DOE/EE-1203

Final Report

Savings and Economic Impacts of the Better Buildings Neighborhood Program

Final Evaluation Volume 2

American Recovery and Reinvestment Act of 2009

June 2015

Prepared For:

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy

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Funded By:

Prepared By:
Research Into Action, Inc.
Evergreen Economics
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U.S. Department of Energy
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Our team of evaluators would like to thank Jeff and Ed for their support and guidance on this project. We also would like to thank the staff of DOE's Better Buildings Neighborhood Program (BBNP). Danielle Sass Byrnett led the staff, with key program support provided by Steve Dunn and Dale Hoffmeyer, as well as by account managers and numerous contractors. We thank Danielle and her staff and contractors for their openness and willingness to talk with us at length and answer numerous email questions.

We interviewed all 41 BBNP grant recipients, as well as 6 subgrantees, and requested project documentation and other information from many of these contacts. The grantees and subgrantees had many people wanting them to explain their activities and their accomplishments during the past five years; although we were one of the many, they were overwhelmingly friendly and cooperative, usually talking with us for several hours to explain what they were doing and what their experiences had been. We anticipate future discussions will continue to illuminate the varied activities and accomplishments of BBNP, and we look forward to those discussions.

We are grateful to the technical advisors that Ed Vine assembled for this research. They guided our detailed evaluation plans and reviewed our draft reports. Their critiques, insights, and interpretations greatly improved the work. Our peer review team comprised Marian Brown, Phil Degens, Lauren Gage, and Ken Keating. Lisa Petraglia and John A. ("Skip") Laitner reviewed the economic impact analysis. Our DOE review team comprised Jeff Dowd and Dale Hoffmeyer. Preliminary research also was reviewed by DOE staff Danielle Sass Byrnett, Claudia Tighe, and Bill Miller.

Finally, DOE staff, their contractors, and LBNL and National Renewable Energy Laboratory (NREL) staff related to BBNP were all extremely responsive to our team's requests for data and were very helpful during the planning and implementation of the evaluation activities. They understood program realities and continually worked to improve the program and its offerings. In addition, they were continually balancing the need for accuracy in reporting without trying to overburden the grantees that are oftentimes short-staffed and over-worked.

NOTICE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Within the body of this report, there are several technical terms that require explanation. Additionally, some of the terms may appear to be similar at first review; however, they have very different meanings. Terms such as “site” and “source” can easily be confused by the reader and are thus defined in this glossary.

Adjustment factor	A value that allows the billing analysis and monitoring and verification (M&V) work to be merged. The adjustment factor was created to address the concern of differing baselines between these two impact evaluation methodologies The billing analysis utilizes existing conditions as the baseline for all energy savings impacts, while the M&V analysis adjusts the baseline for building energy codes or energy efficiency standards.
Base case/ counterfactual scenario	Describes what would have happened in the absence of the program.
Baseline	The expected energy usage level of a specific measure or project before improvements are implemented. This becomes the comparison value for all energy savings calculations.
Benefit-cost ratio	The ratio of program economic benefits (defined as the sum of net economic output and tax revenues) to program costs.
Billing regression	Billing analysis that involves the use of regression models with historical utility billing data to calculate annual energy savings.
Business income	Payments received by small-business owners or self-employed workers; income received by private business owners including doctors, accountants, lawyers, and others. Also called “proprietor income” or “small business income.” See “personal income.”
Cooling degree days (CDD)	The number of degrees that a day's average temperature is above 65° Fahrenheit, the temperature below which buildings need to be cooled.
Deemed savings	Amount of savings for a particular measure provided by documented and validated sources or reference materials. Often used when confidence is high for a specific measure, databases lack sufficient information, or costs of measurement and verification greatly outweigh the benefits.
Direct impacts	Direct impacts represent the initial set of expenditures applied to the predictive model for impact analysis, which result in additional, secondary impacts as the industries affected directly purchase intermediate goods and services, and employee additional labor.

