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Impact Evaluation of the Energy Savers Program for Large Multifamily Buildings

Prepared for:

CNT Energy

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Community Focused Innovation

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Executive Summary

This report presents impact evaluation results for the Energy Savers program for large multi-family buildings. The Energy Savers program is run by CNT Energy and Community Investment Corporation. Initiated in January 2008 and now in its fifth year of existence, the Energy Savers program involves a variety of services to promote energy efficiency improvements for multi-family residential buildings of 5-50 units in the affordable housing market segment. Services include an energy audit, financial guidance for the renovations recommended by the audit, advice on managing renovation construction, and annual savings reports. The energy audits cover a range of possible improvements, including replacing heating units, installing air sealing measures, altering hot water distribution systems, and adding insulation to the roof cavity. Upon receiving the energy audit report the building owner is given the opportunity to work with Energy Savers staff to obtain the financing and expertise to make the recommended changes.

This evaluation estimates the natural gas savings from January 2010 through September 2012 for 21 buildings that completed energy efficiency upgrades through the Energy Savers program before January 2010. Navigant estimates that average natural gas savings were 19.8%, with savings reaching 26.1% during the heating season months of November through March, measured against comparable buildings that did not make efficiency improvements through the Energy Savers program. Savings were 14.6% during the shoulder months of April/May and September/October, and 1.9% during the summer months of June through August. Overall, estimated gas savings for the 21 renovated buildings from the first completed renovation in June 2008 through September 2012 are 587,000 therms. Once renovations on all 21 buildings were complete, the estimated average energy savings were 179,800 therms annually. A breakdown of energy savings in each year since 2008 is shown in Table E-1 below.

Table E-1. Annual program energy savings

Year	Number of Buildings Renovated by End of Year	Number of Units Renovated by End of Year	Annual Gas Savings	Cumulative Program Savings
2008	8	303	15,200	15,200
2009	20	932	98,766	113,966
2010	21	946	179,389	293,356
2011	21	946	179,813	473,169
2012 (through Sept.)	21	946	113,943	587,112

1. Introduction

1.1 Energy Savers program description

This report presents impact evaluation results for the Energy Savers program for large multi-family buildings. The Energy Savers program is run by CNT Energy and Community Investment Corporation. Initiated in January 2008 and now in its fifth year of existence, the Energy Savers program involves a variety of services to promote energy efficiency improvements for multi-family residential buildings of 5-50 units in the affordable housing market segment. Services include an energy audit, financial guidance for the renovations recommended by the audit, advice on managing renovation construction, and annual savings reports. The energy audits cover a range of possible improvements, including replacing heating units, installing air sealing measures, altering hot water distribution systems, and adding insulation to the roof cavity. Upon receiving the energy audit report the building owner is given the opportunity to work with Energy Savers staff to obtain the financing and expertise to make the recommended changes.

Program enrollment began in January 2008 and continues. At least some billing data for the analysis was available from January 2005 through September 2012. This includes billing data for 51 different buildings identified for participation in the program that had not yet undergone energy renovations at the time the impact evaluation was conducted. In this report these are referred to as “pipeline” buildings.

1.2 Evaluation Objective

The objective of the impact evaluation was to estimate the gas savings due to the energy renovations by the 21 buildings with renovations completed by January 2010.

2. Methodology

The main methodological issue for the impact evaluation was to estimate the *counterfactual* energy use by buildings that underwent renovations upon participating in the program –that is, the energy these buildings *would have used in the absence of the renovations.* Comparing energy use after renovation to the counterfactual energy use indicates energy savings due to the renovations.

