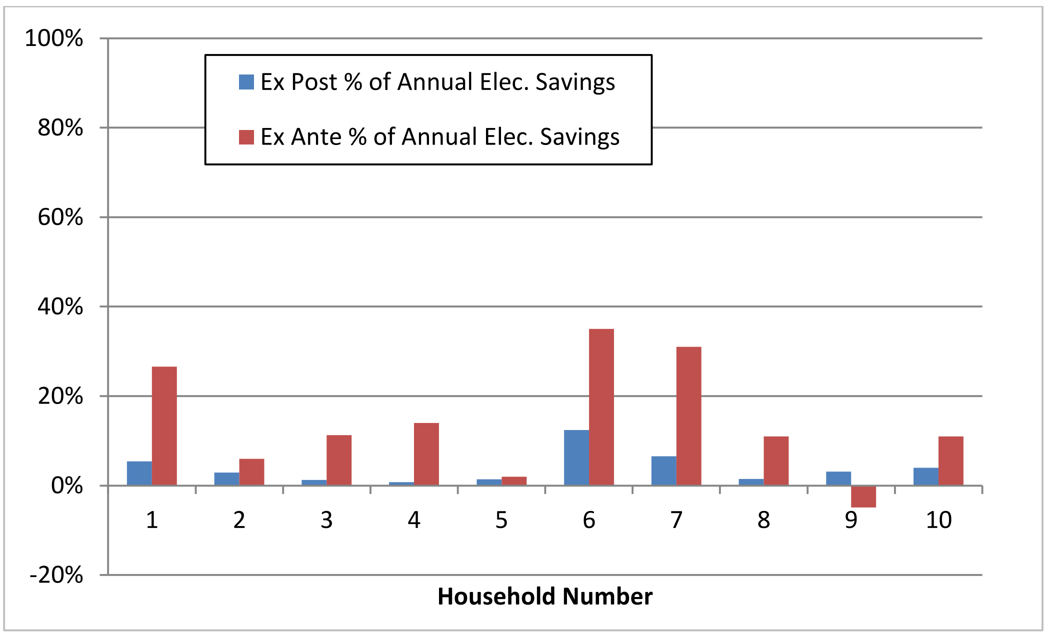
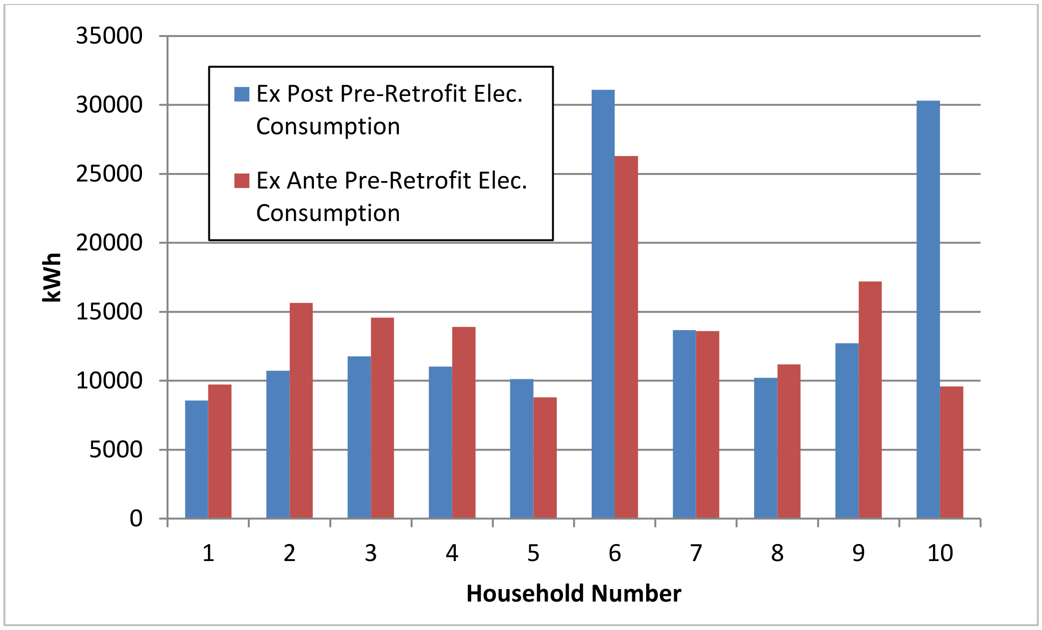


Figure 13 shows the *ex ante* versus the *ex post* pre-retrofit electric consumption.

Figure 13. *Ex Post* and *Ex Ante* Pre-Retrofit Electric Consumption, Atlanta



The EUI of a home is typically expected to decrease gradually as the house size increases, due largely to appliance and other usage patterns that do not scale with home size. Figure 14 and Figure 15 show the *ex post* and *ex ante* EUI by square footage, respectively.

Figure 14. *Ex Post* Electric Utilization Index by Square Footage, Atlanta

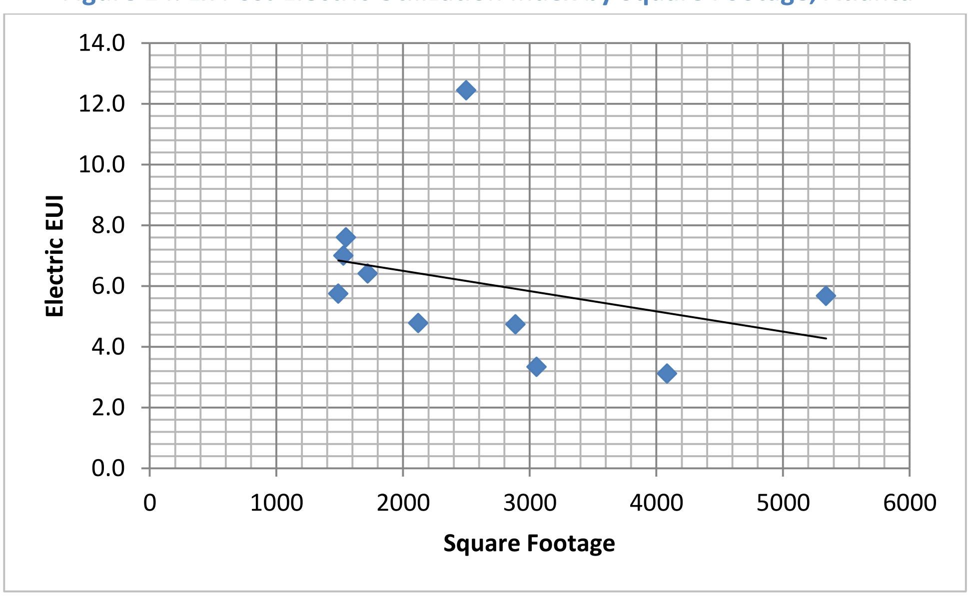
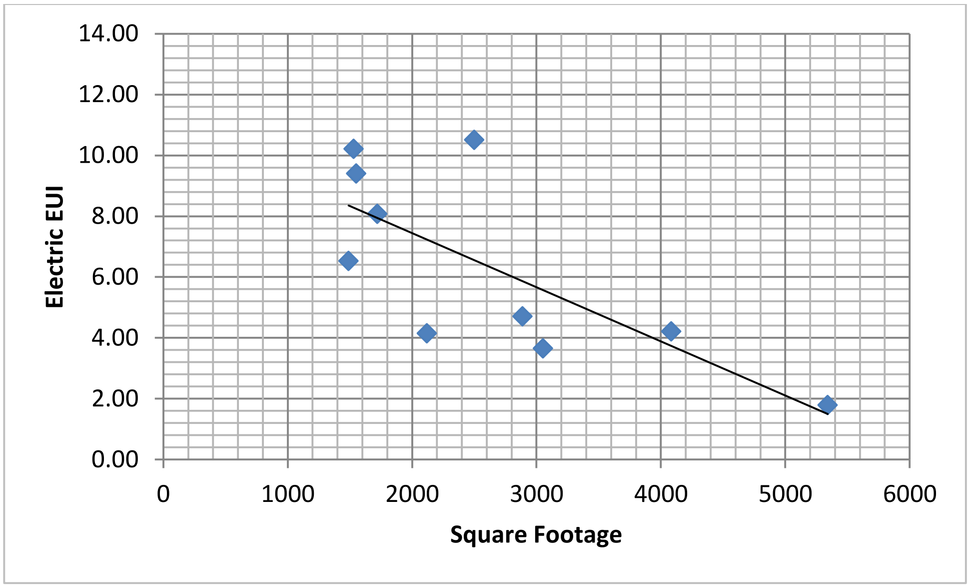


Figure 15. *Ex Ante* Electric Utilization Index by Square Footage, Atlanta



Gas

Figure 16 shows *ex post* versus *ex ante* pre-retrofit annual gas consumption for the 10 evaluated homes in the SHINE program. We sorted houses 1 to 10 by size, from smallest to biggest. Home 5 indicates overestimated pre-retrofit gas consumption compared to its square footage. Home 6 has an air-source heat pump and zero gas consumption.

Figure 16. *Ex Post* and *Ex Ante* Pre-Retrofit Gas Consumption, Atlanta

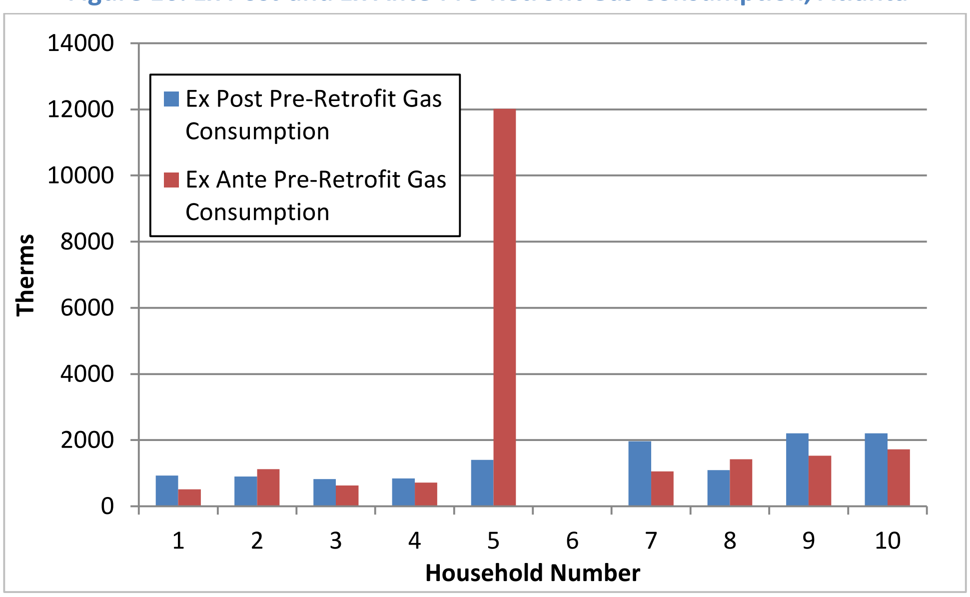
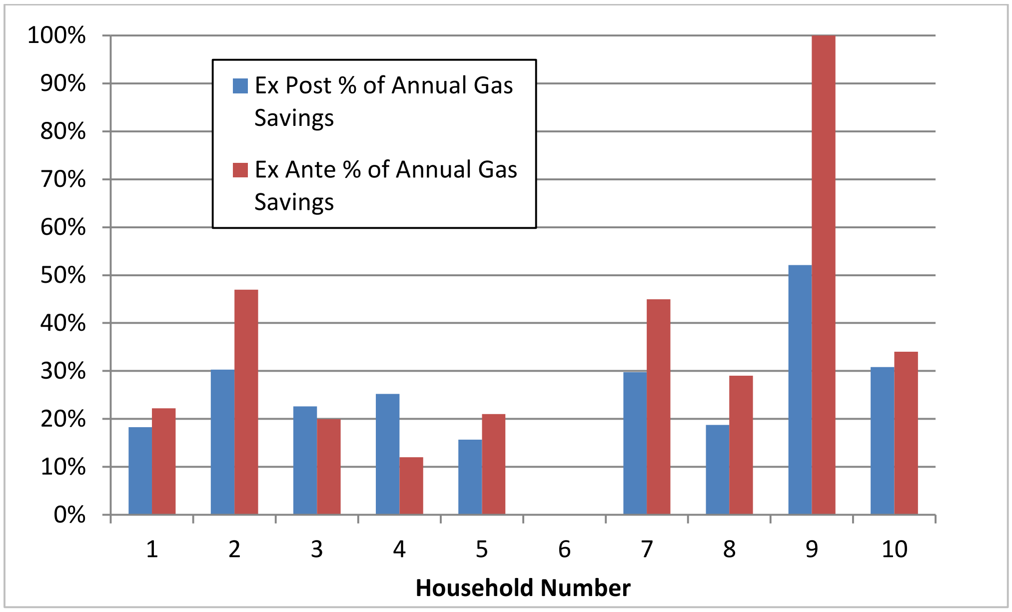


Figure 17 shows the percentage of *ex post* versus *ex ante* gas savings by household for evaluated homes. Home 9 indicates 100% annual gas savings, which is an incorrect estimate.

Figure 17. Percentage of *Ex Post* and *Ex Ante* Gas Savings by Household, Atlanta



Summary of Ex Post Measure-Level Savings (Residential Single-Family Homes)

Using the previously described methodologies to extrapolate measure-level savings for all Atlanta households, Cadmus used the sum of all electric savings to compare our calculated electric savings with those reported in the SEEA tracking database.

Table 35 shows energy savings (kWh) per each measure type installed through the SHINE program.

Table 35. *Ex Post* Residential Measure-Level Energy Savings (kWh) in Atlanta

Measure Category	Measure Type	kWh Savings by Measure	Percentage of Total kWh Savings
Building Shell	Attic Insulation	21,832.2	11.1%
	Wall Insulation	(110.5)	-0.1%
	Floor/Foundation Insulation	3,865.3	2.0%
	Windows Installed/Replaced	5,647.3	2.9%
	Air Sealing	60,664.7	30.8%
	Radiant Barrier or Vapor Barrier	1,518.0	0.8%
Lighting and Appliances	Lighting CFLs	7,671.9	3.9%
HVAC	Air Conditioner	18,042.5	9.2%
	Heat Pump	3,249.0	1.6%
	Duct Sealing and Insulation	58,085.6	29.5%
Domestic Hot Water	Heat Pump Water Heater	13,386.4	6.8%
	Solar Water Heater	3,240.0	1.6%
	TOTAL	**197,092.3**	**100.0%**

Table 36 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the SEEA BBNP in Atlanta. Cadmus based the analysis on savings documented within the SEEA program database.

Table 36. Atlanta SEEA BBNPs Residential Single-Family Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	1,273,674	136,980	197,092	78,946
Lifetime	-	-	2,783,000	1,282,531

* In Atlanta, six records were missing electric savings values. Neither *ex ante* nor *ex post* numbers for electricity include energy savings for these households.

As shown in Table 37 evaluation findings for the SEEA BBNP in Atlanta resulted in realization rates of 15.5% for electricity and 57.6% for gas. We estimated the gas realization rate utilizing the energy savings generated by the REM/*Rate* model.

Table 37. Atlanta SEEA BBNPs Residential Single-Family Realization Rate

Realization Rate	
Electric	Gas
15.5%	57.6%

Multifamily Participants

Although the SEEA BBNP was active in multifamily sector, Cadmus did not receive sufficient data to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project documentation to support an evaluation of the multifamily program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the Atlanta multifamily program. Table 38 lists the *ex ante* savings calculated for the program.

Table 38. Atlanta SEEA BBNPs Multifamily Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	30,714	1,160	30,714	1,160
Lifetime	-	-	52,000	201,099

Total Program Savings

Table 39 shows total gross savings for the SEEA BBNP in Atlanta. These combine savings from both the residential single-family and multifamily programs in Atlanta.

Table 39. Atlanta SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	1,304,388	138,140	227,806	80,106
Lifetime	-	-	2,834,000	1,483,630

Charleston, South Carolina (Climate Zone 3)

Residential Single-Family Participants

CharlestonWISE, operated by local nonprofit, the Sustainability Institute (SI), offers homeowners in and around Charleston low-cost assessments and up to $1,500 in instant rebates on completed home performance improvements for qualified residential customers. This is on top of rebates available from local utility companies. The program offers incentives for implementation of HVAC, building shell, lighting, appliance, and domestic water heating measures. To estimate energy savings for the measures offered through the program, SI utilizes multiple tools including Beacon, CSG Real Home Analyzer, and REM/*Rate* package software. SI had 127 households participate in the CharlestonWISE program during the evaluation timeframe, and operations continue.

Figure 18 shows the geographical distribution of SEEA BBNP residential participants in Charleston, South Carolina.

Figure 18. SEEA BBNP Residential Participants in Charleston, South Carolina

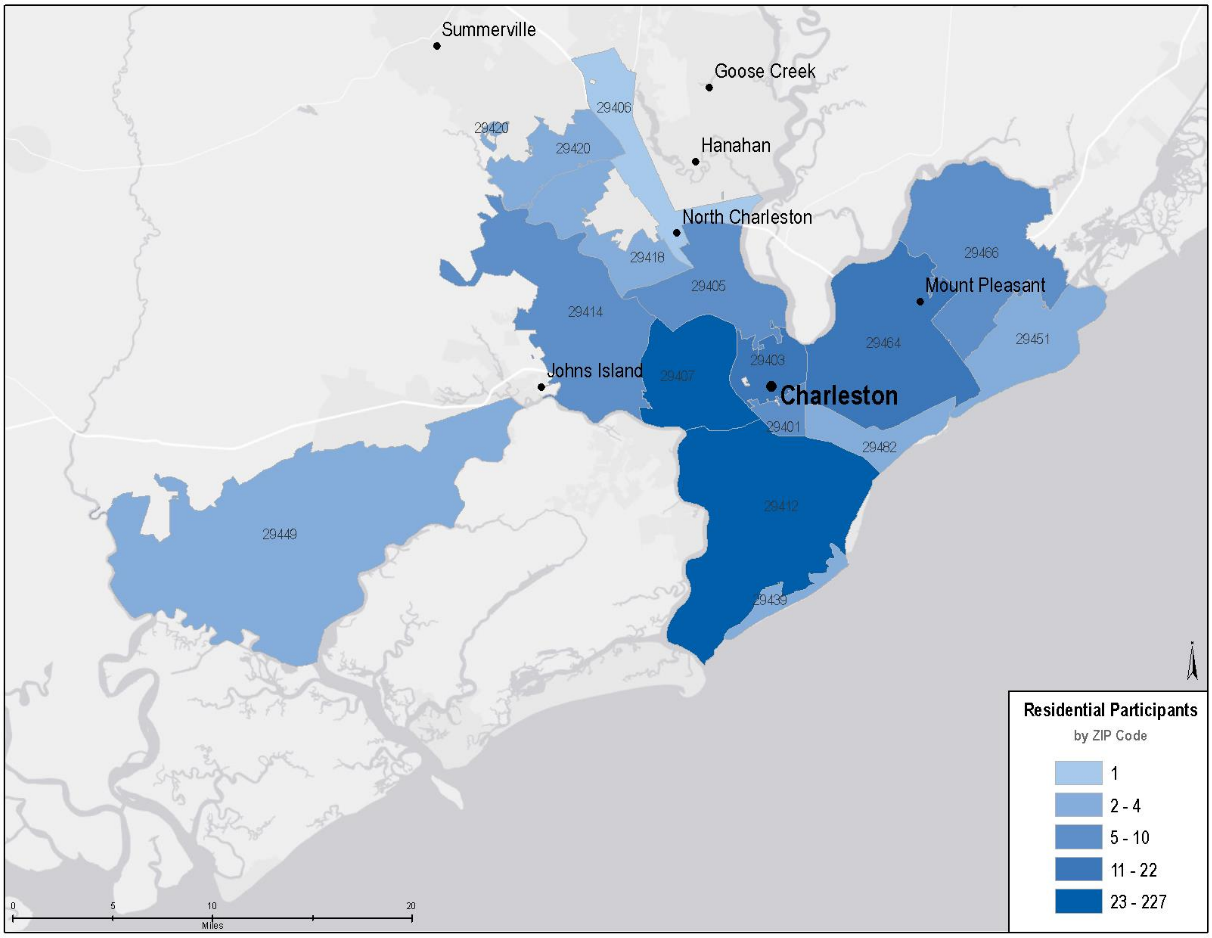


Table 40 lists measure categories, types, and units installed through the CharlestonWISE program, along with the percentage of households receiving each measure type.