Dummy variable	Also known as a binary variable, dummy variables either take on a value of zero or one to indicate the state of the data point (that is, either it does or does not meet the condition).
Fixed effects model	The fixed effects model is a model specification that incorporates non-random, time-invariant explanatory variables in the traditional multivariate regression framework. These constant terms help control for possible influences relating to individual cohorts and time periods that are not controlled for explicitly in the available data. By controlling for these influences using these additional constant terms, the fixed effects model provides a more robust estimation of changes in energy use over time.
Free-rider	A participant who on some level may have used the program regardless of the BBNP influence. Determining free-ridership values is a large component in calculating net-to-gross ratio.
Gross impacts	Overall impacts traced back to the program. As they do not constitute an estimate of the new or additive impacts from BBNP funding over and above what would have accrued had the funds been used by other federal programs, gross impacts represent an upper bound estimate and net impacts, which account for this next best use of program funds by way of a counterfactual or base case scenario, represent a lower bound estimate.
Gross savings	Total amount of a parameter of interest (kWh, kW, MMBtu, CO_2e, water) saved by a project/program.
Heating degree days (HDD)	The number of degrees that a day's average temperature is below 65° Fahrenheit, the temperature below which buildings need to be heated.
Input-output model	A static model that measures the flow of inputs and outputs in an economy at a point in time.
Interaction variable	A variable that combines two or more variables to represent the interaction present.
Job Impacts	Includes both full- and part-time employment measured in full-time equivalent (FTE) units.
Measure spending	Represents spending on efficiency upgrades; allocated to equipment and labor, mapped to North American Industry Classification System (NAICS) codes and then to sectors in the economic impact model.
Net economic impacts	Counts only economic stimuli that are new or additive to the economy. (See the definition of gross impacts, above, for an elaboration of how net impacts differ from gross impacts and of net savings, below, for an application of the "net" concept to program energy savings.)

Net savings	Total amount of a parameter of interest (kWh, kW, MMBtu, CO_2e, water) directly saved by a program; calculated by multiplying gross verified savings by the NTG ratio, it takes into account the realization rate and results of the free-rider and spillover analysis to provide a value of energy savings directly related to the program influence.
Net-to-gross (NTG) ratio	A ratio value determined through the process of surveying decision-makers who implemented projects in order to account for free-ridership and spillover effects. The NTG ratio is multiplied by gross verified savings to produce net savings.
Output	The value of production for a specified period of time. Output is the broadest measure of economic activity, and includes intermediate goods and services and the components of value added (personal income, other income, and indirect business taxes); as such, output and personal income should not be added together.
Personal income	The sum of wages and business income.
Person-year	One person-year of employment is equivalent to one person being employed for the duration of one year, two people being employed for half a year each, etc. Each “person-year” of employment can represent a new job being created, or an existing job from a previous year being sustained for an additional year.
Project	A single activity (lighting retrofit, refrigeration replacement, PV system install, etc.) at a single location.
Program	A group of projects with similar technology characteristics installed in similar applications.
Program outlays	Administrative costs incurred by BBNP grantees, in addition to purchased labor and materials, to carry out energy efficiency programs.
Realization rate	A measure of the amount of verified saving for a project/program compared to the reported savings, defined as the ratio of Gross Verified Savings to Gross Reported Savings: $$Realization\ Rate\ (\%) = \frac{Gross\ Verified\ Savings}{Gross\ Reported\ Savings}$$
Reported savings	Savings calculated and reported by BBNP – in some cases, we recalculated these values to accurately reflect true findings.
Secondary impacts	Secondary impacts represent the impact of local industries buying goods and services from other local industries. The cycle of spending works its way backward through the supply chain until all money leaks from the local economy.
Site energy savings	Savings (gross or net) directly calculated at a facility.

Source energy savings	Savings (gross or net) calculated as the sum of site energy savings and savings from energy not having to be extracted, converted and transmitted to the facility due to the energy efficiency or renewable energy project. Conversion factors between site and source are: $1\ kWh_{site} = 3.318\ kWh_{source}$ $1\ MMBtu_{site} = 1.047\ MMBtu_{source}$
Spillover savings	Energy savings from upgrades motivated by the program yet not receiving program incentives.
Stratify	The process of breaking down a population of projects into groups with similar characteristics (technical, financial, size, location, etc.). This is used during population sampling and allows projects with greater uncertainty or higher budgets to be accurately weighted to assess their impact on a program.
Subgrantee	An entity that received BBNP funding from a grantee to administer or support local BBNP programs.
Sub-strata	The individual groups remaining once a population has been stratified.
Stipulated savings	Same as *Deemed Savings*
Total savings	Savings of electricity (kWh) and natural gas (MMBtu) combined into a single energy value using the following conversion: $1\ kWh = 3412\ Btu\ (or\ 0.003412\ MMBtu)$
Verified savings	Savings determined by we through the collection of data by onsite inspections, phone surveys, and engineering analysis.
Wages	Represents workers' wages and salaries, as well as other benefits such as health and life insurance, retirement payments, and noncash compensation.

PREFACE

This evaluation report is one of a suite of seven reports providing a final evaluation of the U.S. Department of Energy's (DOE) Better Buildings Neighborhood Program (BBNP). The evaluation was conducted under contract to Lawrence Berkeley National Laboratory (LBNL) as a procurement under LBNL Contract No. DE-AC02-05CH11231 with DOE.