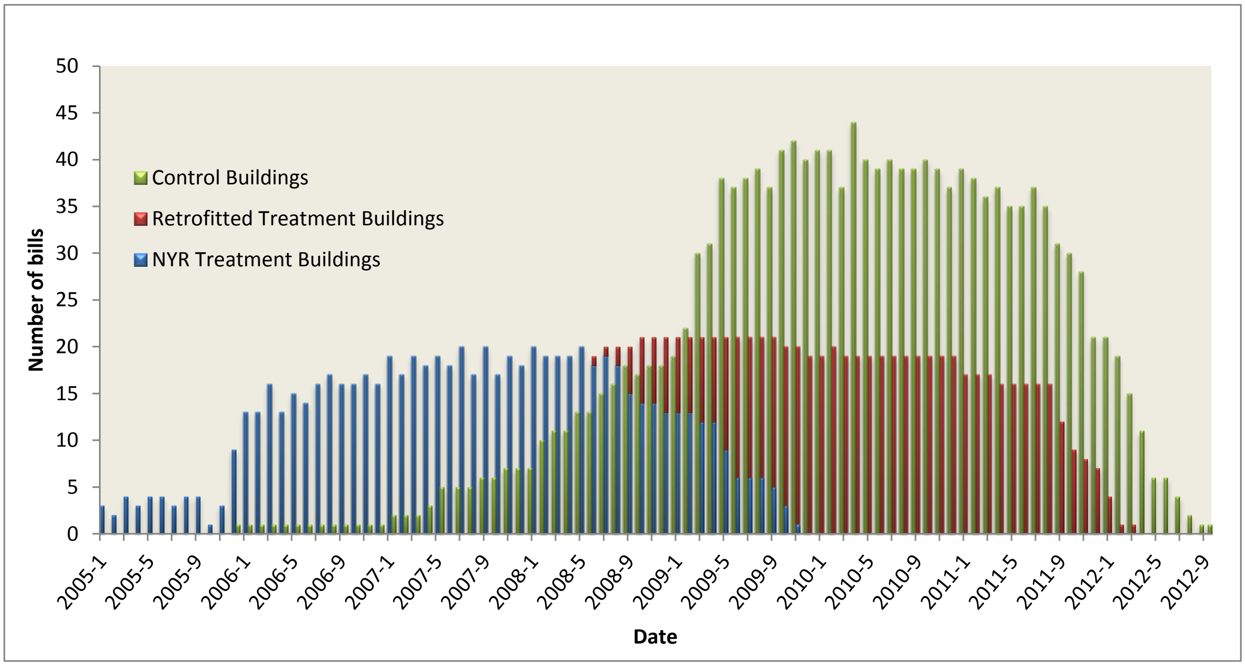
Simply comparing the rate of energy use after renovation to energy use before renovation is not sufficient for estimating savings, because other factors affecting energy use –weather, economic conditions, and other variables–also affect the change in energy use over time. These other factors that are observable can be included in a statistical analysis in an attempt to isolate the effects of the renovation, but even despite great diligence to include such variables there is a strong possibility that some factors will not be adequately represented in the analysis, causing the estimated effect of the renovations to be biased.

The usual approach to account for these other factors is to include in the analysis a set of control buildings to provide an estimate of the counterfactual energy use of the program buildings. The control buildings need to be similar to the program buildings except for the renovations induced by the program. "Similar" buildings, in the case of the statistical analysis, has a specific meaning: these are buildings that generate the same energy use *on average* as what the renovated buildings with the same observable characteristics *would have* generated in the absence of the renovation. It would not make sense, for instance, to randomly choose as control buildings a set of buildings in the service area with 5-50 units, because the buildings in the Energy Savers program are not necessarily typical of the building stock in the service area. Fortunately from an evaluation perspective, the Energy Savers program involves "rolling" participation –buildings receive the renovation at different points in time –and moreover, at the time this evaluation was conducted there were 51 "pipeline" buildings qualified for the program that had not yet fully participated in the program. These are the buildings that Navigant targeted to serve as controls in the statistical analysis because their qualification for the program is a strong signal that they are similar to the buildings actually renovated. In the remainder of this report, the term "control buildings" refers to the pipeline buildings, and "treatment buildings" refer to the 21 program buildings that have undergone renovation.