Table 40. Measures Installed under SEEA BBNP in Charleston

City: Charleston			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	107	84%
	Wall Insulation	13	10%
	Floor/Foundation Insulation	12	9%
	Windows Installed/Replaced	1	1%
	Air Sealing	119	94%
	Radiant Barrier or Vapor Barrier	14	11%
Lighting and Appliances	Lighting CFLs	25	20%
	Refrigerator	4	3%
HVAC	Air Conditioner	26	20%
	Furnace	17	13%
	Heat Pump	20	16%
	Duct Sealing	107	84%
	Duct Insulation	63	50%
	Programmable Thermostat	19	15%
	HVAC tune up	13	10%
Domestic Hot Water	Water Equipment Insulation	1	1%
	Low Flow Faucet Aerator/Shower Head	4	3%
	Water Heater	15	12%

Data Available for Impact Evaluation

Cadmus reviewed the SEEA tracking database (received November 2013) and the available program data and found the tracking database reported 127 records for Charleston. Of these records, 127 of included electric savings and 57 included natural gas savings associated with installed program measures.

Cadmus reviewed electricity savings data in the tracking database and found:

- Records for nine households were missing electric savings values.
- Records for five households were missing the percentage of household electricity consumption saved due to program measure installations.
- Records for four household were missing both electric savings values and the percentages of electric consumption saved.

For the gas savings in the tracking database, we found:

- Records for three households were missing gas savings values.
- Records for four households were missing percentages of household gas consumption saved due to program measure installation.
- Records for three households were missing both gas savings values and percentages of gas consumption saved.

Cadmus also found the following during its database review;

- Measure-level savings were not available for any of the households.
- Electric or gas billing history (meter data) was not available.
- Project documentation was not available for households participating in the program.

Evaluation Approach

For the impact evaluation of the SEEA BBNP in Charleston, Cadmus reviewed the program database and the reported household energy savings. With no billing data or project documentation available, we compared the percentage of expected savings to other programs. The electric realization rate was extrapolated from the realization rate for Jacksonville, Florida, due to having a similar percentage of *ex ante* savings. We derived gas realization rates from the program's overall average realization for gas due to insufficient data in the SEEA database, project documentation, and billing data.

Total Program Savings

Table 41 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the SEEA BBNP Program in Charleston. Cadmus based the analysis on savings documented within the SEEA program database.

Table 41. Charlotte SEEA BBNPs Residential Single-Family Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	573,104	9,002	387,802	6,661
Lifetime	-	-	5,110,000	106,574

* In Charleston, four records were missing electric savings, and an additional five records only showed electric savings as a percentage. Three records were missing gas savings. *Ex ante* numbers do not include savings for these projects.

As Table 42 shows, evaluation findings for the SEEA BBNP in Charleston resulted in realization rates of 67.7% for electricity and 74.0% for gas. The electric realization rate was extrapolated from the realization rate for Jacksonville, Florida, due to having a similar percentage of *ex ante* savings.

Table 42. Charlotte SEEA BBNPs Residential Single-Family Realization Rate

Realization Rate	
Electric	Gas
67.7%	74.0%

Charlotte, North Carolina (Climate Zone 3)

Multifamily Participants

Although the SEEA BBNP was active in the multifamily sector, Cadmus did not receive sufficient data to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project documentation to support an evaluation of the multifamily program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the Charlotte multifamily program. Table 43 lists the *ex ante* savings calculated for the program.

Table 43. Charlotte SEEA BBNPs Multifamily Gross Savings Summary

	Ex Ante Gross Savings	
	kWh	Therms
Annual	963,921	3,867

Commercial Participants

Although a SEEA BBNP for the commercial sector was active in Charlotte, Cadmus did not receive sufficient data to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project details and supporting documentation to support an evaluation of the Jacksonville commercial program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the Charlotte commercial program. Table 44 lists the *ex ante* savings calculated for the program.

Table 44. Charlotte SEEA BBNPs Commercial Gross Savings Summary

	Ex Ante Gross Savings	
	kWh	Therms
Annual	120,341	194

Total Program Savings

Table 45 lists the total gross savings for the SEEA BBNP in Charlotte. These combine savings from both the multifamily and commercial programs in Charlotte.

Table 45. Charlotte SEEA BBNPs Overall Gross Savings Summary

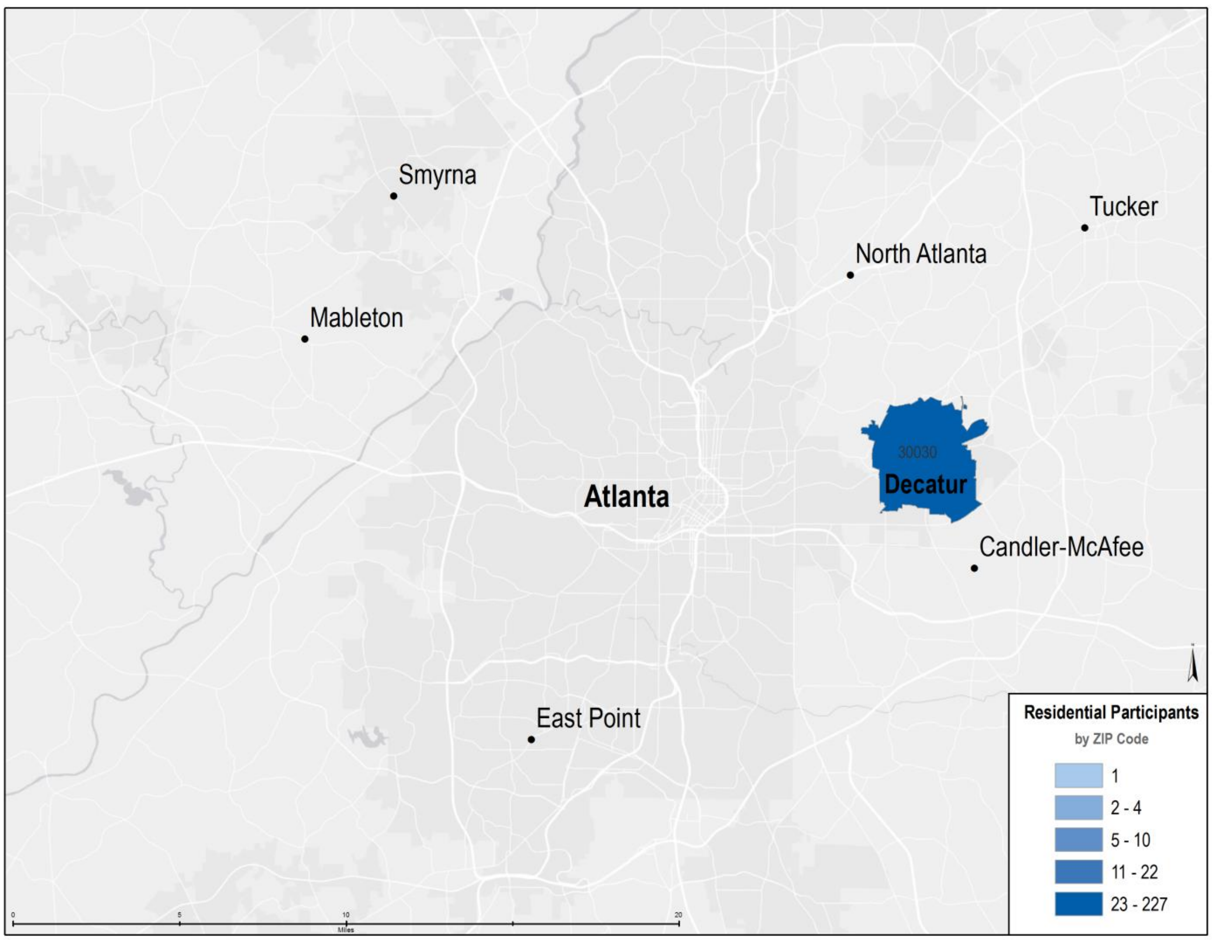
	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	1,084,262	4,061	1,084,262	4,061

Decatur, Georgia (Climate Zone 3)

Residential Single-Family Participants

The small city of Decatur, located in the greater Atlanta metro area, implemented its own program with the assistance of CLEAResult.[9] Like Atlanta's SHINE program, DecaturWISE offered residential participants who achieved at least a 15% reduction in energy use an additional rebate on top of Home Improvement Program rebates available through Georgia Power. Eligible measures included envelope improvements, HVAC equipment, and water heaters. Program staff utilized the Beacon tool to estimate energy savings for the weather-sensitive measures offered through the program. DecaturWISE lasted just six months, but during that time had 54 residential participants. Figure 19 shows the geographical distribution of SEEA BBNP residential participants in Decatur, Georgia.

Figure 19. SEEA BBNP Residential Participants in Decatur, Georgia



[9] CLEAResult is an independent firm that partners with energy management program administrators to assist in program implementation, design, and/or evaluation.

Table 46 lists the measure categories, types, and units installed through the program in Decatur, along with the percentage of households receiving each measure type.

Table 46. Measures Installed under SEEA Program in Decatur

City: Decatur			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	54	100%
	Floor/Foundation Insulation	45	83%
	Air Sealing	54	100%
HVAC	Air Conditioner	12	22%
	Furnace	6	11%
	Heat Pump	3	6%
	Duct Sealing	45	83%
	Duct Insulation	24	44%
Domestic Hot Water	Water Heater	6	11%

Data Available for Impact Evaluation

Cadmus reviewed the SEEA program database, project files, and billing data available for the DecaturWISE program and found the tracking database included 54 records for Decatur. Of these records, 54 included electric savings and 48 included natural gas savings associated with installed program measures.

For the electricity savings data in the tracking database, Cadmus found:

- No household records with missing electric savings values.
- One household record was missing the percentage of household electricity consumption saved due to program measure installation.
- All households records showed electric savings values or a percentage of electricity consumption saved.

For the gas savings in the tracking database, we found:

- No household records with missing gas savings values.
- Four household records were missing the percentage of household gas consumption saved due to program measure installation.
- All households records showed gas savings values or a percentage of gas consumption saved.

Cadmus also found:

- The database did not include household measure-level savings for any of these households.
- Sufficient electric billing history (meter data) was available for 43 households participating in SEEA BBNP in Decatur.

- Gas billing history (meter data) was not available for households participating in DecaturWISE.

Project files received for 54 DecaturWISE program participants included:

- Beacon post-installation home energy audit reports
- Home assessment and whole-house improvement rebate forms
- Terms and conditions
- Decatur WISE rebate application
- Contractor scope of work

Evaluation Approach

To evaluate *ex ante* savings, Cadmus performed billing analysis. The billing analysis resulted in a low electric realization rate of 25.5%. To confirm this finding, Cadmus performed technical desk-reviews and a whole-house energy simulation for a sample of three participant homes based on available project data and documentation. We calibrated the energy savings generated by whole-house modeling to actual participant consumption data and adjusted the energy savings proportionately. Ultimately, the calibrated energy savings (resulting in average realization rate of 20%) explained the low realization rate estimated through billing analysis.

Table 47. The SEEA Program Impact Evaluation Activities for Decatur

Activity	Completed Sample Size (n)
Review of the program database	n/a
Engineering assessment of energy savings using REM/*Rate* modeling software and calibrating to actual consumption data to confirm the billing analysis results	3
Billing analysis (electricity)	43

To validate tracked energy savings for the SEEA BBNP in Decatur, Cadmus relied primarily on the following:

- **Tracking Database Review.** Cadmus reviewed the data and measure types reported in the program tracking database, which provided energy savings at a household level.
- **Technical Desk-Review.** We collected pre- and post-measure installation building data through all available project documentation and satellite imaging for a random sample of three households participating in the program. We performed a technical desk-review of homes based on the assumptions related to the building parameters and characteristics and the measure descriptions previously used by the implementer/contractor.
- **Billing Analysis.** Cadmus compared participant billing data for a period of time before the installation of energy-efficient measures to post-installation billing data. See the Billing Analysis section for the details.

- **Whole-House Energy Modeling.** We performed energy simulation using data collected through the technical desk-review and the REM/*Rate* simulation software package.
- **Model Calibration.** To estimate the evaluated home's *ex post* energy savings, we calibrated the energy savings generated by REM/*Rate* models to the home's actual annual consumption data and adjusted the savings proportionately.

Energy Savings Assessment. Cadmus assessed the reported savings by comparing the reported savings to simulated savings using REM/*Rate.* We developed two REM/*Rate* building models for each home:

- The first model simulated the existing (or pre-measure) home's annual energy use.
- The second model simulated the home's energy use after installation of the installed measures.

Thus, the pre-calibration energy savings equal the difference in annual energy use between the as-built (pre-measure installation) home and the upgraded home.

Cadmus considered the three sampled participant homes representative of the range of house sizes across the full Decatur census. Table 48 shows square footage of each modeled home.

Table 48. Square Footage of Modeled Households

Household Number	Square Footage
1	2,044
2	2,800
3	3,078

Table 49 shows the percentage of various house size categories in the Decatur population versus the sample population.

Table 49. Square Footage of Decatur BBNP Households

House Size Category	Percentage of Households in the Decatur Population	Percentage of Households in the Sample Population
0-1,000	0%	0%
1,000-2,200	89%	33%
2,200-3,500	11%	66%
≥ 3,500	0%	0%

Energy Savings Impact Findings (Residential-Single Family Homes)

Electricity

For the three homes modeled, the electric savings percentages were found to diverge noticeably between the reported *ex ante* and modeled *ex post* values. Changes in electric energy use due to program envelope measures typically resulted from changes in air conditioning use, air handler fan operations during heating, and increased use of whole-home mechanical ventilation; the evaluated homes used natural gas heating systems, so shell and HVAC alterations would more greatly impact gas consumption. Figure 20 shows estimates for *ex ante* versus *ex post* percentage of electric savings.

Figure 20. Percentage of *Ex Ante* and *Ex Post* Electric Savings by Household, Decatur

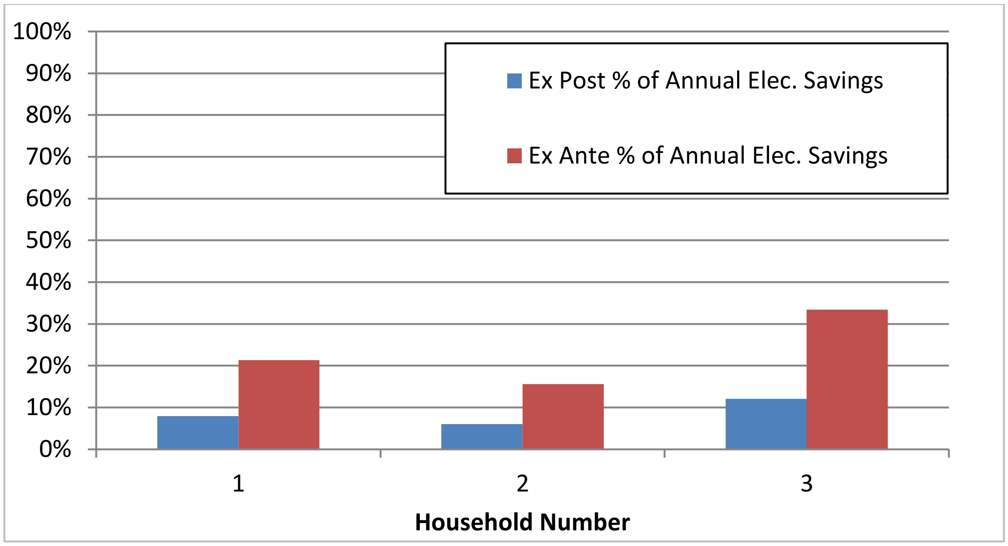
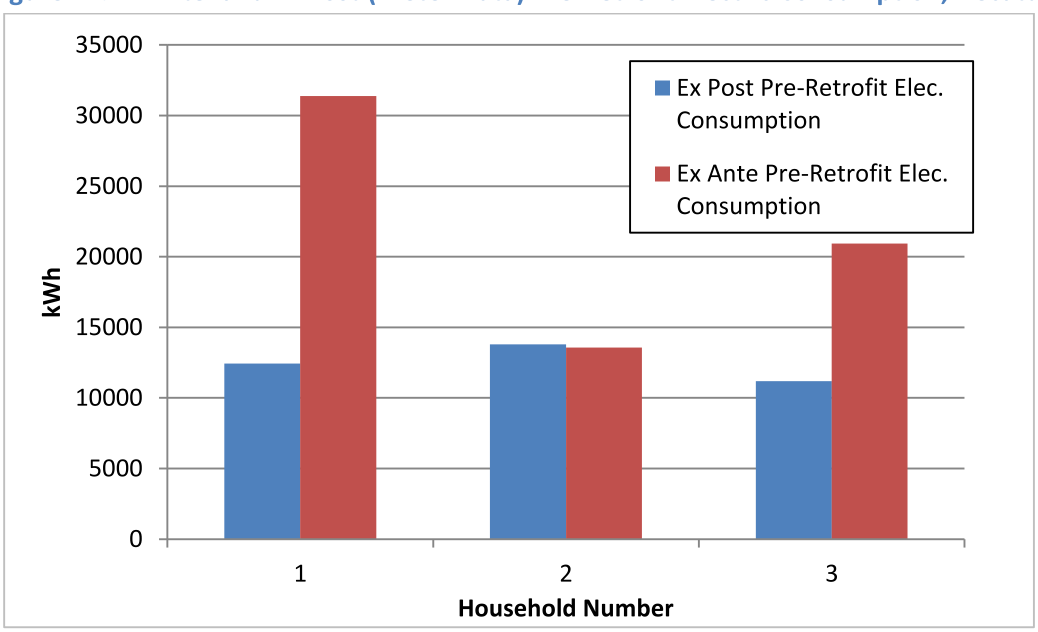


Figure 21 shows *ex ante* versus *ex post* values for the pre-retrofit electric consumption. The *ex post* pre-retrofit consumption shown here is equal to the actual electric consumption indicated by the evaluated homes' billing data (meter).