The suite of evaluation reports comprises:

- *Evaluation of the Better Buildings Neighborhood Program* (Final Synthesis Report, Volume 1)
- *Savings and Economic Impacts of the Better Buildings Neighborhood Program* (Final Evaluation Volume 2)
- *Drivers of Success in the Better Buildings Neighborhood Program – Statistical Process Evaluation* (Final Evaluation Volume 3)
- *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4)
- *Market Effects of the Better Buildings Neighborhood Program* (Final Evaluation Volume 5)
- *Spotlight on Key Program Strategies from the Better Buildings Neighborhood Program* (Final Evaluation Volume 6)

The evaluation commenced in late 2011 and concluded in mid-2015. The evaluation issued two preliminary reports:

- *Preliminary Process and Market Evaluation: Better Buildings Neighborhood Program* (December 28, 2012; appendices in a separate volume) (Research Into Action and NMR Group, 2012a, 2012b)
- *Preliminary Energy Savings Impact Evaluation: Better Buildings Neighborhood Program* (November 4, 2013) (Research Into Action, Evergreen Economics, Nexant, and NMR Group, 2013)

Four firms conducted the multi-faceted evaluation:

- Research Into Action, Inc. led the teams and process evaluation research.
- Evergreen Economics conducted the analysis of economic impacts, the billing regression analysis of program savings, and worked with Nexant to estimate program savings.
- Nexant, Inc. led the impact evaluation, conducted project measurement and verification (M&V) activities, and estimated program savings and carbon emission reductions.
- NMR Group, Inc. led the market effects assessment.

LBNL managed the evaluation; DOE supported it.

This document is *Savings and Economic Impacts of the Better Buildings Neighborhood Program*. Nexant and Evergreen Economics were the principal author and evaluator, supported in both roles by Research Into Action.

The Nexant team was led by Lynn Roy, supported by Wyley Hodgson, Cherlyn Seruto, Laura Ruff, and Andrew Dionne.

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) administered the Better Buildings Neighborhood Program (BBNP) to support programs promoting whole building energy upgrades. BBNP distributed a total of $508 million to support efforts in hundreds of communities served by 41 grantees. DOE awarded funding of $1.4 million to $40 million per grantee through the competitive portions of the Energy Efficiency and Conservation Block Grant (EECBG) Program ($482 million from American Recovery and Reinvestment Act of 2009 [ARRA, the Recovery Act] funds) and the State Energy Program (SEP; $26 million). DOE awarded grants between May and October 2010, intended to provide funding over a three-year period ending September 30, 2013. In 2013, DOE offered an extension to programs that included a BBNP-funded financing mechanism to operate through September 30, 2014, using BBNP funds exclusively for financing.

While the federal government has issued periodic funding opportunities for energy efficiency, none has been on the scale of BBNP.

State and local governments received the grants and worked with nonprofits, building energy efficiency experts, contractor trade associations, financial institutions, utilities, and other organizations to develop community-based programs, incentives, and financing options for comprehensive energy-saving upgrades. Each of the 41 grant-funded organizations, assisted by 24 subgrantees, targeted a unique combination of residential, multifamily, commercial, industrial, and agriculture sector buildings, depending on their objectives.

This report provides the impact findings from a comprehensive impact, process, and market effects evaluation of the original grantee program period, spanning fourth quarter (Q4) 2010 through third quarter (Q3) 2013. A team of four energy efficiency evaluation consulting firms conducted the evaluation – Research Into Action, Inc. (lead contractor), Evergreen Economics, Nexant, Inc., and NMR Group, Inc. – which was managed by Lawrence Berkeley National Laboratory (LBNL) and supported by DOE. Nexant led the impact research, with principal support provided by Evergreen Economics and additional support provided by the two other firms. The study constitutes one report among a suite of six evaluation reports assessing BBNP.

EVALUATION OBJECTIVES AND METHODS

To assess whether BBNP was successful in meeting its goals and objectives, this study developed independent, quantitative estimates of the impacts of the BBNP. These impacts include energy and bill savings and carbon emission reductions for projects installed during the three-year BBNP, as well as economic impacts such as jobs generated. Based on the investigation and findings, we provide lessons learned and recommendations to DOE and the grantees are continuing their programs after the grant funding has ended.

The impact evaluation comprised two broad activities to determine gross verified savings:

- **Measurement and Verification** (M&V) of a sample of grantees and projects
- **Billing regression analysis** on projects from grantees with sufficient utility bill data

Our M&V approach used an ex-post analysis (actual savings based on post-retrofit conditions) in order to estimate the energy savings for each project in a representative sample selected to provide high confidence and precision. We determined gross verified energy savings through: 1) participant onsite inspections and surveys; 2) review of project files and documentation; and 3) engineering analysis of projects. We compared gross verified savings to reported savings to determine a realization rate for each sector with the exception of the agriculture sector due to a small amount of activity and a lack of available data.