Figure 2-1 below shows the available monthly billing data for control and treatment buildings over the period January 2005-September 2012. The treatment buildings are classified according to whether they are not yet renovated (NYR) –that is, they have not yet been treated —or whether they have indeed been renovated. The first renovation was completed in June 2008 and by January 2010 the renovations for all 21 treatment buildings examined in this analysis were completed, though as indicated in Figure 2-1 the available billing data for these buildings is greatest in the period July 2006-August 2011 before tapering off sharply. Importantly, post-renovation data is greatest from November 2009 through August 2011, and so for the treatment buildings we had available good billing data for two full heating seasons before renovation (2006/2007 and 2007/2008) and for two full heating seasons after renovation (2009/2010 and 2010/2011). For the control buildings, observations of monthly billing data rise sharply through 2008, with over 35 observations between April 2009 and July 2011, and drop sharply after that.

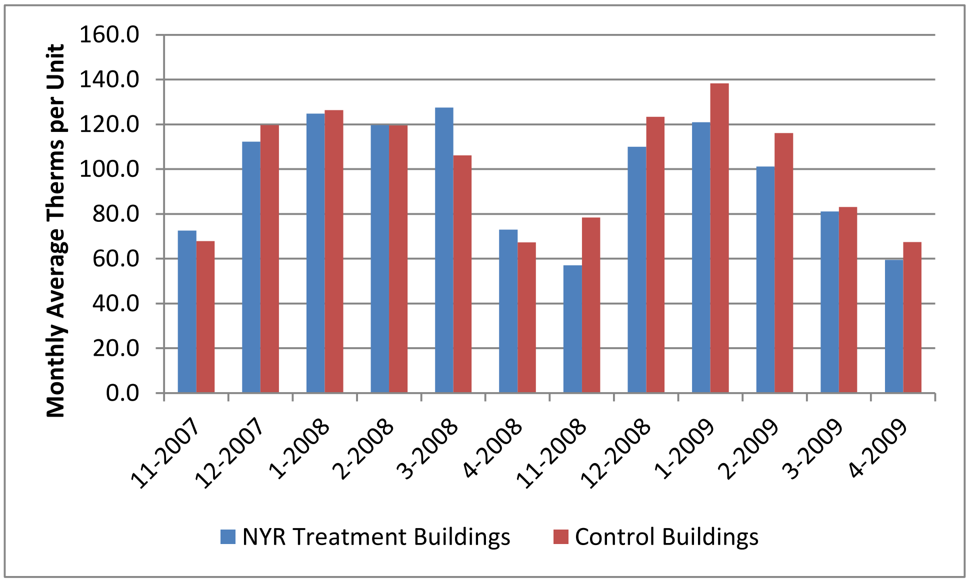
Figure 2-2 compares average monthly therm use per unit by control buildings and NYR treatment buildings during the heating seasons of 2007/2008 and 2008/2009. This comparison provides insight to the question of whether the control and treatment buildings are in fact similar except for the effects of the renovations. Due to data availability, the number of control buildings used in the figure grows from 7 buildings in November 2007 to 38 buildings in April 2009, while the number of observations for treatment buildings is fairly steady in the 2007/2008 heating season at about 18 buildings per month, and drops in the 2008-2009 heating season from 14 to 12 as renovations for two of the treatment buildings were completed during the season. Overall the comparison suggests that energy use by the control buildings is quite similar to that of NYR treatment buildings.

Figure 2-1. Available billing data for the control and treatment buildings, January 2005-September 2012.



Source: Navigant analysis

Figure 2-2. Comparison of monthly average natural gas use per unit by control and NYR treatment buildings.



Source: Navigant analysis

2.1 *Regression model to determine whether control buildings and treatment buildings are similar*

The similarity between treatment and control buildings can be examined formally using a regression model of energy use comparing energy use by control buildings and NYR treatment buildings. To generate a good statistical fit, the model is estimated during the period in which at least 10 observations for both control buildings and NYR treatment buildings are available, January 2008-April 2009. The dependent variable is a building's natural gas use per unit in therms. The regressors include a variable indicating whether a building is a control building or an NYR treatment building. Finding that the estimated effect of the indicator variable is small and not statistically different than zero is strong evidence that, conditional on the explanatory variables included in the analysis, the control buildings will indeed serve as good estimates for the counterfactual energy use by treatment buildings after the renovations are completed.