Figure 21. *Ex Ante* and *Ex Post* (Meter Data) Pre-Retrofit Electric Consumption, Decatur



The EUI of a home is typically expected to decrease gradually as the house size increases, due largely to appliance and other usage patterns that do not scale with home size. Figure 22 and Figure 23 show *ex post* and *ex ante* EUI by square footage, respectively.

Figure 22. *Ex Post* Electric Utilization Index by Modeled Home Square Footage, Decatur

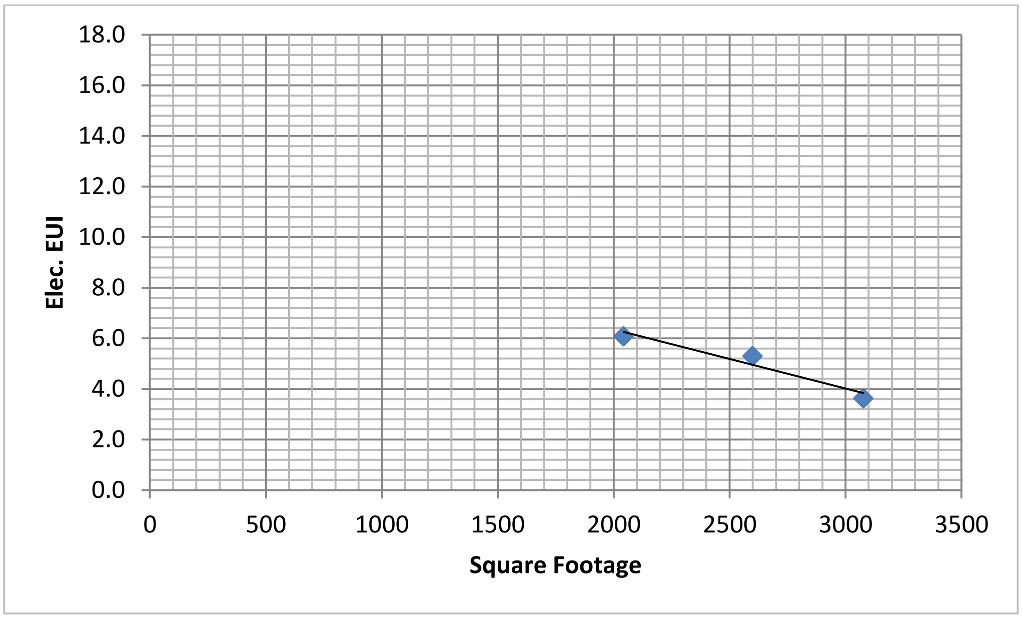
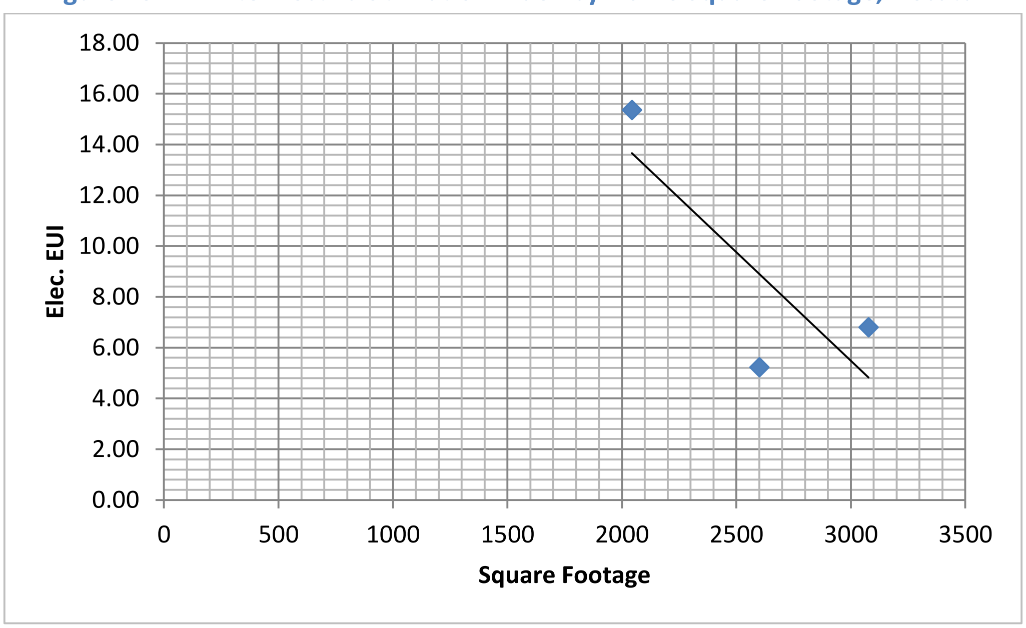


Figure 23. *Ex Ante* Electric Utilization Index by Home Square Footage, Decatur



Gas

As shown in Figure 24 and Figure 25, the percentages of annual natural gas savings vary between *ex ante* and *ex post*.

Figure 24. *Ex Post* and *Ex Ante* Pre-Retrofit Gas Consumption, Decatur

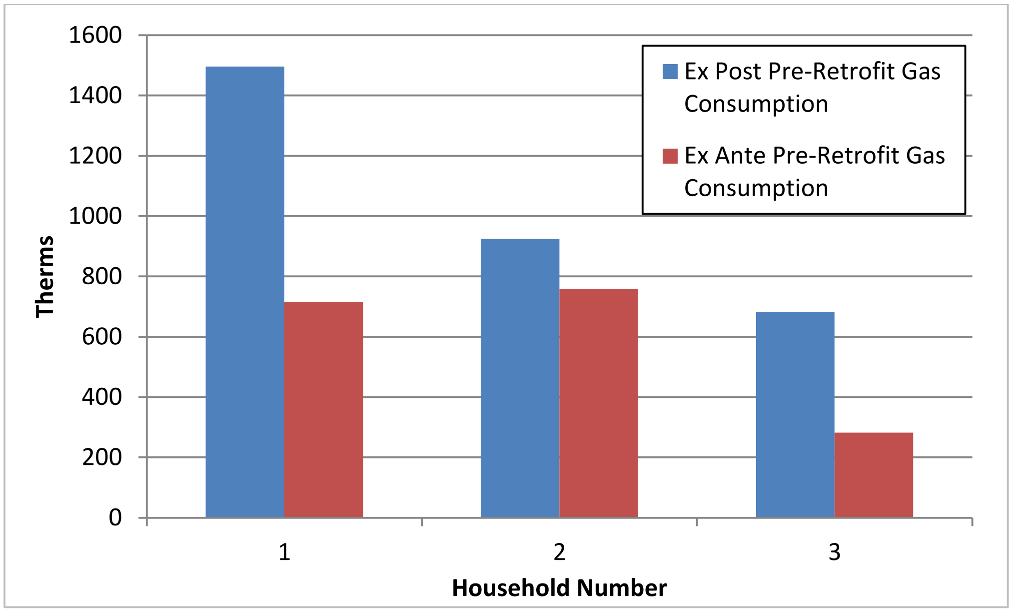
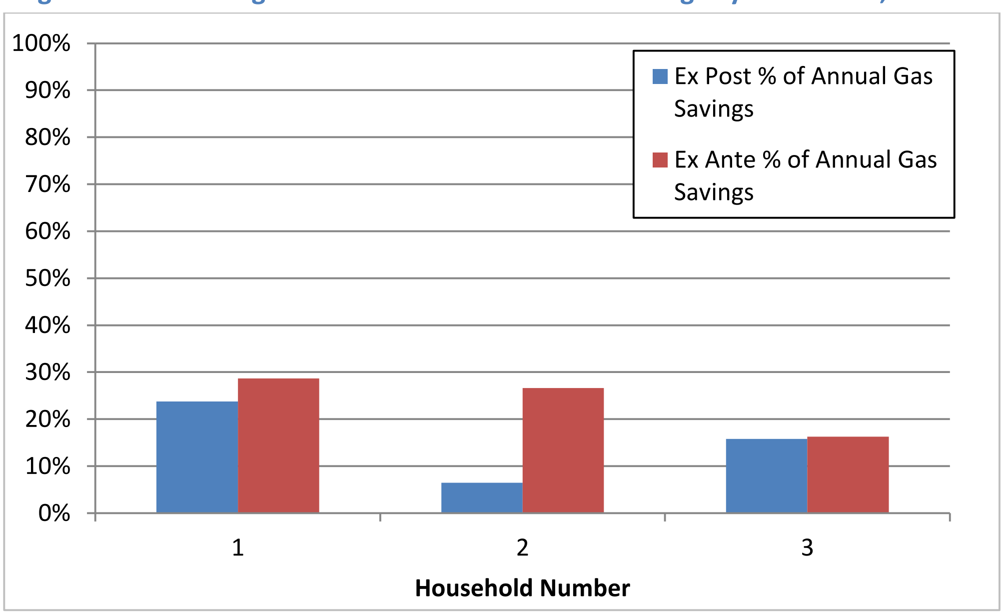


Figure 25. Percentage of *Ex Post* and *Ex Ante* Gas Savings by Household, Decatur



Total Program Savings

Table 50 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the DecaturWISE program. Cadmus based its analysis on savings documented within the SEEA program database.

Table 50. Decatur SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	250,012	17,866	62,409	16,158
Lifetime	-	-	946,000	71,206

* All records in the SEEA database included savings. None of the records showed savings only as a percentage. Therefore, *ex ante* numbers represent all of the reported savings for Decatur residential participants.

As shown in Table 51, evaluation findings for the SEEA BBNP in Decatur resulted in realization rates of 25.0% for electricity and 90.4% for gas. Cadmus estimated these results through billing analysis.

Table 51. Decatur SEEA BBNPs Overall Realization Rate

Realization Rate	
Electric	Gas
25.0%	90.4%

Huntsville, Alabama (Climate Zone 3)

Residential Single-Family Participants

Nexus Energy Center administered the HuntsvilleWISE Gold Homes program (SEEA BBNP in Huntsville). Initially partnering with the local utility, Huntsville Utilities (HU), the program offered homeowners free audits (conducted by HU) and up to $400 in rebates for efficiency measures resulting in energy savings of 20% or more. After the program partnership with HU dissolved, HuntsvilleWISE offered a $350 refund on the cost of a home assessment if the participant implemented all recommended improvements at once and achieved 20% savings. Nexus used a deemed savings method to estimate energy savings for measures offered through the program. Eligible measure categories were HVAC, building shell, lighting, appliances, and domestic water heating. See Table 52 for a full list of program measures.

The HuntsvilleWISE program had 735 participating households during the evaluation timeframe and continues operation today with State Energy Program (SEP) funding. Figure 26 shows the geographical distribution of SEEA BBNP residential participants in Huntsville, Alabama.

Figure 26. SEEA BBNP Residential Participants of Huntsville, Alabama

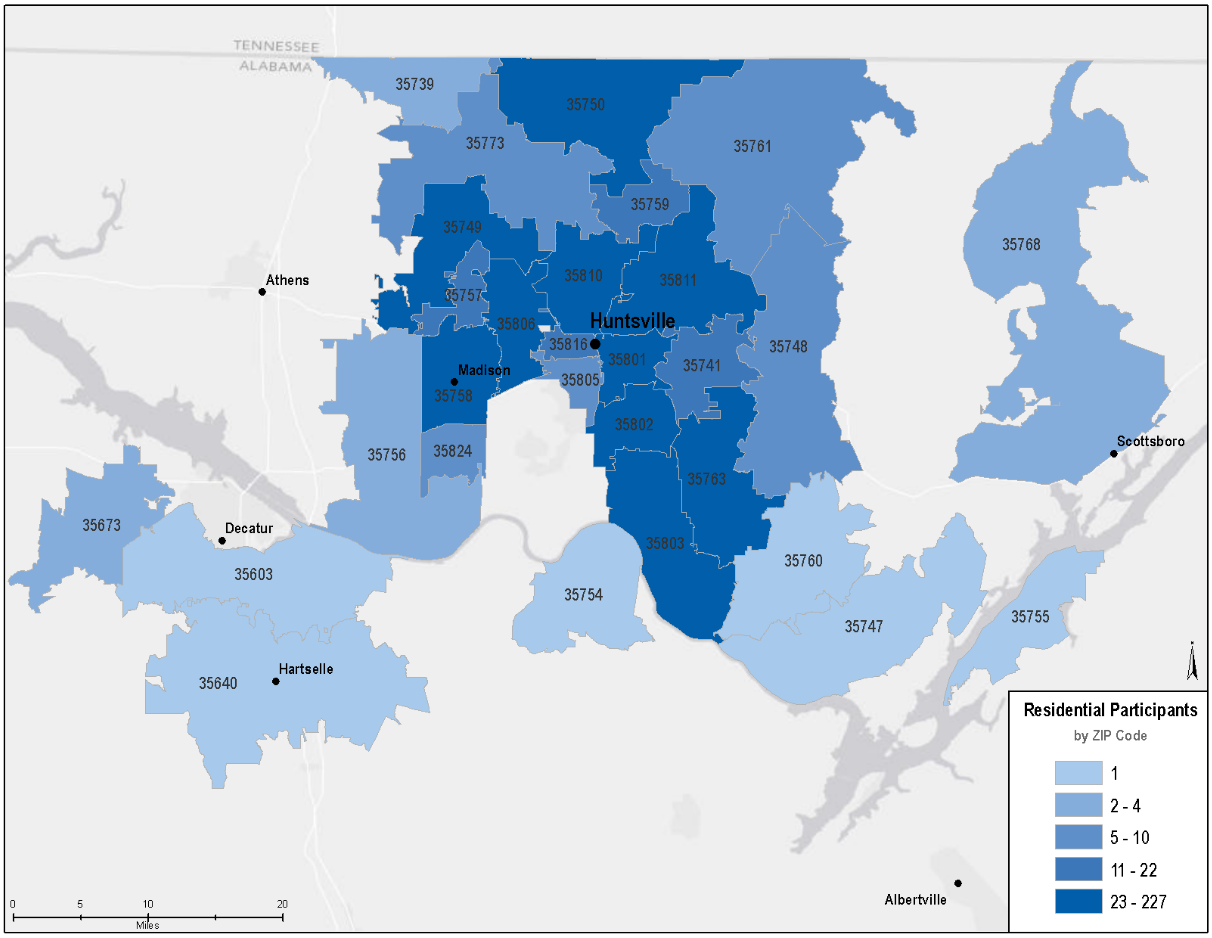


Table 52 summarizes the measure categories, types, and units installed under the program in Huntsville, along with the percentage of households receiving each measure type.

Table 52. Measures Installed under SEEA BBNP in Huntsville

City: Huntsville			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	129	19%
	Floor/Foundation Insulation	26	4%
	Windows Installed/Replaced	275	40%
	Window Repairs not Replacements	14	2%
	Air Sealing	100	15%
	Radiant Barrier or Vapor Barrier	12	2%
Lighting and Appliances	Lighting CFLs	9	1%
HVAC	Air Conditioner	169	25%
	Furnace	12	2%
	Heat Pump	131	19%
	Duct Sealing	71	10%
	Duct Insulation	7	1%
	Programmable Thermostat	36	5%
	HVAC tune up	116	17%
Domestic Hot Water	Water Equipment Insulation	9	1%
	Low Flow Faucet Aerator/Shower Head	2	0%
	Water Heater	8	1%

Data Available for Impact Evaluation

Cadmus reviewed the SEEA tracking database (received November 2013) and available program data and found the tracking database reported 735 records for Huntsville. Of these records, 735 included electric savings and 256 included natural gas savings associated with installed program measures.

For the electricity savings data in the tracking database, Cadmus found:

- Electric savings values were missing for 326 household records.
- Records for eight households were missing the percentage of household electricity consumption saved due to program measure installation.
- Records for eight households were missing both electric savings values and percentages of electricity consumption saved.

For the gas savings in the tracking database, we found:

- Gas savings values were missing for 95 household records.
- Records for eight households were missing the percentage of household gas consumption saved due to program measure installation.
- Records for four households were missing both gas savings values and percentages of gas consumption saved.

Cadmus also found:

- Measure-level savings were not available for any of the households.

- Sufficient electric billing history (meter data) was available for 172 households participating in SEEA BBNP in Huntsville.
- Gas billing history (meter data) was available for participating households.
- Project documentation did not address participant household data.

Evaluation Approach

For the impact evaluation of the SEEA BBNP in Huntsville, Cadmus reviewed the program database and the reported household energy savings. We also performed billing analysis for a sample of 172 participant homes, based on available meter data, to evaluate *ex ante* energy savings. Table 53 summarizes the impact evaluation activities and sample sizes.

Table 53. SEEA BBNPs Impact Evaluation Activities for Huntsville

Activity	Completed Sample Size (n)
Review of the program database	n/a
Billing analysis (electric)	213
Billing analysis (gas)	43

Total Program Savings

Table 54 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the SEEA Program in Huntsville. Cadmus based its analysis on savings documented within the SEEA program database.

Table 54. Huntsville SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	2,824,148	29,206	2,148,094	19,859
Lifetime	-	-	16,010,000	196,926

* Due to a large number of missing records, supplemental data was supplied directly by Huntsville program coordinators. This billing data was used to fill in the missing *ex ante* pre-measure installation consumption, which was multiplied by percentage of savings reported in SEEA tracking database to estimate *ex ante* savings.

As shown in Table 55, the evaluation findings for the SEEA BBNP in Huntsville resulted in a realization rate of 76.1% for electricity and 68.0% for gas.

Table 55. Huntsville SEEA BBNPs Overall Realization Rate

Realization Rate	
Electric	Gas
76.1%	68.0%

Carrboro, North Carolina (Climate Zone 4)

Implemented by Clean Energy Solutions, Inc., the Carrboro WISE program (the SEEA BBNP in Carrboro) initially provided loans to Carrboro businesses, including multifamily properties, for energy-efficiency upgrades. If recommended by a comprehensive energy audit, a variety of efficiency improvements qualified for financing through this program. The program offered incentives for installations of HVAC equipment, building shell, lighting and appliances, and domestic water heating measure categories. Clean Energy Solutions conducted an engineering analysis using REM/*Rate* package software to estimate energy savings for measures installed through the program. The program was later expanded to residential customers, offering assessment incentives and rebates for whole-home retrofits achieving at least a 20% reduction in energy use. Only a small number of participants completed residential projects (10 households). Clean Energy Solutions still offers the program, though the incentives and requirements have changed.

Residential Single-Family Participants

Figure 27 shows the geographical distribution of SEEA BBNP residential participants in Carrboro, North Carolina.

Figure 27. SEEA Residential Participants of Carrboro, North Carolina

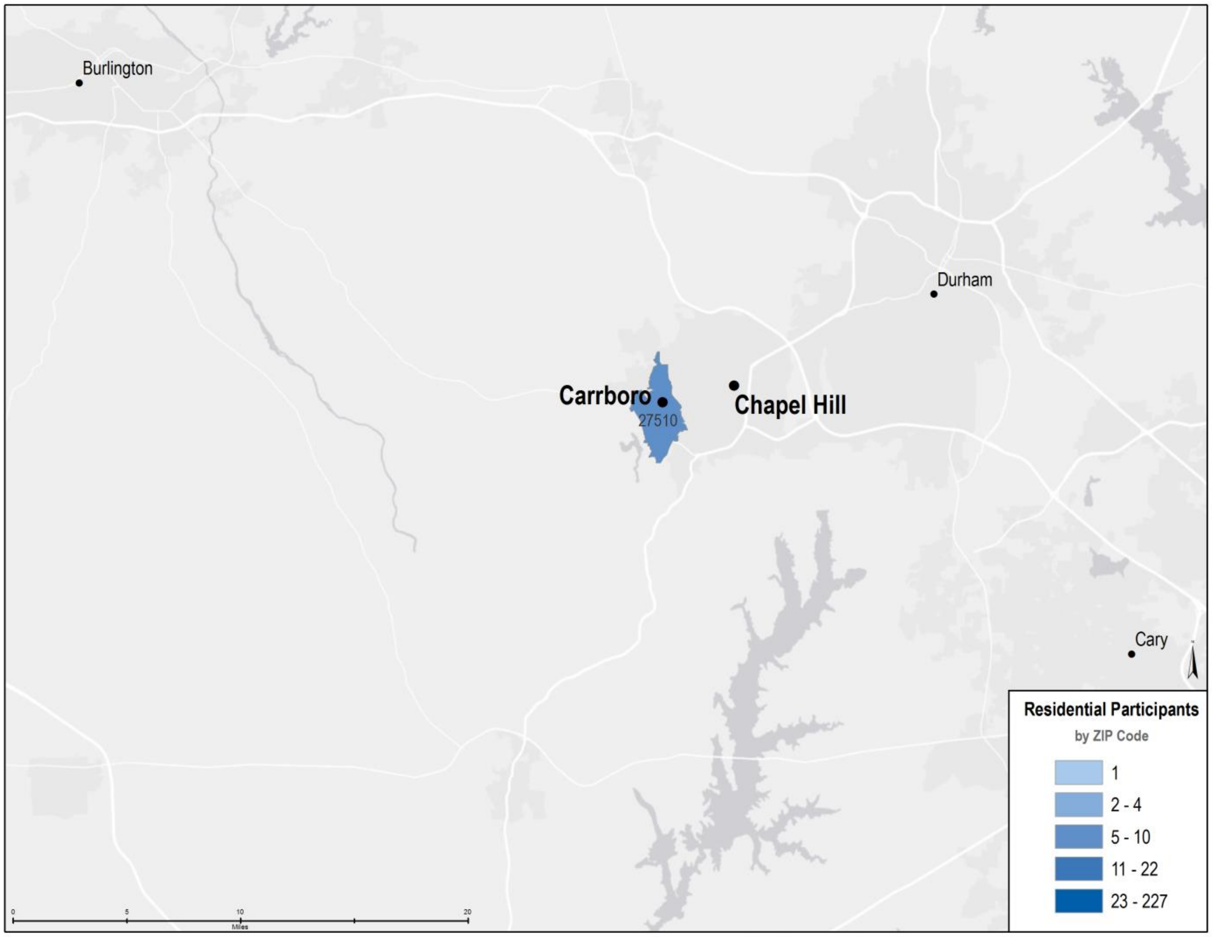


Table 56 lists the measure categories, types, and units installed under the program in the City of Carrboro, along with the percentage of households receiving each measure type.

Table 56. Measures Installed under SEEA BBNP in Carrboro

City: Carborro			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	11	110%
	Floor/Foundation Insulation	8	80%
	Air Sealing	14	140%
	Radiant Barrier or Vapor Barrier	3	30%
Lighting and Appliances	Lighting CFLs	4	40%
	Refrigerator	1	10%
HVAC	Air Conditioner	1	10%
	Heat Pump	3	30%
	Duct Sealing	10	100%
	Duct Insulation	4	40%
	Programmable Thermostat	6	60%
Domestic Hot Water	Water Equipment Insulation	3	30%

Data Available for Impact Evaluation

Cadmus reviewed the SEEA tracking database (received November 2013) and available program data and found the tracking database reported 18 records for Carrboro. Of these records, all 18 included electric savings, and 14 included natural gas savings associated with installed program measures. Measure-level savings were unavailable for these households.

For the electricity savings data in the tracking database, Cadmus found:

- None of the household records had missing electric savings values.
- None of the household records had missing percentages of household electricity consumption saved due to program measure installations.
- All household records included either electric savings values or percentages of electricity consumption saved.

For the gas savings in the tracking database, we found:

- Records for two households were missing gas savings values.
- Records for two households were missing percentages of household gas consumption saved due to program measure installation.
- Records for two households were missing both gas savings values and percentages of gas consumption saved.

For this evaluation, electric and gas billing histories (meter data) and project documentation were unavailable. Evaluation Approach

Cadmus reviewed the program database and reported household energy savings. With no billing data or project documentation available, Cadmus used Huntsville's electric realization rate (based on a billing analysis of the city's participant homes) to evaluate Carrboro's *ex ante* energy savings. We chose

Huntsville's realization rate due to similar weather profiles between the two cities. Cadmus also derived the gas realization rate from the realization rate for the Huntsville program's gas measures due to insufficient data in the SEEA program database, project documentation, and/or billing data. We selected the Huntsville gas realization rate based on similarities in climate zone and other jurisdiction characteristics.

Energy Savings Impact Findings (Residential Single-Family Homes)

Table 57 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the SEEA BBNP in Carrboro. Cadmus based its analysis on savings documented within the SEEA BBNP database.

Table 57. Carrboro SEEA BBNPs Residential Single-Family Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	33,803	1,796	25,711	1,221
Lifetime	-	-	359,000	19,533

* Two records were missing gas savings. *Ex ante* numbers do not include savings for these projects.

As shown in Table 58, evaluation findings for the SEEA BBNP in Carrboro resulted in realization rates of 76.1% for electricity and 68.0% for gas. The electric and gas realization rates were extrapolated from the realization rate for Huntsville, Alabama, due to similar weather profiles between the two cities.

Table 58. Carrboro SEEA BBNPs Residential Single-Family Realization Rate

Realization Rate	
Electric	Gas
76.1%	68.0%

Multifamily Participants

Although a SEEA BBNP was active in the multifamily sector, we did not receive sufficient resources to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project documentation for the Carrboro multifamily program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the Carrboro multifamily program. Table 59 lists the *ex ante* savings calculated for the program.

Table 59. Carrboro SEEA BBNPs Multifamily Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	303,965	550	303,965	550
Lifetime	-	-	3,237,000	2,995,819

Commercial Participants

Although a commercial BBNP was active in Carrboro, we did not receive sufficient resources to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project documentation for the Carrboro commercial program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the Carrboro commercial program. Table 60 lists the *ex ante* savings calculated for the program.

Table 60. Carrboro SEEA BBNPs Commercial Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	8,240	823	8,240	823
Lifetime	-	-	81,000	7,274

Total Program Savings

Table 61 shows total gross savings for Carrboro. These combine savings from the residential single-family, multifamily, and commercial programs in Carrboro.

Table 61. Carrboro SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	346,008	3,169	337,916	2,594
Lifetime	-	-	3,677 ,000	3,022,625

Chapel Hill, North Carolina (Climate Zone 4)

Residential Single-Family Participants

The city of Chapel Hill contracted with Clean Energy Solutions, Inc., to implement Chapel Hill WISE. Chapel Hill WISE, during the BBNP implementation period, offered incentives to homeowners to perform comprehensive retrofits on their homes. Incentives covered measures within the HVAC equipment, building shell, lighting and appliances, and domestic water heating measure categories. Clean Energy Solutions conducted engineering analysis using REM/*Rate* package software and HESpro to estimate energy savings for measures installed under the program. Chapel Hill WISE gave qualified homeowners $150 toward a home energy assessment site visit, plus a subsidy of up to 50% of building shell measure costs and 25% of HVAC measure costs. Rebate amounts varied over the duration of the program. The program recently closed, but covered 161 households during its operation.

Figure 28 shows the geographical distribution of SEEA BBNP residential participants in Chapel Hill, North Carolina.

Figure 28. SEEA BBNP Residential Participants of Chapel Hill, North Carolina

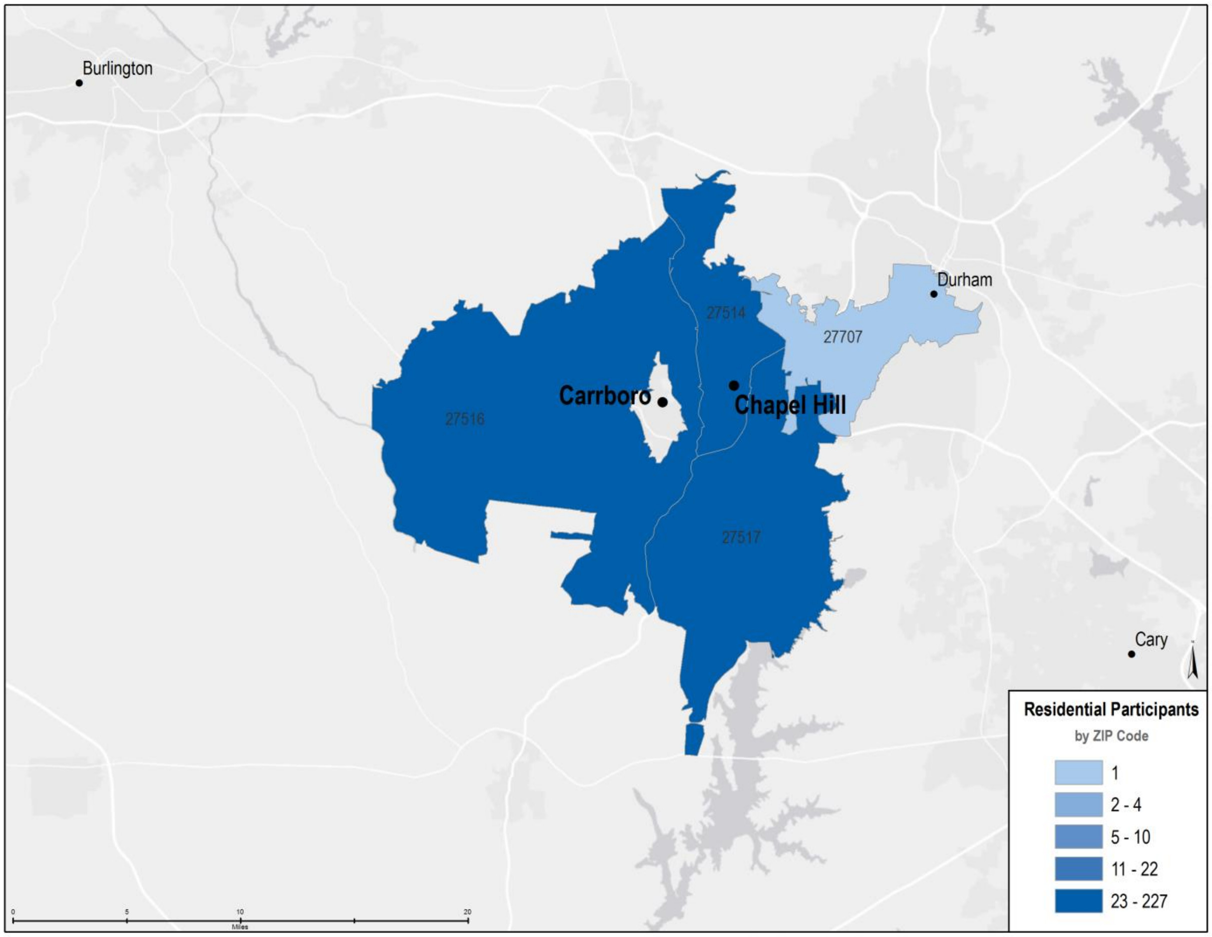


Table 62 lists measure categories, types, and units installed under the program in Chapel Hill, along with the percentage of households receiving each measure type.

Table 62. Measures Installed under SEEA BBNP in Chapel Hill

City: Chapel Hill			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	111	97%
	Wall Insulation	15	13%
	Floor/Foundation Insulation	54	47%
	Windows Installed/Replaced	2	2%
	Air Sealing	137	119%
	Radiant Barrier or Vapor Barrier	46	40%
Lighting and Appliances	Lighting CFLs	20	17%
	Refrigerator	8	7%
HVAC	Air Conditioner	20	17%
	Furnace	27	23%
	Boiler	2	2%
	Heat Pump	20	17%
	Duct Sealing	109	95%
	Duct Insulation	25	22%
	Programmable Thermostat	7	6%
	HVAC tune up	9	8%
Domestic Hot Water	Water Equipment Insulation	6	5%
	Low Flow Faucet Aerator/Shower Head	1	1%
	Water Heater	19	17%

Data Available for Impact Evaluation

Cadmus reviewed the SEEA tracking database (received November 2013) and available program data and found the tracking database reported 158 records for Chapel Hill. Of these records, 158 included electric savings and 119 included natural gas savings associated with installed program measures. Measure-level savings were unavailable for these households.

For the electricity savings data in the tracking database, Cadmus found:

- Records for three households were missing electric savings values.
- Two household records were missing the percentages of household electricity consumption saved due to program measure installations.
- Two household records were missing both electric savings value and the percentage of electric consumption saved.

For the gas savings in the tracking database, we found:

- Records for eight households were missing gas savings values.
- Records for seven households were missing percentages of household gas consumption saved due to program measure installations.

- Records for seven households were missing both gas savings values and percentages of gas consumption saved.

For this evaluation, electric and gas billing histories (meter data) and project documentation were unavailable.

Evaluation Approach

For the SEEA impact evaluation in Chapel Hill, Cadmus reviewed the SEEA program database and the reported household energy savings. With no billing data or project documentation available, we assigned Huntsville's electric realization rate (based on billing analysis of the city's participant homes) to evaluate Chapel Hill's *ex ante* energy savings. We chose Huntsville's realization rate due to similarities in Huntsville and Chapel Hill weather profiles and percentages of expected savings.

We derived the gas realization rate from the realization rate for the Huntsville program's gas measures due to insufficient data in the SEEA database, project documentation, and/or billing data.

Energy Savings Impact Findings (Residential Single-Family Homes)

Table 63 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the SEEA BBNP in Chapel Hill. Cadmus based its analysis on savings documented within the SEEA program database.

Table 63. Chapel Hill SEEA BBNPs Residential Single-Family Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	530,072	29,362	403,181	19,966
Lifetime	-	-	6,174,000	319,463

* Two records were missing electric savings, and an additional record only included electric savings as a percentage. Seven records were missing gas savings, and an additional record only included gas savings as a percentage. *Ex ante* numbers do not include savings for these projects.

As shown in Table 64, evaluation findings for the SEEA BBNP in Chapel Hill resulted in realization rates of 76.1% for electricity and 68.0% for gas.

Table 64. Chapel Hill SEEA BBNPs Residential Single-Family Realization Rate

Realization Rate	
Electric	Gas
76.1%	68.0%

Multifamily Participants

Although a SEEA BBNP was active in the multifamily sector, we did not receive sufficient resources to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project documentation for the Chapel Hill multifamily program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the Chapel Hill multifamily program. Table 65 lists the *ex ante* savings calculated for the program.

Table 65. Chapel Hill SEEA BBNPs Multifamily Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	12,788	-	12,788	-
Lifetime	-	-	136,000	139,135*

* No gas savings were reported in the tracking database for the Chapel Hill multifamily program; however, based on the measures installed, Cadmus made appropriate assumptions to calculate lifetime gas savings.

Total Program Savings

Table 66 lists total gross savings for Chapel Hill. These combine savings from both the residential single-family and multifamily programs in Chapel Hill.

Table 66. Chapel Hill SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	542,859	29,362	415,969	19,966
Lifetime	-	-	6,310,000	458,598

Charlottesville, Virginia (Climate Zone 4)

Residential Single-Family Participants

The Local Energy Alliance Program (LEAP), a Charlottesville nonprofit, ran the Home Performance with ENERGY STAR® and BetterBasics residential single-family programs, each funded in part with SEEA grant monies. The programs offered low-cost assessments, plus savings-based rebates. The programs employed a broad list of eligible measures covering building shell improvements, HVAC measures, lighting and appliance rebates, and water heating measure categories. The Home Performance with ENERGY STAR® program still operates in the area. During the evaluation timeframe, the SEEA-funded residential programs in Charlottesville covered 1,215 participants.

Figure 29 shows the geographical distribution of SEEA BBNP residential participants in Charlottesville, Virginia.

Figure 29. SEEA BBNPs Residential Participants of Charlottesville, Virginia

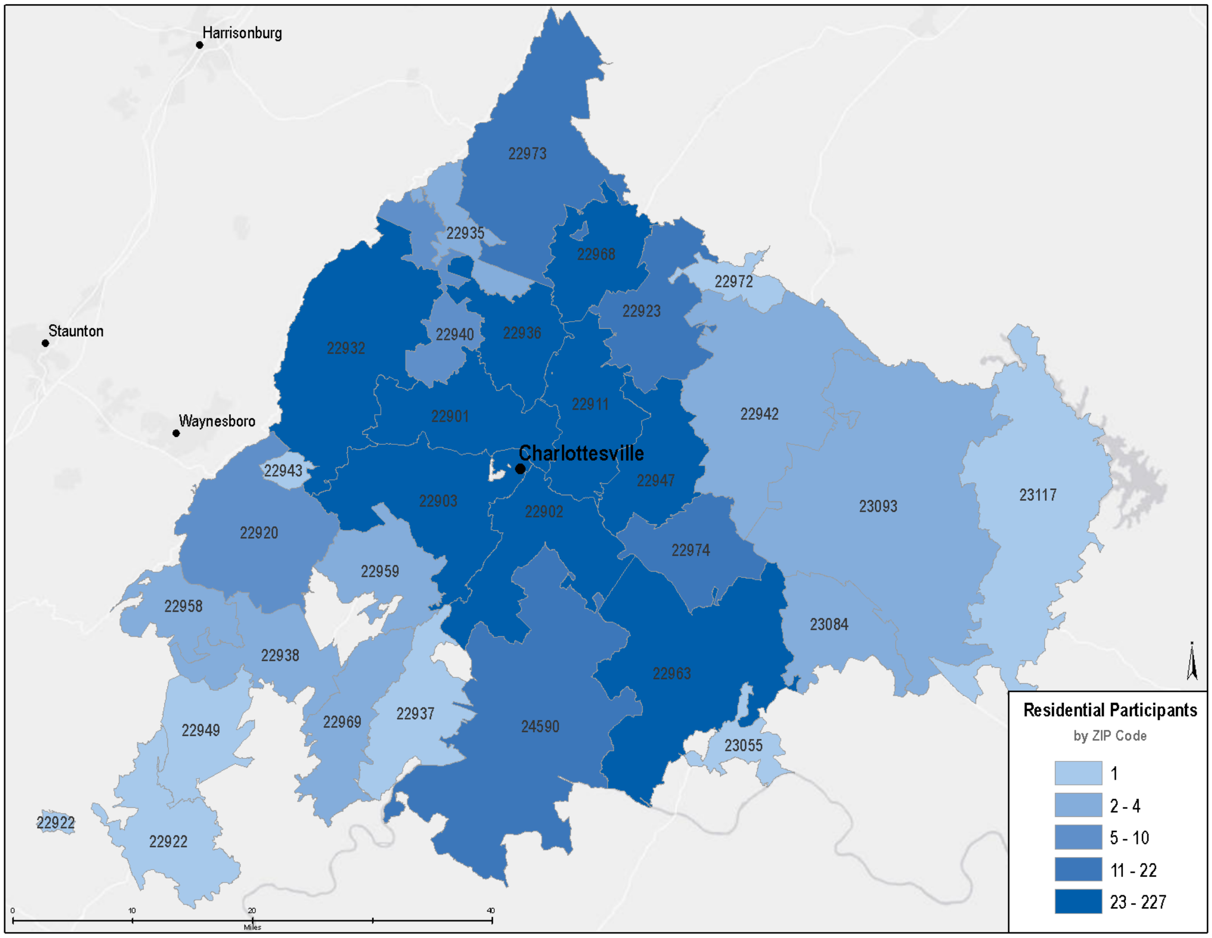


Table 67 lists measure categories, types, and units installed under the Charlottesville BBNPs, along with the percentage of households receiving each measure type.