Formally, defining ADT_{jt} as average daily therm consumption per unit by building j in month t, we specify the following model:

Model 1

$$
\begin{aligned}
ADT_{jt} = {} & \alpha_t + \beta_1 \cdot SqFt_j + \beta_2 \cdot SqFt_j \cdot Summer_t + \beta_3 \cdot SqFt_j \cdot Shoulder_t \\
& + \gamma_1 \cdot Units_j + \gamma_2 \cdot Units_j \cdot Summer_t + \gamma_3 \cdot Units_j \cdot Shoulder_t \\
& + \delta_1 \cdot Treatment_j + \delta_2 \cdot Treatment_j \cdot Summer_t + \delta_3 \cdot Treatment_j \cdot Shoulder_t + \varepsilon_{jt},
\end{aligned}
$$

where all Greek letters denote coefficients to be estimated –in particular α_t is a month-specific constant—and:

$SqFt_j$	=	the square footage of building j;
$Units_j$	=	the number of units in building j;
$Summer_t$	=	an indicator variable taking a value of 1 if month *t* is one of the months June through August, and 0 otherwise;
$Shoulder_t$	=	an indicator variable taking a value of 1 if month *t* is one of the months April, May, September and October, and 0 otherwise;
ε_{jt}	=	an error term of the regression accounting for unobserved factors affecting energy use. Errors are assumed to be clustered by building.

The constant term α_t varies by month –it is a monthly *fixed effect* –to allow for the fact that on average, across all buildings, energy use is greater in some months than others. Although the dependent variable is therm use per unit, the inclusion of *SqFt* and *Units* account for the fact that buildings with greater mass tend to use less energy per unit. Interaction terms involving *Summer* and *Shoulder* reflect the assumption that the effects of variables depend on the season, with the heating season of November-March serving as the baseline season. So, for instance, including the interaction terms *SqFt·Summer* and *SqFt·Shoulder* reflects the assumption that the effect of building square footage on energy use varies seasonally.

The coefficients on the terms involving the variable *Treatment* are the coefficients of interest. In particular, the coefficients δ_1, δ_2, and δ_3 concern the average effect of being in the set of treatment households *before actually receiving the treatment* (that is, before renovation). Under the assumption that the control and treatment buildings are not different before the treatment households are renovated, these coefficients should be close to zero and not statistically significant. Finding otherwise would be evidence that the control buildings do not provide good estimates of the counterfactual energy use of the treatment buildings after renovation.

Results are presented in Table 2-1 below. Results indicate that the average difference between control and NYR treatment buildings in energy use per unit is 2.76 therms/month, which is 2.5% of energy use. In summer months the average difference is the sum of the coefficients on the variables *Treatment* and *Treatment·Summer* –1.24 therms per month (6.3%)—and in shoulder months the difference is 1.67 therms per month (3.0%). None of these differences is statistically significant. In estimating program savings these relatively small differences can be controlled using appropriate regression models, as explained below. Overall these results indicate that the control buildings will provide excellent estimates of the counterfactual energy use by renovated treatment buildings.

Table 2-1. Regression results for energy use by control and NYR treatment buildings, January 2008-April 2009.

Variable	Coefficient Estimate	Standard Error	t-Statistic
SqFt	0.001842	0.0002173	8.48
SqFt·Summer	-0.001657	0.0002216	-7.48
SqFt·Shoulder	-0.001047	0.0001649	-6.35
Units	-2.193554	0.2138842	-10.26
Units·Summer	1.98524	0.2139307	9.28
Units·Shoulder	1.261113	0.1697363	7.43
Treatment	2.76063	12.7363422	0.22
Treatment·Summer	-4.008381	12.6863619	-0.32
Treatment·Shoulder	-1.092857	9.8218591	-0.11

Coefficients for monthly dummy variables are omitted. Standard errors are cluster-robust. Source: Navigant analysis.