Table 67. Measures Installed Under the SEEA BBNPs in Charlottesville

City: Charlottesville			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	406	40%
	Wall Insulation	132	13%
	Floor/Foundation Insulation	259	25%
	Windows Installed/Replaced	40	4%
	Window Repairs not Replacements	9	1%
	Air Sealing	423	42%
	Radiant Barrier or Vapor Barrier	52	5%
	Shade Screen Addition	1	0%
Lighting and Appliances	Lighting CFLs	14	1%
	Refrigerator	17	2%
HVAC	Air Conditioner	73	7%
	Furnace	108	11%
	Wood Stove	2	0%
	Boiler	13	1%
	Heat Pump	717	70%
	Duct Sealing	407	40%
	Duct Insulation	154	15%
	Programmable Thermostat	110	11%
	HVAC tune up	38	4%
Domestic Hot Water	Water Equipment Insulation	4	0%
	Water Heater	45	4%

Data Available for Impact Evaluation

Cadmus reviewed the SEEA tracking database (received November 2013) and available program data and found the tracking database reported 1,215 records for Charlottesville. Of these records, 1,154 of included electric savings and 275 included natural gas savings associated with installed program measures. None of these household records included measure-level savings.

For the electricity savings data in the tracking database, Cadmus found:

- Records for 25 households were missing electric savings values.
- Records for 10 households were missing percentages of household electricity consumption saved due to program measure installations.
- All of the household records included either electric savings values or percentages of electricity consumption saved.

For the gas savings in the tracking database, we found:

- Records for nine households were missing gas savings values.
- Records for 10 households were missing percentages of household gas consumption saved due to program measure installations.

- Records for six households were missing both gas savings values and percentages of gas consumption saved.

Cadmus also found:

- Sufficient electric billing history (meter data) was available for 81 households participating in SEEA BBNP in Charlottesville.
- Gas billing history (meter data) was unavailable for households participating in SEEA Program in Charlottesville.
- A sample of project files for 12 Charlottesville LEAP participants with billing data. The project included a Home Energy Usage Report, which provided information on a household's energy use per month and the home's energy-savings potential.
- Cadmus also received project files for each program participant that included:
  - All written correspondence with the homeowner
  - Contractor invoices
  - Home Performance with ENERGY STAR® quality assurance inspection form
  - Home Performance with ENERGY STAR® quality assurance inspection follow-up work order
  - QA field findings and contractor performance scoring.

Evaluation Approach

Cadmus reviewed the program tracking database (received November 2013) and the reported household energy savings. To evaluate *ex ante* energy savings, we performed both billing analysis and whole-house energy simulation for a sample of 12 participant homes. Our evaluation was based on available project data and documentation. Cadmus chose to use whole-house energy simulations to supplement the billing data savings analysis, due to the high participation rate in Charlottesville (32%) and the significant impact its *ex post* energy savings have on overall program *ex post* energy savings.

Table 68. The SEEA BBNP Impact Evaluation Activities for Charlottesville

Activity	Completed Sample Size (n)
Review of the program database	n/a
Engineering assessment of energy savings using REM/*Rate* modeling software and calibrating to actual consumption data	12
Billing analysis (electric)	81

To validate tracked energy savings for SEEA BBNP in Charlottesville, Cadmus relied primarily on the following:

- **Tracking Database Review.** Cadmus reviewed the data and measure types reported in the program tracking database, which provided energy savings at a household level.
- **Technical Desk-Review.** We collected pre- and post-measure installation building data through all available project documentation and satellite imaging for a random sample of 12 households

participating in the program. We performed technical desk-review of homes based on the assumptions related to the building parameters and characteristics and the measure descriptions previously used by the implementer/contractor.

- **Whole-House Energy Modeling.** Cadmus performed energy simulation using data collected through the technical desk-review and the REM/*Rate* simulation software package.
- **Model Calibration.** To estimate the evaluated home's *ex post* energy savings, we calibrated the energy savings generated by REM/*Rate* models to the participant's actual annual consumption data and adjusted the savings proportionately.
- **Energy Savings Assessment.** We assessed the reported savings by comparing the reported savings to simulated savings using REM/*Rate*.
- **Billing Analysis**. Cadmus compared participant billing data for a period of time before the installation of energy-efficient measures to post-installation billing data. See the Billing Analysis section for the details.

Cadmus conducted an extensive technical review of reported savings for 12 homes in Charlottesville. We developed two REM/*Rate* building models for each home:

- The first model simulated the existing (or pre-measure) home's annual energy use.
- The second model simulated the home's energy use after installation of the installed measures.

Thus, the pre-calibration energy savings equal the difference in annual energy use between the as-built (pre-measure installation) home and the upgraded home.

For the analysis, we randomly selected 12 sampled participant homes (which had project documentation and billing data available) that represented the range of house sizes across the full Charlottesville census. Table 69 shows the square footage of each Charlottesville home modeled.

Table 69. Square Footage of Charlottesville Modeled Households

Household Number	Square Footage
1	899
2	1,310
3	1,368
4	1,520
5	1,680
6	2,600
7	2,610
8	2,979
9	3,263
10	3,318
11	3,371
12	3,544

Table 70 shows the percentage of various house size categories in the Charlottesville population versus the sample population.

Table 70. Square Footage of SEEA BBNP Households in Charlottesville

House Size Category	Percentage of Households in the Charlottesville Population	Percentage of Households in the Sample Population
0-1,000	6%	8%
1,000-2,200	52%	33%
2,200-3,500	32%	50%
≥ 3,500	10%	8%

For each measure installed through the SEEA BBNPs in Charlottesville, Cadmus estimated total *ex ante* savings using a whole-building (custom) method, and on a household basis.

Energy Savings Impact Findings (Residential Single-Family Homes)

Electricity

The changes in electric energy use due to the program's building shell measures typically resulted from changes in air conditioning use, air handler fan operations during heating, and increased use of whole-home mechanical ventilation, and in case of homes having electric heating system type also from changes in heating use.

Figure 30 shows *ex ante* versus *ex post* percentage of electric energy-savings estimates.

Figure 30. Percentage of *Ex Post* and *Ex Ante* Electric Savings by Household, Charlottesville

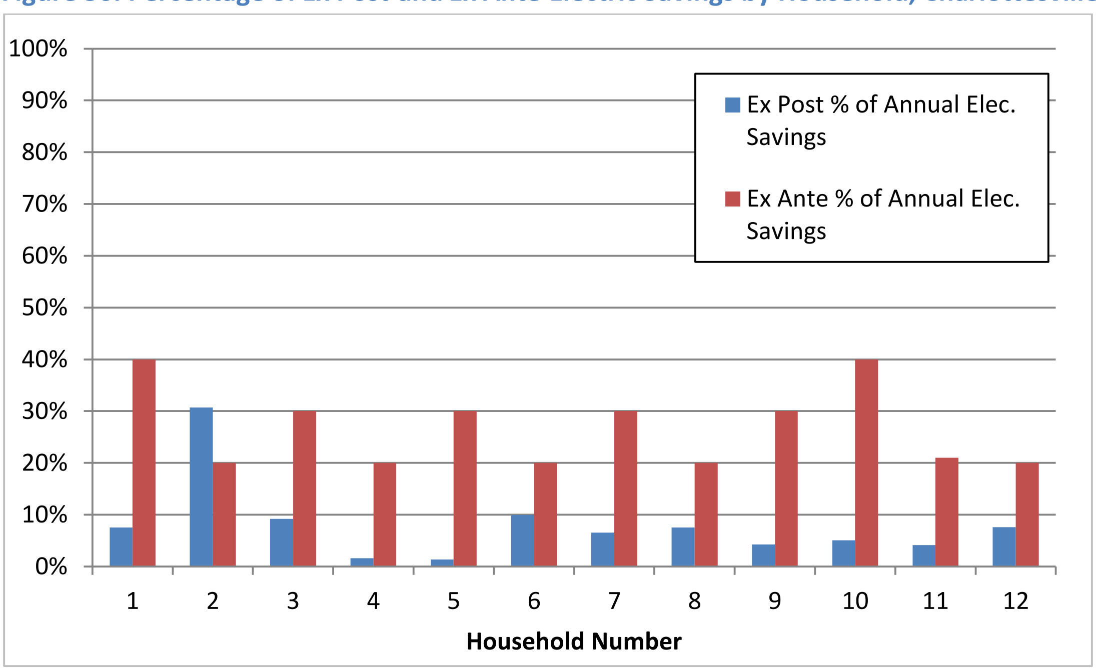
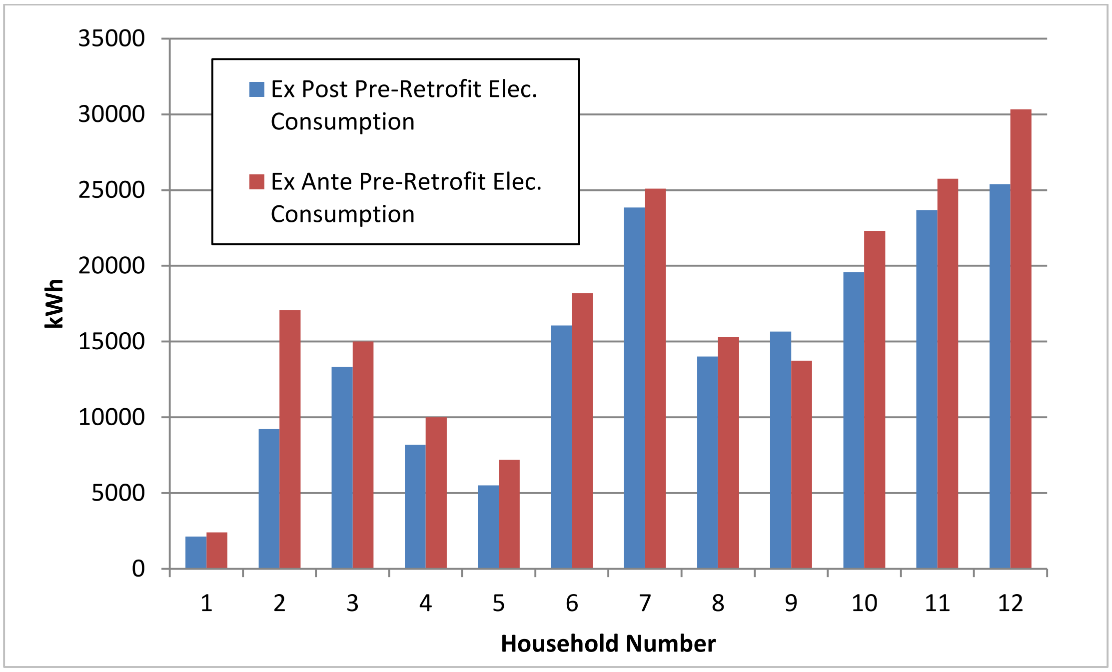


Figure 31 shows *ex ante* versus *ex post* pre-retrofit electric consumption. In this case, *ex post* pre-retrofit consumption is equal to the actual electric consumption indicated by the evaluated homes' billing data (meter).

Figure 31. *Ex Post* (Meter Data) and *Ex Ante* Pre-Retrofit Electric Consumption, Charlottesville



The EUI of a home is typically expected to decrease gradually as the house size increases, due largely to appliance and other usage patterns that do not scale with home size. Figure 32 and Figure 33 show *ex post* and *ex ante* EUI by square footage, respectively.

Figure 32. *Ex Post* Electric Utilization Index by Square Footage, Charlottesville

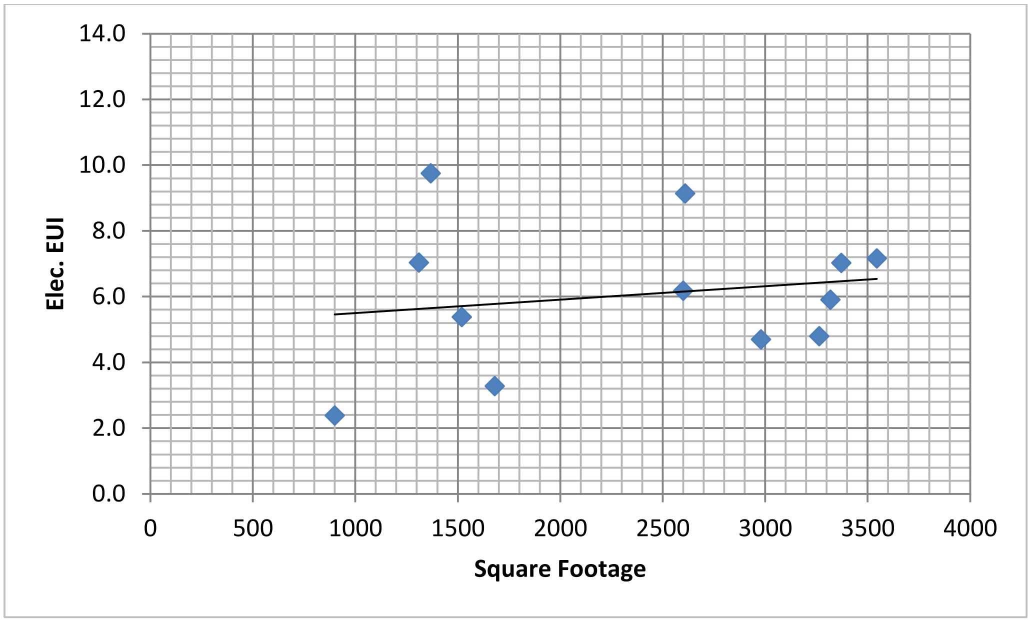
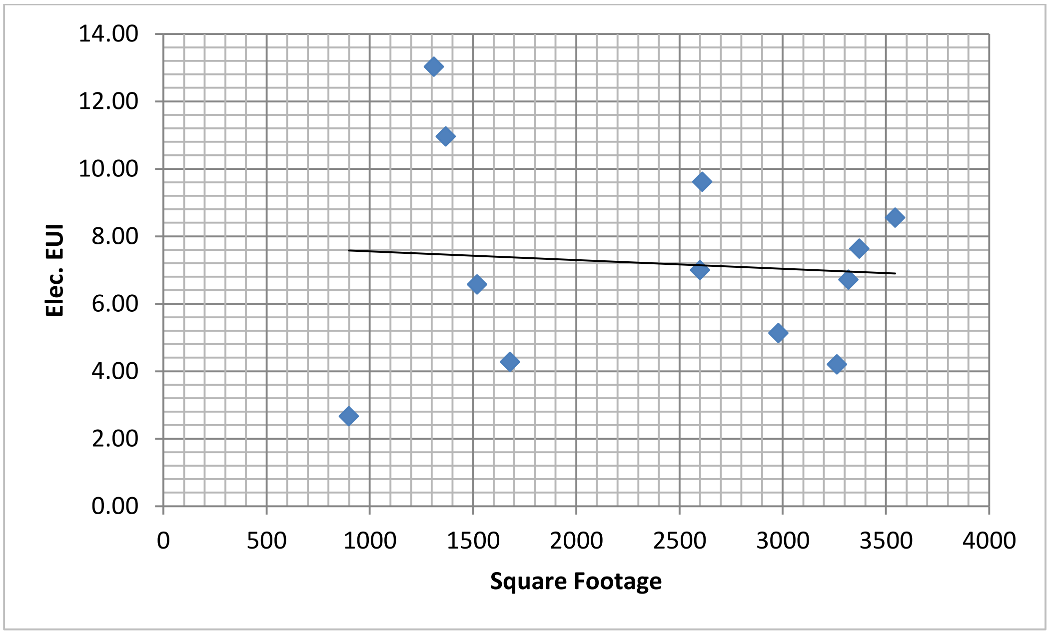


Figure 33. *Ex Ante* Electric Utilization Index by Square Footage, Charlottesville



Gas

As shown in Figure 34 and Figure 35 the percentages of annual natural gas savings and pre-retrofit gas consumption vary between *ex ante* and *ex post* savings.