2.2 *Model to estimate savings from the renovations*

The analysis above establishes that the pipeline buildings provide an excellent control group for estimating energy savings from the program renovation buildings. We used two different regression models to actually estimate savings. The first simply extends Model 1 by including the indicator variable $Post_t$, which takes a value of 1 if a building is renovated in month *t* and 0 otherwise. Control buildings are never renovated during the evaluation period and so for these buildings $Post_t$ is always 0. Formally,

Model 2a

$$\begin{aligned} ADT_{jt} = {} & \alpha_t + \beta_1 \cdot SqFt_j + \beta_2 \cdot SqFt_j \cdot Summer_t + \beta_3 \cdot SqFt_j \cdot Shoulder_t \\ & + \gamma_1 \cdot Units_j + \gamma_2 \cdot Units_j \cdot Summer_t + \gamma_3 \cdot Units_j \cdot Shoulder_t \\ & + \delta_1 \cdot Treatment_j + \delta_2 \cdot Treatment_j \cdot Summer_t + \delta_3 \cdot Treatment_j \cdot Shoulder_t \\ & + \theta_1 \cdot Post_t \cdot Treatment_j + \theta_2 \cdot Post_t \cdot Treatment_j \cdot Summer_t + \theta_3 \cdot Post_t \cdot Treatment_j \cdot Shoulder_t \\ & + \varepsilon_{jt} \end{aligned}$$

As in Model 1, interaction terms account for seasonal variation in effects, with the heating season serving as the baseline season. Interactions involving *Post* indicate the effect of renovations on average daily therms used. In particular, the coefficient on *Post·Treatment*, θ_1 indicates average daily gas savings due to renovation during the heating season; the sum of the coefficients $\theta_1 + \theta_2$ indicates average daily gas savings during the summer months; and the sum of coefficients $\theta_1 + \theta_3$indicates average daily gas savings during the shoulder months. Keeping the variables $Treatment_j$, $Treatment_j \cdot Summer_t$, and $Treatment_j \cdot Shoulder_t$ in the model corrects for the small baseline differences between treatment and control buildings observed in the estimation of Model 1.

The second model includes building-level constants ϕ_j to account for all time-invariant building characteristics (observable and unobservable). It is a "two-way" fixed effects model because it includes fixed effects both temporally, as reflected in the monthly constants α_t, and cross-sectionally, as reflected in the building-specific constants ϕ_j. Formally,

Model 2b

$$\begin{aligned} ADT_{jt} = {} & \alpha_t + \phi_j + \beta_2 \cdot SqFt_j \cdot Summer_t + \beta_3 \cdot SqFt_j \cdot Shoulder_t \\ & + \gamma_2 \cdot Units_j \cdot Summer_t + \gamma_3 \cdot Units_j \cdot Shoulder_t \\ & + \delta_2 \cdot Treatment_j \cdot Summer_t + \delta_3 \cdot Treatment_j \cdot Shoulder_t \\ & + \theta_1 \cdot Post_t \cdot Treatment_j + \theta_2 \cdot Post_t \cdot Treatment_j \cdot Summer_t + \theta_3 \cdot Post_t \cdot Treatment_j \cdot Shoulder_t \\ & + \varepsilon_{jt} \end{aligned}$$

Note that in this model all terms in Model 2a that don't change over time are dropped because their effects are subsumed in the building-specific constants. This is the preferred model for energy savings estimates because, by virtue of the building-specific constants (and unlike Model 2a), it accounts for any unobserved time-invariant factors that could be correlated with renovation, and that would thereby bias the estimate of program energy savings if left unaccounted for.

3. Impact Findings

Models 2a and 2b were estimated using all available billing data, which spanned the period January 2005 to September 2012 (see Figure 2-1). Table 3-1 and Table 3-2 provide regression results. Keeping in mind that estimates of average daily gas savings due to the renovations are θ_1 for the heating season, $\theta_1 + \theta_2$ for the summer, and $\theta_1 + \theta_3$for the shoulder months, several results relevant to the estimates of savings stand out:

- All savings estimates are statistically significant.
- In both models, estimates of average daily gas savings are highest during the heating season and lowest in the summer.
- Estimates of average daily gas savings are quite similar for the two models: 29.57 vs. 30.29 therms per day for Models 2a and 2b in the heating season; 9.53 vs. 9.04 therms per day in shoulder months; and 2.21 vs. 0.81 therms per day in summer months.