Figure 34. *Ex Post* and *Ex Ante* Pre-Retrofit Gas Consumption, Charlottesville

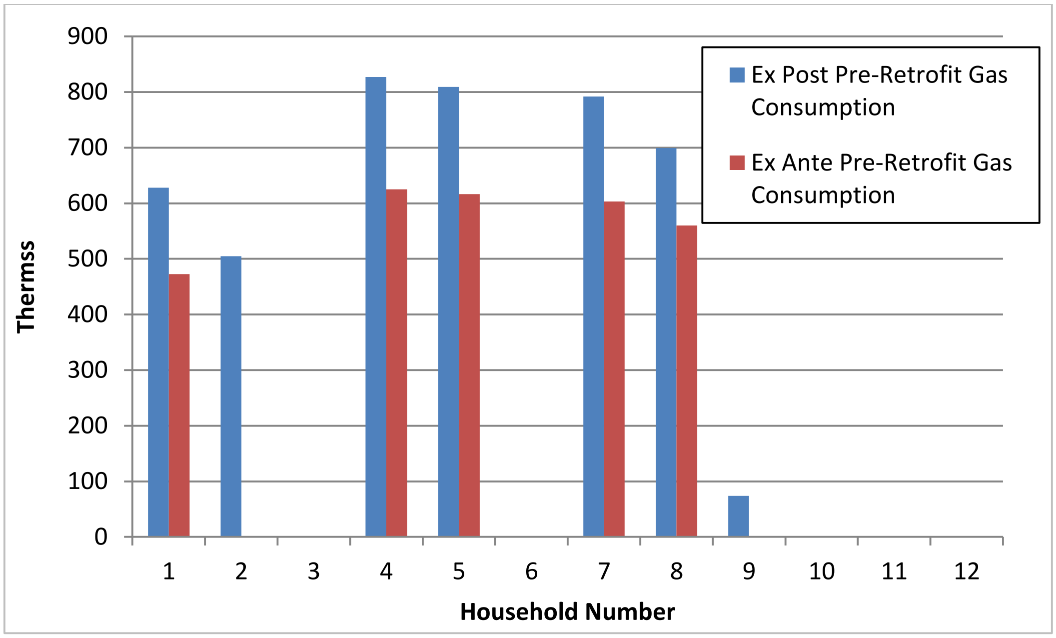
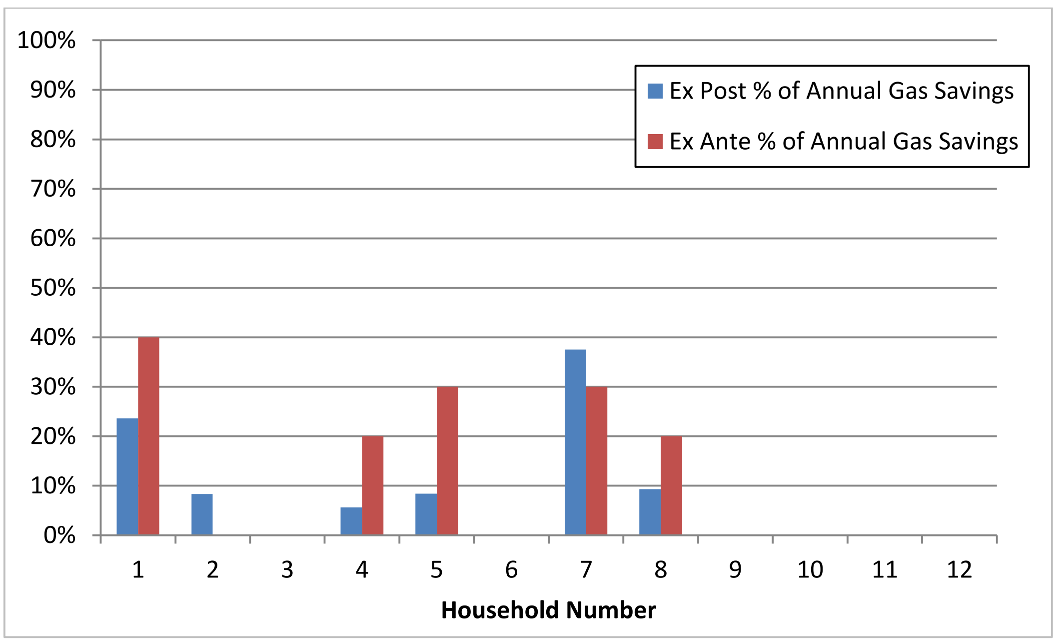


Figure 35. Percentage of *Ex Post* and *Ex Ante* Gas Savings by Household, Charlottesville



Overall Savings (Residential Single-Family Homes)

Table 71 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the single-family residential SEEA BBNPs in Charlottesville. Cadmus based its analysis on savings documented within the SEEA program database.

Table 71. Charlottesville SEEA BBNPs Residential Single-Family Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	3,649,047	154,068	2,139,399	132,283
Lifetime	-	-	33,829,000	1,949,369

* For Charlottesville, 25 records included electric savings only as a percentage. Six records were missing gas savings, and an additional three records only included gas savings as a percentage. *Ex ante* numbers do not include savings for these projects.

As shown in Table 72, evaluation findings for the SEEA BBNPs in Charlottesville resulted in realization rates of 58.6% for electricity and 85.9% for gas.

Table 72. Charlottesville SEEA BBNPs Residential Single-Family Realization Rate

Realization Rate	
Electric	Gas
58.6%	85.9%

Commercial Participants

Although SEEA-funded commercial projects were executed in Charlottesville, we did not receive sufficient resources to support an analysis of the savings under this program. We did not receive billing data, building parameters, or project documentation for the Charlottesville commercial program.

Without the required documentation, Cadmus chose to apply a realization rate of 100% to the Charlottesville commercial program. Table 73 lists the *ex ante* savings calculated for the program.

Table 73. Charlottesville SEEA BBNPs Commercial Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	116,512	33,672	116,512	33,672
Lifetime	-	-	1,805,000	377,992

Total Program Savings

Table 74 lists the total gross savings for SEEA BBNPs in Charlottesville. These combine savings from the residential single-family and commercial programs in Charlottesville.

Table 74. Charlottesville SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	3,765,559	187,740	2,255,911	165,955
Lifetime	-	-	35,635,000	2,327,361

Hampton Roads, Virginia (Climate Zone 4)

Residential Single-Family Participants

The Green Jobs Alliance operated the NEXT STEP program (the SEEA BBNP), which offered homeowners in the southeastern tip of Virginia 25% off the cost of air sealing, duct sealing, and insulation up to $2,500. It also offered 5% off the cost of ENERGY STAR® mechanical systems, doors, windows and lighting, up to $1,500, plus other energy-efficiency upgrades to the home. The program offered training incentives to participating contractors and energy auditors. To estimate energy savings for measures offered through the program, Green Jobs Alliance applied a deemed savings method and conducted an engineering analysis using REM/*Rate* package software. Sixty-two households participated in the program before it closed in 2012.

Figure 36 shows the geographical distribution of SEEA BBNP residential participants in Hampton Roads, Virginia.

Figure 36. SEEA BBNP Residential Participants of Hampton Roads, Virginia

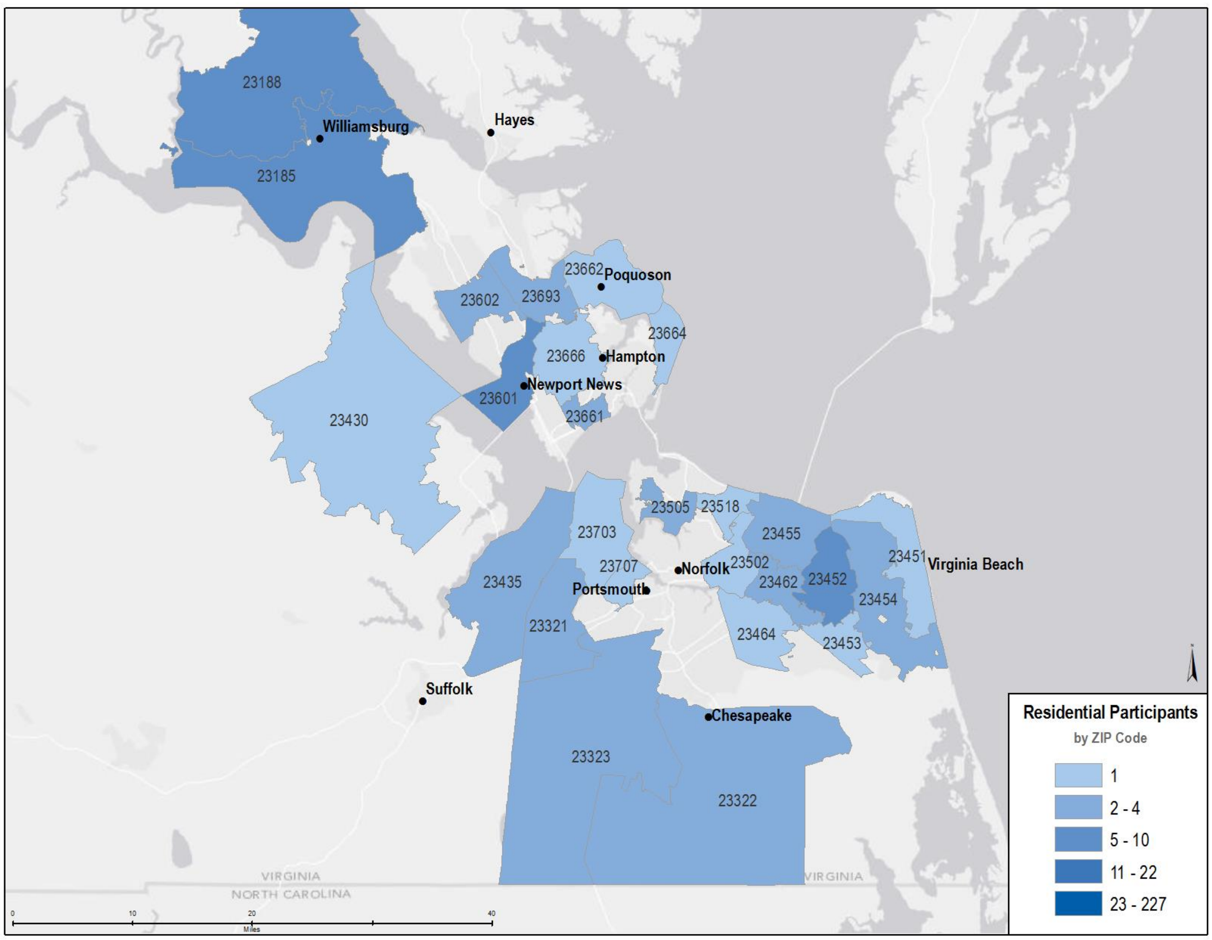


Table 75 lists measure categories, types, and units installed under the NEXTSTEP program, along with the percentage of households receiving each measure type.

Table 75. Measures Installed under SEEA BBNP in Hampton Roads

City: Hampton Roads			
Measure Category	**Measure Type**	**Count of Installed Measures**	**Percentage of Households**
Building Shell	Attic Insulation	60	97%
	Wall Insulation	13	21%
	Floor/Foundation Insulation	33	53%
	Windows Installed/Replaced	1	2%
	Air Sealing	60	97%
HVAC	Air Conditioner	2	3%
	Furnace	3	5%
	Heat Pump	2	3%
	Duct Sealing	58	94%
	Duct Insulation	30	48%
Domestic Hot Water	Water Heater	2	3%

Data Available for Impact Evaluation

Cadmus reviewed the SEEA tracking database (received November 2013) and available program data and found the tracking database included 62 records for Hampton Roads. Of these records, 62 included electric savings and 47 included natural gas savings associated with installed program measures. Measure-level savings were not available for any of these households.

For the electricity savings data in the tracking database, Cadmus found:

- Records for six households were missing electric savings values.
- Records for six households were missing percentages of household electricity consumption saved due to program measure installation.
- Records for six households were missing both electric savings values or percentages of electric consumption saved.

For the gas savings in the tracking database, we found:

- Records for 18 households were missing gas savings values.
- Records for 20 households were missing percentages of household gas consumption saved due to program measure installation.
- Records for 18 households were missing both gas savings values and percentages of gas consumption saved.

Cadmus also found:

- Sufficient electric billing history (meter data) was available for 26 households participating in SEEA BBNP in Hampton Roads.
- Gas billing history (meter data) was unavailable for households participating in SEEA BBNP in Hampton Roads.
- Project documentation was unavailable for households participating in SEEA BBNP in Hampton Roads.

Evaluation Approach

Cadmus reviewed the program database and reported household energy savings. To evaluate *ex ante* energy savings, we also performed billing analysis for a sample of 26 participant homes (based on available meter data).

We derived gas realization rates from the program's overall realization for gas due to insufficient data in the SEEA database, project documentation, and/or billing data.

Total Program Savings

Table 76 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the SEEA BBNP in Hampton Roads. Cadmus based its analysis on savings documented within the SEEA BBNP program database.

Table 76. Hampton Roads SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	159,262	10,068	163,425	7,450
Lifetime	-	-	2,598,000	119,200

* Six records were missing electric savings, and 18 records were missing gas savings. Ex *ante* numbers do not include savings for these projects.

As shown in Table 77 evaluation findings for the SEEA BBNP in Hampton Roads resulted in realization rates of 102.6% for electricity and 74.0% for gas.

Table 77 Hampton Roads SEEA BBNPs Overall Realization Rate

Realization Rate	
Electric	Gas
102.6%	74.0%

Nashville, Tennessee (Climate Zone 4)

Residential Single-Family Participants

Nashville Energy Works (NEW), implemented by the City of Nashville, offered homeowners up to $650 for completing upgrades recommended through a comprehensive assessment and achieving at least

15% energy savings in the home. In order to receive NEW rebates, participants were required to participate in the Tennessee Valley Authority home rebate program. NEW offered incentives for installations in the following measure categories: HVAC equipment, building shell, and domestic water heating. City staff used Conservation Services Group's Real Home Analyzer tool to estimate energy savings for measures installed through the program. The program established a low-interest loan product for low- and middle-income residents of Davidson County through The Housing Fund, a local community development financial institution. The SEEA BBNP in Nashville had 510 households participate during the evaluation timeframe. In May 2013, the program discontinued its rebates, transferred program management to Hands On Nashville, which now only offers the loan product.

Figure 37 shows the geographical distribution of SEEA BBNP residential participants in Nashville, Tennessee.

Figure 37. SEEA Residential Participants in Nashville, Tennessee

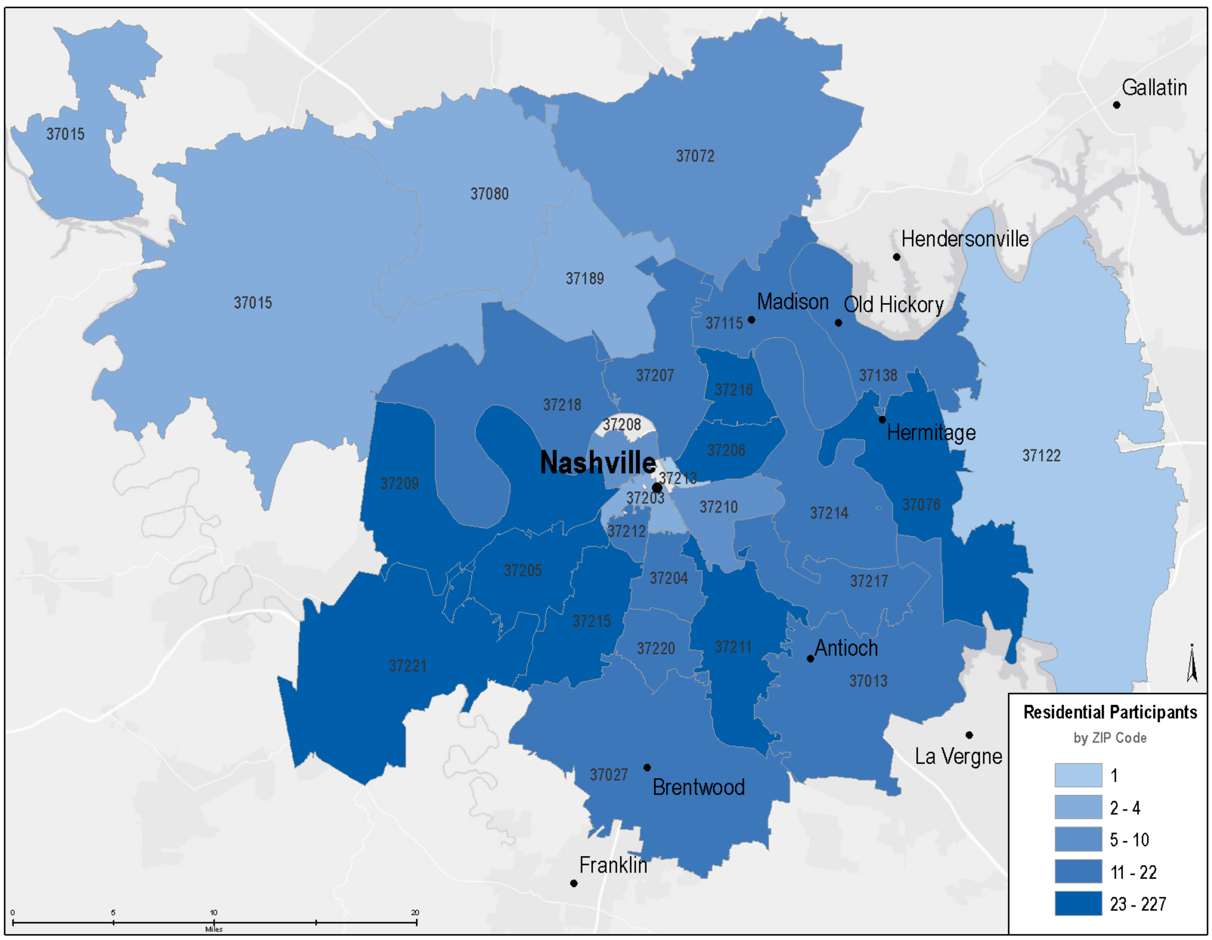


Table 78 lists the measure categories, types, and units installed through the program in the City of Nashville, along with the percentage of households receiving each measure type.

Table 78. Measures Installed under SEEA BBNP in Nashville

City: Nashville			
Measure Category	Measure Type	Count of Installed Measures	Percentage of Households
Building Shell	Attic Insulation	370	73%
	Wall Insulation	48	9%
	Floor/Foundation Insulation	109	21%
	Windows Installed/Replaced	140	27%
	Air Sealing	304	60%
	Radiant Barrier or Vapor Barrier	15	3%
HVAC	Air Conditioner	53	10%
	Furnace	13	3%
	Heat Pump	8	2%
	Duct Sealing	283	55%
	Duct Insulation	13	3%
	Programmable Thermostat	5	1%
	HVAC tune up	129	25%
Domestic Hot Water	Water Equipment Insulation	3	1%
	Water Heater	2	0%

Data Available for Impact Evaluation

Cadmus reviewed the SEEA tracking database (received November 2013) and available program data and found the tracking database reported 510 records for Nashville. Of these records, 510 included electric savings and 38 included natural gas savings associated with installed program measures. Measure-level savings were not available for any of these households.

For the electricity savings data in the tracking database, Cadmus found:

- None of the household records had missing electric savings values.
- None of the household records had missing percentages of household electricity consumption saved due to program measure installations.
- All household records included either electric savings values or percentages of electricity consumption saved.

For the gas savings in the tracking database, we found:

- Records for 37 households were missing gas savings values.
- Records for 37 households were missing percentages of household gas consumption saved due to program measure installation.
- Records for 37 households were missing both gas savings values and percentages of gas consumption saved.

Cadmus also found:

- Electric or gas billing history (meter data) was unavailable for households participating in the SEEA BBNP in Nashville.
- Project documentation was unavailable for households participating in the SEEA BBNP in Nashville.

Evaluation Approach

Cadmus reviewed the program database and reported household energy savings. We assigned Huntsville's electric realization rate (based on billing analysis of the city's participant homes) to evaluate Nashville's *ex ante* energy savings due to similarities in the weather profiles between the two cities.

Table 79. SEEA BBNP Impact Evaluation Activities for Nashville

Activity	Completed Sample Size (n)
Review of the program database	n/a
Engineering assessment of energy savings using Huntsville's billing analysis	n/a

Total Program Savings

Table 80 shows overall claimed gross and evaluated gross energy impacts (kWh and therms) for the SEEA BBNP in Nashville. Cadmus based its analysis on savings documented within the SEEA program database.

Table 80. Nashville SEEA BBNPs Overall Gross Savings Summary

	Ex Ante Gross		*Ex Post* Gross	
	kWh	Therms	kWh	Therms
Annual	1,663,805	66	1,265,517	66
Lifetime	-	-	19,846,000	1,050

* Thirty-seven records were missing gas savings. Ex *ante* numbers do not include savings for these projects.

As shown in Table 81, evaluation findings for the SEEA BBNP in Nashville resulted in realization rates of 76.0% for electricity and 100.0% for gas given the insignificant amount of claimed gas energy savings. The electric realization rate was extrapolated from the realization rate for Huntsville, Alabama, due to similarities in the weather profiles between the two cities.

Table 81. Nashville SEEA BBNPs Overall Realization Rate

Realization Rate	
Electric	Gas
76.0%	100%

Billing Analysis

Cadmus conducted billing analysis as the preferred method of estimating energy savings for each program with sufficient pre- and post- participation data. We were able to use billing analysis in this study for in six of the 11 residential single-family programs.

Methodology

Where possible, SEEA provided electric and gas billing data that it collected from the subgrantees from March 2009 through April 2013. Post-installation billing data were unavailable for five cities: Atlanta, Carrboro, Chapel Hill, Charleston, and Nashville.

Cadmus defined the pre-installation period as the 12 months before measure installation and post-installation period as the 12 months after measure installation. A billing analysis typically requires 12 months of pre-installation billing data and 12 months of post-measure installation billing data. As 12 months of data could not be obtained for all cities, Cadmus set a minimum threshold of four months for pre- and post-measure billing data, requiring a “paired months” approach to ensure the pre and post periods used the same months.

Data Screening

Cadmus screened customer billing data to ensure that the customer records used would contain sufficient data for the billing analysis. Cadmus excluded customer records if the data included one or more of the following attributes:

- Less than four months of pre- and post-measure billing data
- No summer cooling months available
- Energy usage changed by more than 70%
- Mismatched pre- and post-billing cycles
- Energy usage less than 1,200 kWh in the pre- or post-measure periods
- Unreliable PRISM estimates (negative slopes for both heating and cooling)

After application of the screening criteria, we could only use 504 of 3,149 accounts for billing analysis.

As a final quality control step to ensure the remaining customer billing data proved acceptable for use in the billing analysis, Cadmus reviewed pre- and post-monthly billing data for each of the 504 customers to identify vacancies, outliers, mismatched billing periods, and other anomalies. This data review excluded an additional 38 accounts. These accounts exhibited signs of vacancy in the pre- or post-measure period, the addition of heat pumps or heating equipment outside the program, or monthly billing data outliers.

Comprehensive screening resulted in 466 customers available for use in the billing analysis savings regression modeling. Table 82 lists the data received for electric accounts. The highlighted accounts contained enough usable data for the billing analysis. Of all accounts, only 15% contained sufficient billing data and passed all the screens necessary for the billing analysis regression modeling.

Table 82. City Level Participation Counts and Electric Billing Analysis Sites

Program	Pre Bills Available	Post Bills Available	Electric Population N	Electric Analysis n	% Usable Data
Atlanta			294	0	0%
Carrboro	X		10	0	0%
Chapel Hill	X		112	0	0%
Charleston	X		127	0	0%
Charlottesville	X	X	962	81	9%
Decatur	X	X	54	43	80%
Hampton Roads	X	X	62	26	42%
Huntsville	X	X	684	213	31%
Jacksonville	X	X	206	94	46%
Nashville			510	0	0%
New Orleans	X	X	128	9	8%
Overall	**n/a**	**n/a**	**3,149**	**466**	**15%**

Weather Data

To account for weather impacts on the billing analysis, Cadmus collected weather data from the National Climatic Data Center for 24 stations, representing all SEEA cities. For each station, analysis calculated the sum of heating degree days (HDDs) and cooling degree days (CDDs), allowing base temperatures (home heating and cooling system set points) to range between 45 and 85 degrees Fahrenheit.[10] Using participants' ZIP codes, Cadmus matched each billing data period for the associated HDDs and CDDs, based on the nearest weather station. These are used in the billing analysis regression model estimation to weather normalize the usage.

For each station, Cadmus obtained normal TMY3[11] HDDs and CDDs. Table 83 shows TMY3 base 65 normal CDDs and HDDs. Due to a limited number of normal weather stations, multiple weather stations, in close proximity to each other, may exhibit the same normal.

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10 The HDD for a given day is equal to the difference between the average outside temperature and the estimated heating reference temperature on days where the reference temperature is higher; similarly, the CDD for a given day is the difference between the average outside temperature and the cooling reference temperature on days where the reference is lower than the outside temperature. In our analysis, we required that the heating reference be lower than the cooling reference temperature.

11 A TMY data set is a collection of selected weather data for a specific location, generated from a database spanning many years of weather data. The TMY data set is intended to present the range of weather phenomena specific to that location with annual averages that are consistent with the location's long term averages. The TMY data sets were produced by NREL's Electric Systems Center under the Solar Resource

Table 83. Weather Station and Normal Heating and Cooling Degree Summaries

State	Best Station	Station Name	Station ID	Normal CDD (TMY3)	Normal HDD (TMY3)
AL	KGAD	GADSEN MUNI (AWOS)	722285	1,313	3,108
AL	KHSV	HUNTSVILLE/MADISON	723230	1,609	3,445
FL	KJAX	JACKSONVILLE INTL	722060	2,826	1,094
FL	KNRB	MAYPORT (NS)	722066	2,662	1,033
FL	KLEE	LEESBURG MUNI AIRPORT	722213	2,895	718
GA	KATL	ATLANTA INTL AIRPORT	722190	1,514	2,947
GA	KFTY	ATLANTA/FULTON CO.	722195	1,630	3,366
GA	KPDK	ATLANTA/DEKALB	722196	1,630	3,366
GA	KMGE	DOBBINS AFB/MARIETT	722270	1,630	3,366
LA	KMSY	NEW ORLEANS/MOISANT	722310	2,729	1,349
LA	KNEW	NEW ORLEANS/LAKEFRO	722315	2,947	1,243
LA	KNBG	NEW ORLEANS (NAS)	722316	2,471	1,187
NC	KRDU	RALEIGH-DURHAM	723060	1,482	3,481
SC	KCHS	CHARLESTOWN MUNI	722080	2,155	2,054
TN	KBNA	NASHVILLE METRO	723270	1,738	3,665
VA	KNTU	OCEANA (NAS)	723075	1,562	3,263
VA	KORF	NORFOLK INTL AIRPORT	723080	1,610	3,398
VA	KNGU	NORFOLK (NAS)	723085	1,610	3,398
VA	KPHF	NEWPORT NEWS	723086	1,671	3,397
VA	KCHO	CHARLOTTESVILLE	724016	1,079	3,695
VA	KEZF	SHANNON AIRPORT	724033	1,355	4,573
VA	KLYH	LYNCHBURG/P. GLENN	724100	1,256	4,204
VA	KSHD	STAUNTON/SHENANDOAH	724105	1,077	4,757
VA	KLFI	LANGLEY AFB/HAMPTON	745980	1,440	4,156

Modeling

Cadmus utilized two models to evaluate the usable electric and gas billing data in order to assess savings: a fixed-effects model for each city and a customer-specific model. We used these two models to triangulate savings estimates. The customer-specific models yielded the best precisions and hence we used these to determine the final savings estimates.

Characterization Project, which is funded and monitored by the U.S. Department of Energy's Energy Efficiency and Renewable Energy Office.

The TMY3 data sets are based on more recent and accurate data, and therefore, are recommended for use in place of earlier TMY2 data. They are derived from the 1991 to 2005 National Solar Radiation Data Base (NSRDB) archives. The TMY3 data sets are available at: http://rredc.nrel.gov/solar/old_data/nsrdb/

A detailed description follows of the specifications for each model.

Electric Fixed-Effects Overall Model

Fixed-effects estimation uses parameters from a panel data set, which derive from a (usually small) number of observations over time on a (usually large) number of cross-sectional units, such as individuals, households, firms, or governments. The fixed-effects estimator uses ordinary least squares on deviations from the means of each unit or time period. This approach proves relevant when one expects the averages of dependent variables will differ for each cross-sectional unit or each time period, but the variance of errors will not.[12]

To obtain overall model savings for direct-install and major measure groups, Cadmus estimated a fixed-effects model specification for each city, as follows:

$$ADC_{it} = \alpha_i + \beta_1 HDD_{it} + \beta_2 CDD_{it} + \beta_3 POST_{it} + \varepsilon_{it}$$

Where, for customer 'i' and billing month 't':

ADC_{it}	=	The average daily kWh consumption in the pre and post period.
α_i	=	The average pre-period base load kWh usage for each customer—part of the fixed-effects specification.
β_1	=	The average pre-period kWh usage per HDD.
HDD_{it}	=	The average daily base 65 HDD for the nearest weather station based on location.
β_2	=	The average pre-period kWh usage per CDD.
CDD_{it}	=	The average daily base 65 CDD for the nearest weather station based on location.
β_3	=	The average daily kWh savings for the direct install or major measures.
$POST_{it}$	=	An indicator variable that is 1 in the post-installation period and 0 in the pre-installation period.
ε_{it}	=	The model error term.

The following calculation shows how Cadmus derived final savings estimates from the model coefficients:

$\beta_3 * 365$	=	Annual overall kWh savings for each customer.

12 http://economics.about.com

Electric Customer-Specific Models (PRISM)

Cadmus used customer-specific models to develop weather-normalized pre and post usage estimates. These models provided an alternate weather-normalization methodology with which to compare the fixed-effects savings estimates.

Customer-specific models (also known as PRInceton Scorekeeping Method or "PRISM" models) offer an added advantage in that they weather-normalize the pre and post periods for each customer.

Cadmus allowed the heating and cooling reference temperatures (τ or taus) – the estimated heating and cooling system set points – to range from 45 to 85 degrees, although we excluded models where the heating reference temperature was higher than the cooling reference temperature, as this would indicate simultaneous heating and cooling within a home. This modeling approach runs account-level models for the pre and post periods and for each heating and cooling base combination.

The analysis used the following heating and cooling PRISM model specification:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer 'i' and billing month 't':

ADC_{it}	=	The average daily kWh consumption in the pre or post program period.
α_i	=	The participant intercept, representing the average daily kWh base load.
β_1	=	The model space heating slope.
$AVGHDD_{it}$	=	The base tau (45–85) average daily HDDs for the specific location.
β_2	=	The model space cooling slope.
$AVGCDD_{it}$	=	The base tau (45–85) average daily CDDs for the specific location.
ε_{it}	=	The error term.

From the above model, the analysis determined the weather-normalized annual consumption (NAC) as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_i + \beta_2 LRCDD_i + \varepsilon_i$$

Where for each customer 'i':

NAC_i	=	The normalized annual kWh consumption.
α_i	=	The intercept equal to the average daily or base load for each participant, representing the average daily base load from the model.
$\alpha_i * 365$	=	The annual base load kWh usage (non-weather sensitive).
β_1	=	The heating slope (in effect, usage per heating degree from the model above).
$LRHDD_i$	=	The annual, long-term HDDs of a typical month year (TMY3) in the 1991–2005 series from the National Climatic Data Center (NCDC) at the National Oceanic

and Atmospheric Administration(NOAA), based on the home location.

$\beta_1 * LRHDD_i$ = The weather-normalized, annual weather-sensitive (heating) usage, also known as HEATNAC.

β_2 = The cooling slope (in effect, usage per cooling degree from the model above).

$LRCDD_i$ = The annual, long-term CDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location.

$\beta_2 * LRCDD_i$ = The weather-normalized, annual weather-sensitive (cooling) usage, also known as COOLNAC.

ε_i = The error term.

From the various heating and cooling tau combinations, the analysis kept only models with the correct positive cooling and/or heating slope signs. Of the models with the correct signs for the heating and cooling parameters, models with the highest r-square presented the best pre and post models, and thus the best fit between the monthly billing usage and the associated HDDs and CDDs.

From this final, best pre and post PRISM models, PRENAC–POSTNAC (called DNAC) provided the customer-specific savings—the values from which we calculated the overall average savings for each customer.

Natural Gas Customer-Specific Models (PRISM)

Cadmus estimated natural gas savings using gas-only variable degree day PRISM models. To produce reliable results, the modeling only included customers with at least 10 months of pre- and post-measure billing data.

Only Huntsville offered a sufficiently large sample with good billing data to estimate natural gas savings[13] (with natural gas billing data for 74 Huntsville sites). Of the74 sites with gas billing data, 19 sites did not have percent *ex ante* savings. We eliminated an additional 12 sites as they had less than 10 months of pre- and post-measure billing data, monthly usage outliers, vacancies, or unreliable PRISM usage estimates. This resulted in a final natural gas sample size of 43 sites.

To compare PRISM model savings to the correct percent savings *ex ante* estimates, we removed the 19 customers with missing *ex ante* savings from the analysis, as previously discussed.[14] Thus, Huntsville

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13 Only five sites from all the other cities combined offered sufficient natural gas billing data. Given the small sample size, statistically significant savings could not be estimated for those cities.

14 Although the 19 sites did not have the expected savings, some sites still indicated significant savings. Furthermore, the SEEA tracking database produced available natural gas percent savings identical to the electric percent savings. The Huntsville gas measure data were fairly incomplete, and did not obviously indicate which gas measures had been installed in each site.

offered only percent *ex ante* savings. To obtain the actual therms savings expected required multiplying the percent savings by the weather-normalized pre period usage, derived from the PRISM models (this is known as PRENAC: pre period normalized annual consumption).

Cadmus used customer-specific models to develop weather-normalized pre and post usage estimates for the 43 natural gas sites with usable data. Customer-specific (PRISM) models offer an added advantage in that they weather-normalize the pre and post periods for each customer.

Cadmus allowed the heating reference temperatures (τ or taus) to range from 45 to 85 degrees. This modeling approach ran account-level models for the pre period and post periods and for each heating base.

Analysis used the following heating PRISM model specification:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \varepsilon_{it}$$

Where for each customer 'i' and billing month 't':

ADC_{it}	=	The average daily therms consumption in the pre or post program period.
α_i	=	The participant intercept, representing the average daily therms base load.
β_1	=	The model space heating slope.
$AVGHDD_{it}$	=	The base tau (45–85) average daily HDDs for the specific location.
ε_{it}	=	The error term.

The above model allowed the NAC to be computed as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_i + \varepsilon_i$$

Where for each customer 'i':

NAC_i	=	The normalized annual therms consumption.
α_i	=	The intercept equaling the average daily or base load for each participant, representing the average daily base load from the model.
$\alpha_i * 365$	=	The annual base load therms usage (non-weather sensitive).
β_1	=	The heating slope (in effect, the usage per heating degree from the model above).
$LRHDD_i$	=	The annual, long-term HDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location.
$\beta_1 * LRHDD_i$	=	The weather-normalized, annual, weather-sensitive (heating) usage, also known as HEATNAC.
ε_i	=	The error term.

From the various heating tau combinations, the analysis only retained models with the correct positive heating slope signs. Of models with the correct signs for the heating parameters, the models with the highest r-square offered the best pre and post models, and the best fit between monthly billing usage and associated HDDs.

From these final, best, pre and post PRISM models, customer-specific savings derive from PRENAC–POSTNAC (DNAC). Cadmus used these values to calculate the overall natural gas average savings for each customer.

Electric Billing Analysis Results

Cadmus compared the precision of the fixed-effects city models and the PRISM models. Generally, savings from the customer-specific models provided higher savings estimates, and the customer-specific models offered precision superior to the fixed-effects models. Thus, all final billing analysis savings estimates derive from the PRISM modeling approach, which performs better when less than 12 months of billing data is available.

Table 84 summarizes the final PRISM electric billing analysis results. The percent savings varied from 8% to 27%, with an average of 16%. The average savings of 16% is less than the estimates generated by SEEA; expected savings ranged from 9% to 32%, with an average of 24%. The overall 70% realization rate indicates that the SEEA Consortium achieved 70% of its estimated savings.

Table 84. Electric Billing Analysis Savings

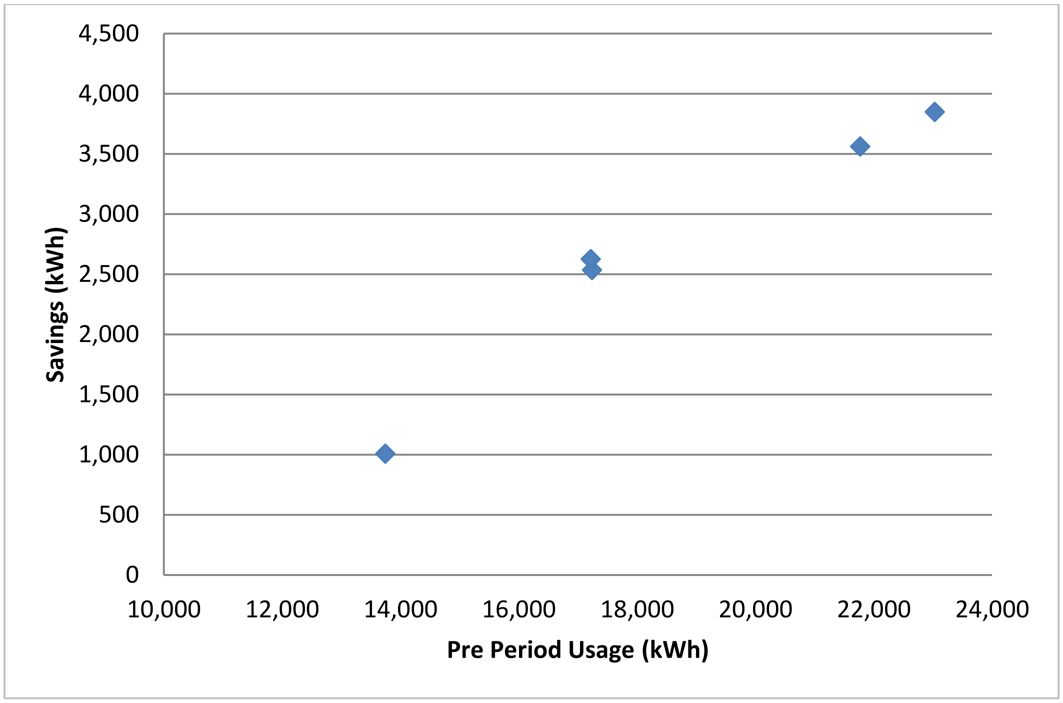
City	n	PRENAC*	Model kWh Savings	Ex Ante kWh	Realization Rate	Relative precision at the 90% Confidence Level	Modeled Billing Analysis Percent Savings	Expected Percent Savings
Charlottesville	81	16,247	2,535	4,323	59%	29%	16%	27%
Decatur	43	12,761	1,008	4,037	25%	48%	8%	32%
Hampton Roads	26	16,299	2,625	2,558	103%	45%	16%	16%
Huntsville	213	22,404	3,849	5,061	76%	10%	17%	23%
Jacksonville	94	21,545	3,561	5,263	68%	18%	17%	24%
New Orleans**	9	18,178	4,969	1,726	288%	38%	27%	9%
OVERALL	**466**	**19,849**	**3,254**	**4,675**	**70%**	**9%**	**16%**	**24%**

* The paired pre period, weather-normalized usage, based on the analysis months.