Table 3-3 summarizes the estimated history of gas savings due to the program renovation. It makes clear that Models 2a and 2b generate very similar results; cumulative program savings at the end of the evaluation period, September 2012, are 596,654 under Model 2a and 587,112 under Model 2b, a difference of 1.6%

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Model 2b is the preferred model because, by virtue of its use of building-specific fixed effects, it controls for unobservable time-invariant building characteristics that might be correlated with baseline differences in energy use between treatment buildings and control buildings. With that in mind, Table 3-4 provides summary estimates of savings for each year 2008-2012 using Model 2b.

Using this model, Navigant estimates that between January 2010 and September 2012 average energy savings by the 21 program buildings were 19.8%. By season, savings were 26.1% during the heating season months of November-March, 14.6% during the shoulder months of April/May and September/October, and 1.9% during the summer months of June-August.

Figure 3-1 illustrates the estimated cumulative energy savings history using Model 2b. Savings increase relatively slowly initially when fewer buildings are in the program, and accumulate most rapidly during the heating season.

Table 3-1. Regression results, Model 2a.

Variable	Coefficient Estimate	Standard Error	t-Statistic
SqFt	0.0015	0.0002	6.38
SqFt·Summer	-0.0014	0.0002	-5.97
SqFt·Shoulder	-0.0009	0.0002	-5.71
Units	-1.6051	0.2245	-7.15
Units·Summer	1.4572	0.2172	6.71
Units·Shoulder	1.0423	0.1549	6.73
Treatment	-6.0221	11.7370	-0.51
Treatment·Summer	3.7618	10.6900	0.35
Treatment·Shoulder	5.1554	8.1997	0.63
Post·Treatment	-29.5685	9.8786	-2.99
Post·Summer	27.3619	9.9273	2.76
Post·Shoulder	20.0341	7.1956	2.78

Coefficients for monthly dummy variables are omitted. Standard errors are cluster-robust.
Source: Navigant analysis.

Table 3-2. Regression results, Model 2b.

Variable	Coefficient Estimate	Standard Error	t-Statistic
SqFt·Summer	-0.001379	0.0002262	-6.1
SqFt·Shoulder	-0.00093	0.0001622	-5.74
Units·Summer	1.47682	0.213965	6.9
Units·Shoulder	1.062517	0.1548442	6.86
Treatment·Summer	1.712588	10.0300166	0.17
Treatment·Shoulder	4.298164	7.7167324	0.56
Post·Treatment	-30.290351	8.057034	-3.76
Post·Summer	29.481428	9.2084165	3.2
Post·Shoulder	21.240565	6.5086983	3.26

Coefficients for monthly dummy variables are omitted. Standard errors are cluster-robust.
Source: Navigant analysis.

Table 3-3. Cumulative program energy savings.

Year	Season	Number of Buildings Renovated by End of Season	Number of Units Renovated by End of Season	Model 2a		Model 2b	
				Seasonal Gas Savings	Cumulative Program Savings	Seasonal Gas Savings	Cumulative Program Savings
2008	Summer	1	33	146	146	53	53
2008	Shoulder (Fall)	5	174	2,746	2,892	2,606	2,660
2008-09	Winter	8	303	39,119	42,011	40,074	42,734
2009	Shoulder (Spring)	9	315	6,007	48,017	5,701	48,435
2009	Summer	15	648	3,846	51,864	1,410	49,845
2009	Shoulder (Fall)	16	744	13,272	65,135	12,597	62,442
2009-10	Winter	21	946	133,798	198,933	137,064	199,506
2010	Shoulder (Spring)	21	946	18,039	216,972	17,122	216,629
2010	Summer	21	946	6,263	223,235	2,296	218,924
2010	Shoulder (Fall)	21	946	18,039	241,274	17,122	236,046
2010-11	Winter	21	946	139,859	381,133	143,273	379,320
2011	Shoulder (Spring)	21	946	18,039	399,172	17,122	396,442
2011	Summer	21	946	6,263	405,434	2,296	398,738
2011	Shoulder (Fall)	21	946	18,039	423,473	17,122	415,860
2011-12	Winter	21	946	139,859	563,332	143,273	559,133
2012	Shoulder (Spring)	21	946	18,039	581,372	17,122	576,255
2012	Summer	21	946	6,263	587,634	2,296	578,551
2012	Shoulder (Fall)	21	946	9,020	596,654	8,561	587,112