** Though included, the New Orleans savings derive from a low sample size and produce unusually high billing analysis savings and realization rates. Consequently, simulation modeling should probably be used to determine the New Orleans savings.

Figure 38 graphically shows the savings for the five cities.[15] From this chart it is clear that the higher the average pre-period usage, the higher the resulting savings.

Figure 38. Relationship Between Average City Pre-Period Usage and Electric kWh Savings



Natural Gas Savings Results

Table 85 summarizes the PRISM-based natural gas savings for the final analysis group of 43 Huntsville sites. Huntsville achieved 15% savings, compared to expected savings of 23%, for a natural gas realization rate of 68%.

Table 85. Gas Billing Analysis Savings Summary

City	n	PRENAC*	Model Therms Savings	*Ex Ante*	Realization Rate	Precision	Modeled Billing Analysis Savings	Expected Savings
Huntsville	43	576	88	131	68%	37%	15%	23%

* The paired pre period, weather-normalized usage, based on the analysis months.

15 This excludes New Orleans, given its low sample size and unreasonably high billing analysis estimate.

Cost-Effectiveness Study

In assessing cost-effectiveness, Cadmus analyzed program costs and benefits from the societal cost test perspective, using Cadmus' DSM Portfolio Pro[16] model. We chose to use the societal cost test for this analysis because it encompasses both the involved utilities' and program participants' costs and benefits. In addition, this program produces many non-energy benefits, and the societal cost test accounts for non-energy and externality benefits through the application of a 10 percent adder to the energy benefits. The California Standard Practice Manual for assessing demand-side management program cost-effectiveness describes the benefit and cost methodologies used for this test.

The societal cost test perspective examined the BBNP program benefits and costs from a combined utility and customer perspective. On the benefit side, this included avoided energy costs, avoided capacity costs, and line losses, plus a 10% adder to reflect non-quantified benefits. On the cost side, it included total project costs, regardless of who paid for them.

Error! Reference source not found. provides the discount rate and line losses used for the cost-effectiveness analysis. Use of the discount rate allowed future energy savings benefits and costs to be adjusted into present day values. Line losses allowed customer site savings to be adjusted to savings realized at the generator.

Table 86. Discount Rate and Line Loss Inputs

Input Description	Value	Source
Discount rate	3.19%	U.S. Dept. of Treasury, Daily Long Term Rate from 7/3/13
Line loss	6.80%	Potential study conducted by Cadmus for Georgia utility

Avoided Electric and Gas Energy Costs

Multiplying energy savings by avoided electric and gas costs allowed estimation of the program's societal benefits. Temporal variations in the times that energy savings occurred throughout the year allowed more accurate assessment of benefits, as the value of energy saved also varied by time of year.

Cadmus used natural gas delivered prices from the Energy Information Administration 2013 Annual Energy Outlook report[17] as the basis for electric avoided costs. Nominal prices were adjusted for on and off-peak heat rates, monthly variations (using Henry Hub natural gas futures prices), and spark spreads. The analysis developed two sets of avoided costs: one for South Atlantic states (Georgia, North Carolina, South Carolina, Virginia) and one for East South Central states (Alabama, Tennessee, Louisiana).

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16 DSM Portfolio Pro has been independently reviewed by various utilities, their consultants, and a number of regulatory bodies, including: the Iowa Utility Board, the Public Service Commission of New York, the Colorado Public Utilities Commission, and the Nevada Public Utilities Commission.

17 www.eia.gov

Natural gas avoided costs derived from regional city gate prices from the EIA. The gas avoided costs split into the same regions—South Atlantic and East South Central—as for electric avoided costs.

Cadmus estimated:

Electric avoided costs by month and peak/off-peak hours, for a total of 24 unique values per year; and

Gas avoided costs monthly for a total of 12 unique values per year.

Error! Reference source not found. shows the electric and gas avoided costs used in the cost-effectiveness analysis for 2013 (avoided costs addressed 2010 through 2040).

Table 87. 2013 Avoided Energy Costs

Month	South Atlantic			East South Central		
	Electric ($/MWh)		Gas ($/therm)	Electric ($/MWh)		Gas ($/therm)
	Off-Peak	On-Peak		Off-Peak	On-Peak	
1	$39.84	$56.55	$0.47	$32.99	$47.63	$0.47
2	$34.63	$49.77	$0.45	$28.71	$42.07	$0.47
3	$36.26	$51.88	$0.45	$30.05	$43.80	$0.46
4	$37.00	$52.85	$0.41	$30.65	$44.59	$0.41
5	$39.99	$56.74	$0.43	$33.11	$47.79	$0.40
6	$42.82	$60.43	$0.48	$35.44	$50.82	$0.40
7	$41.84	$59.15	$0.42	$34.63	$49.77	$0.44
8	$43.08	$60.77	$0.51	$35.66	$51.10	$0.45
9	$39.37	$55.94	$0.49	$32.61	$47.14	$0.43
10	$32.97	$47.61	$0.45	$27.35	$40.29	$0.45
11	$32.23	$46.65	$0.45	$26.74	$39.50	$0.47
12	$30.75	$44.72	$0.47	$25.53	$37.92	$0.46

Avoided Electric Capacity Costs

This program's societal benefits included avoided electric capacity costs, multiplied by capacity savings. These costs represented the reduction in generation capacity needed to meet peak hour loads.

Cadmus used PJM[18] residual auction capacity prices as the source for the avoided capacity prices. **Error! Reference source not found.** shows annual avoided electric capacity prices for 2010 to 2020.

18 PJM is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia.

Table 88. 2013 Avoided Capacity Costs

Year	$/KW
2010	$63.62
2011	$63.62
2012	$40.15
2013	$6.01
2014	$10.12
2015	$45.97
2016	$49.14
2017	$49.80
2018	$50.43
2019	$51.20
2020	$51.93

Load Shapes

Cost-effectiveness analysis uses load shapes to allocate annual energy savings to specific hours of the year. For example, heating measures produce energy savings mostly during winter peak and off-peak hours, while cooling measures produce energy savings mostly during summer on-peak hours only.

As shown in **Error! Reference source not found.**, the magnitude of the avoided cost benefits from energy savings varies by season and hour; so utilizing load shapes allows a more accurate estimation of avoided cost benefits.

Cadmus developed 8760 load shapes (8760 representing the number of hours in a non-leap year) using building simulation software. These load shapes can be uniquely distinguished by:

Climate zone: Baltimore, Houston, Memphis, Miami.

Fuel type: Electric, natural gas.

Sector: Residential, commercial.

Building segment: Single-family and multifamily for residential, various segments for commercial.

End use: Varying by sector (e.g., heating, cooling, water heating, large appliances).

Cost-Effectiveness Results by City, Sector, and Year

For the cost-effectiveness analysis, Cadmus used energy savings derived from this study's evaluated electric and gas savings. This included electric and gas savings estimated by city, sector, measure installation year, and end use. Measure lives used derived from the Pennsylvania 2013 Technical Reference Manual.[19]

Error! Reference source not found. shows lifetime gas and electric energy savings—at the generator by city and for the overall program—for all measures installed between 2010 and November 25, 2013.

Table 89. 2010-13 Lifetime Electric and Gas Energy Savings by City

City	MWh	Therms
Atlanta	2,834	1,483,630
Carrboro	3,677	3,022,625
Chapel Hill	6,310	458,598
Charleston	5,110	106,574
Charlottesville	35,635	2,327,361
Decatur	946	71,206
Hampton Roads	2,598	119,200
Huntsville	16,010	196,926
Jacksonville	24,894	-
Nashville	19,846	1,050
New Orleans	27,979	12,912,485
Better Buildings Total	**145,838**	**20,699,653**

Cadmus analyzed cost-effectiveness for all combinations of cities, sectors, and installation years. However, the cost-effectiveness model is based on the program database received in July 2013 when we did not build the cost-effectiveness model to include Charlotte or the U.S. Virgin Islands due to limited program activity and thus energy savings. But, the database received on November 25, 2013 reports an additional non-negligible amount of energy savings in these two cities most significantly under multifamily and commercial sectors.

The following tables show the societal cost test benefit/cost ratios for these combinations. A benefit/cost ratio greater than or equal to 1.0 indicates a cost-effective program for that particular combination.

[19] Available online at: http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

Error! Reference source not found. shows the societal test benefit/cost ratios by year for the SEEA BBNP, across all cities and sectors combined. The program did not prove cost-effective in any year or for the overall evaluation period.

Table 90. SEEA BBNP Benefit/Cost Ratios by Year

Category	2010	2011	2012	2013	2010–2013
SEEA Better Buildings	0.58	0.41	0.44	1.66	0.73

Error! Reference source not found. shows the societal test benefit/cost ratios by year and city for all residential projects and measures. If measurable costs or benefits do not appear for a city and year combination, the benefit/cost ratio equals zero.

Table 91. Residential Projects Benefit/Cost Ratios by Year and City

City	2010	2011	2012	2013	2010–2013
Atlanta	0.58	0.41	0.33	0.22	0.42
Carrboro	-	0.46	4.98	5.15	4.90
Chapel Hill	-	0.39	0.36	0.24	0.32
Charleston	-	0.77	0.65	0.43	0.64
Charlottesville	-	0.60	0.30	0.25	0.37
Decatur	-	0.20	-	-	0.20
Hampton Roads	-	0.34	-	-	0.34
Huntsville	-	0.51	0.54	0.43	0.48
Jacksonville	-	0.63	0.41	-	0.48
Nashville	-	0.43	0.41	0.44	0.42
New Orleans	-	1.45	0.52	10.47	5.94
Residential Total	**0.58**	**0.45**	**0.42**	**1.80**	**0.78**

Error! Reference source not found. shows the societal test benefit/cost ratios by year and city, for all commercial projects and measures.

Table 92. Commercial Projects Benefit/Cost Ratios by Year and City

City	2010	2011	2012	2013	2010-2013
Carrboro	-	0.21	0.09	-	0.13
Charlottesville	-	0.12	0.74	0.10	0.16
Jacksonville	-	-	0.62	-	0.62
New Orleans	-	-	-	19.13	19.13
Commercial Total	**-**	**0.12**	**0.61**	**0.14**	**0.35**

Net Program Impacts

The net impacts of a program are those that can definitely be attributed to a program's effect and would not have occurred without the program being in place. Some degree of efficiency upgrades take place in the absence of a program. Participating households or businesses that would have made upgrades without the program are known as freeriders. The net impacts subtract their savings from what is attributed to the program. Conversely, some program participants are induced by their participation to take additional energy saving actions. These are known as program "spillover" and are added to the full program impact.

The Cadmus team did not conduct a full net impacts analysis for the Better Buildings evaluation. Because the estimate of freeridership depends on an estimate of a counterfactual—what would have happened without the program—the estimate is subject to significant measurement error. Moreover, since the purpose of the ARRA funds was not only to achieve energy savings but also to provide economic stimulus, we believe it is the gross impacts that are the best measure of the program's success.

Nevertheless, in our survey of residential participants we asked questions that capture some insight into the effect of the program on individual decision-making. We asked respondents to assess for themselves the impact of the program on their decision to install energy efficiency upgrades. On a four-point scale, rated from "very important" to "not at all important," we asked respondents to rate the importance of information received through the home energy assessment, their low interest loan (where relevant), and the incentive they received, on their decision to invest in energy improvements. The sample for each city was too small to be meaningful. However, the participant responses were all quite consistent.

Freeridership

Ninety-four percent of respondents rated the information they received when participating in the program as "somewhat" or "very" important to their decision to invest in energy improvements.

Table 93. Importance of Home Energy Assessment Information

Response	Total Frequency	Total %
Very important	110	69%
Somewhat important	41	26%
Not too important	4	3%
Not at all important	4	3%
Total	**159**	**100%**

Among the sub-set of respondents who had received a low-interest loan, 100% of survey respondents said the loan had been "somewhat" or "very" important to their decision to invest in energy improvements.

Table 94. Importance of Low Interest Loan

Response	Total Frequency	Total %
Very important	14	78%
Somewhat important	4	22%
Not too important	0	0%
Not at all important	0	0%
Total	**18**	**100%**

Ninety-one percent of respondents said the incentive they had received to invest in energy improvements had been "somewhat" or "very" important to their decision.

Table 95. Importance of Incentive

Response	Total Frequency	Total %
Very important	79	63%
Somewhat important	35	28%
Not too important	9	7%
Not at all important	3	2%
Total	**126**	**100%**

Looking across responses to the three items, 81% of respondents rated at least one of three factors, information, loan, or incentive, as "very important" to their decision. Only 2% of respondents (3 out of 150) did not rate at least one of the three factors as at least "somewhat important." So, while we have not made net adjustments to saving based on these responses, it is very clear that freeridership was not a significant factor in the program's impact.

Spillover

Just as we have not attempted to adjust savings based on freeridership, we have not included program spillover in the savings. Like freeridership, estimates of program influence on subsequent actions are subject to considerable measurement error because they are based on subjective assessments. Nevertheless, survey respondents did attribute program influence on various energy saving actions they took after participation in the program. Respondents were asked, "Besides completing the home energy improvements through this program, have you made any other energy-efficiency improvements or purchases on your own without any assistance from a utility or energy-efficiency program?" Forty-five percent of respondents said they had.

Table 96 Respondents Saying They Made Additional Improvements

Response	Total Frequency	Total %
Yes	72	45%
No	88	55%

Total	**160**	**100%**

As shown in Table 97, the types of improvements varied widely, from actions with a relatively small energy savings impact such as installing CFLs, to significant upgrades such as installing new windows. To estimate spillover as energy savings we would attempt to assign a savings value to each measure. This can be problematic because it is difficult to collect sufficient data in a survey to accurately gauge the savings. For that, more detailed information about equipment types and installation are helpful.

Table 97. Energy-Efficiency Improvements Made without Program Assistance

Response	Total Frequency	Total %
Compact Fluorescent Light bulbs	18	17%
LED bulbs	4	4%
Increased the level of insulation	15	14%
Reduced air infiltration or leaks	8	8%
Efficient appliances	17	16%
Efficient air conditioner, furnace, boiler or other heating or cooling equipment	3	3%
Efficient water heater	3	3%
Low flow shower heads or faucet aerators	2	2%
Water heater tank wrap or pipe insulation	4	4%
Efficient windows	16	15%
Other	16	15%
Total	**106**	**100%**

Spillover is not assigned to all subsequent upgrades, moreover. Instead, savings typically are adjusted based on the survey respondents' assessment of the program's influence on their actions. Table 98 shows survey responses to the question, "Would you say the program was very important, somewhat important, not too important or not at all important in your decision to make the additional energy?" Forty-nine percent of respondents who had made improvements—so 21% of all respondents-- said the program was very important in their decision to make additional energy efficient improvements. Thus, there is strong indication that the program did have spillover effects.

Table 98. Rating of Program's Importance in Energy-Efficiency Improvements Made

Response	Total Frequency	Total %
Very important	34	49%
Somewhat important	11	16%
Not too important	7	10%
Not at all important	17	25%
Total	**69**	**100%**

Although this study did not include a full investigation of freeridership and spillover attributed to the BBNP, Cadmus believes these survey results indicate adjustments to the evaluated gross savings would be relatively small. We also note that the spillover effects appear to be higher among this group than we see in other regions of the country for similar utility-sponsored programs. While not conclusive, this may result from the promotion of energy efficiency benefits in a region of the country that has historically had much lower investment in energy-efficiency programs.[20] It could also suggest that the community-based outreach approaches used by most of the programs was successful in reaching new segments of the population in areas where other energy efficiency programs have been offered.

[20] Brown, Marilyn A., and Etan Gumerman, Xiaojing Sun, Youngsun Baek, Joy Wang, Rodrigo Cortes and Diran Soumonni. 2010. Energy Efficiency in the South. Atlanta, GA: Southeast Energy Efficiency Alliance.

Impact Evaluation Conclusions and Recommendations

Tracking Database

Primary inputs and contextual data should be specified and tracked by the program database in a consistent way to inform the evaluation and apply the energy savings properly.

Recommendation 1. Keep track of building parameters and characteristics that can impact the energy savings associated with the measure type in a significant way. Cadmus found that the majority of building parameter values and characteristics associated with weather-sensitive measure types were missing in the SEEA tracking database.

Recommendation 2. Track detailed descriptions of installed measure types. Electronically track specific measure information that is necessary to evaluate the measure-level savings. All programs should collect these variables and store data electronically in the program's tracking database. For example, for a lighting measure, the installed lamp type, wattage and unit are essential to estimating energy savings.

Recommendation 3. Keep track of number of measures installed per measure type. The units of each measure type installed in a participant's home has a direct impact on the energy savings associated with that measure and therefore, it is essential to be tracked consistently.

Identifying Energy Efficiency Measure Types

Recommendation 4. Select weather-sensitive measures according to climatic conditions. Adopt and prioritize weather-sensitive measures that save more energy in relationship to the specific climatic characteristics of that region to maximize the energy savings and improve the benefit/cost ratios. Through the city-by-city impact evaluation effort, Cadmus found trends of measure types getting installed in accordance to the contractor's resources and skills, or market availability rather than what measure types potentially impact the energy savings in a more significant way. For example, an unusually large quantity of new windows (231) were installed in the city of Huntsville compared to other SEEA cities.

Energy Savings Calculation

Recommendation 6. Set consistent guidelines and procedures for calculating energy savings associated with program measures for both deemed and custom energy savings. Adopt one single tool for estimating energy savings associated with weather-sensitive measures and use that same whole-house modeling tool across all local programs to avoid inconsistency in savings estimates as a result of incorporating different methodologies and set of assumptions/parameters used by each tool.

Recommendation 7. Use the same set of appropriate assumptions for the parameters impacting the energy savings for the same measures types and similar climate zones. Adopt consistent assumptions and standards for savings calculation inputs so that results are easily verifiable.

Recommendation 8. Set unified deemed energy savings methodologies for non-weather-sensitive measures. A consistent and traceable source for algorithms used in savings calculations is necessary for future evaluation efforts, and provides for more reliable savings estimates.

Recommendation 9. Establish a set of consistent baseline parameters for each measure type or track baseline parameters on a household basis. Consistent methodologies and assumptions used for savings calculations are necessary for future evaluation efforts, and provide for more reliable savings estimates.

Recommendation 10. Set up a procedure beforehand to aggregate billing (meter) data for all the program participants. Billing data provides a direct measure of home energy consumption on a household-by-household basis.

Recommendation 11. Evaluate the impact of energy savings resulted from multifamily and commercial sectors once all the program activities are completed. Based on the database that Cadmus received on November 25, 2013, there has been a significant increase in energy savings resulted from multifamily and commercial sectors, especially in the cities of New Orleans, Charlotte, Carrboro and Charlottesville. The total of these recent energy savings are substantial enough to warrant an impact evaluation, particularly if sufficient program documentation is available for review and evaluation as the new database does not provide sufficient data for evaluation.