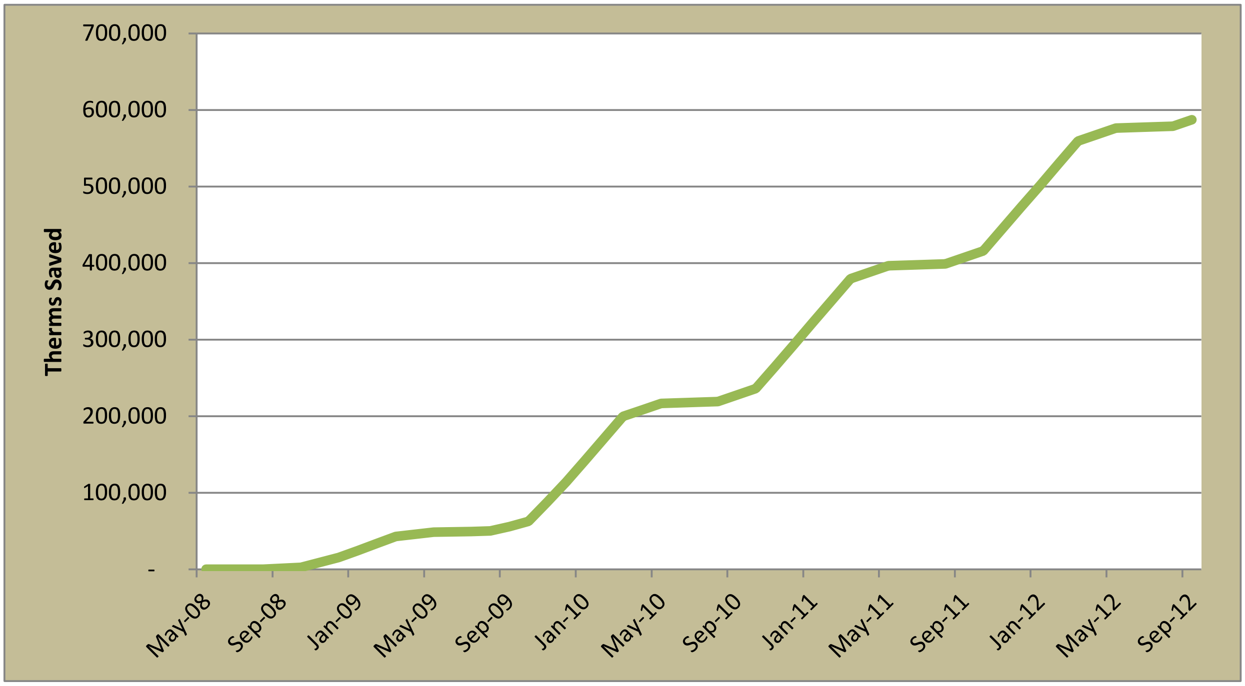
Source: Navigant analysis.

Table 3-4. Annual program energy savings

Year	Number of Buildings Renovated by End of Year	Number of Units Renovated by End of Year	Annual Gas Savings	Cumulative Program Savings
2008	8	303	15,200	15,200
2009	20	932	98,766	113,966
2010	21	946	179,389	293,356
2011	21	946	179,813	473,169
2012 (through Sept.)	21	946	113,943	587,112

Source: Navigant analysis.

Figure 3-1. Illustration of cumulative program energy savings, Model 2b.



Source: Navigant analysis.