We conducted a billing regression analysis to estimate realized energy savings at the project level. We reviewed all billing data that grantees provided to DOE and determined that 19 grantees had provided sufficient data to support regression analysis. We needed both participant billing (monthly electricity or natural gas consumption before and after program participation) and participant tracking data (for example, information on when measures were installed).

We quantified impact metrics for the entire three-year BBNP grant cycle based on findings from preliminary and final evaluations. The preliminary evaluation assessed a sample of projects reported between Quarter 4 2010 and Quarter 2 2012 (inclusive). The final evaluation verified grantee reported activities and quantified metrics for a sample of projects reported between Quarter 3 (Q3) of 2012 and Quarter 3 (Q3) of 2013. We conducted the preliminary research and analysis from January 2013 through May 2013; we conducted the final research and analysis from December 2013 to October 2014.

In order to calculate the overall verified energy savings associated with BBNP, the team extrapolated the sample findings to the population through the use of case weights and realization rates. Due to the intrinsic differences in baseline conditions between the M&V analysis and billing regression analysis, we developed an adjustment factor based on a subset of overlapping projects between each analysis (see section 3.4). This adjustment factor was applied to the savings estimates of the billing regression analysis to make the savings estimates comparable to the M&V savings estimates. We then extrapolated the M&V sample frame and the billing regression analysis sample frame separately, and we combined the resulting realization rates and extrapolated to the entire BBNP. Finally, we calculated and applied a net-to-gross (NTG) ratio estimated from survey research to the extrapolated savings to estimate BBNP's total net energy savings.

The impact evaluation also estimated the economic impacts of BBNP. These impacts included jobs as well as estimates of economic output, income (personal and business), and tax revenue that result from the program spending relative to a base case scenario where BBNP did not exist.

BBNP GOALS AND OBJECTIVES

DOE designed BBNP to meet the three principal ARRA goals (Table ES-1), as well as seven objectives developed by DOE staff to guide the BBNP initiative (Table ES-2). Below, we identify which of the three types of evaluation (impact, process, or market effects) provide findings relevant to our assessment of goal and objective attainment. This study addresses the goals and objectives flagged in the tables as relating to the impact evaluation. For an investigation of the other goals and objectives noted in the tables, see the companion reports *Process Evaluation of the Better Buildings Neighborhood Program*

(Final Evaluation Volume 4), and *Market Effects of the Better Buildings Neighborhood Program* (Final Evaluation Volume 5).

Table ES-1: ARRA Goals

GOALS	EVALUATION TYPE		
	Impact	Process	Market Effects
Create new jobs and save existing ones	✓	✓	✓
Spur economic activity and invest in long-term growth	✓	✓	✓
Provide accountability and transparency in spending BBNP funds	✓	✓	

Table ES-2: BBNP Objectives

OBJECTIVES	EVALUATION TYPE		
	Impact	Process	Market Effects
Develop sustainable energy efficiency upgrade programs		✓	✓
Upgrade more than 100,000 residential and commercial buildings to be more energy efficient	✓		
Save consumers $65 million annually on their energy bills	✓		
Achieve 15% to 30% estimated energy savings from residential energy efficiency upgrades	✓		
Reduce the cost of energy efficiency program delivery by 20% or more		✓	
Create or retain 10,000 to 30,000 jobs	✓		
Leverage $1 to $3 billion in additional resources	✓		

GOAL AND OBJECTIVE ATTAINMENT

By the end of the three-year evaluation period (Q4 2010 to Q3 2013) BBNP had met the three ARRA goals, as shown in Table ES-3, which presents our findings, including net jobs, net economic activity, and net benefit-cost ratio. For the economic metrics, the term "net" signifies BBNP's contribution to these outcomes above and beyond the outcomes that would have occurred had the BBNP funding been spent according to historical non-defense federal spending patterns.

By the end of the three-year evaluation period, BBNP met two of the five impact-related BBNP objectives (Table ES-4). Unverified program-reported accomplishments for Q4 2013 through Q3 2014 suggest the program likely was successful in meeting four of the five impact-related objectives by the end of the four-year program period. These findings indicate that BBNP met its objectives to spur energy efficiency upgrade activity, achieve energy savings, and create or maintain jobs.

Table ES-3: Attainment of ARRA Goals, through Q3 2013

GOALS	METRICS	RESULTS	ATTAINED?
Create new jobs and save existing ones	Number of jobs created and retained	The evaluation estimated 10,191 net jobs resulted from BBNP during the 3-year evaluation period.	Yes
Spur economic activity and invest in long-term growth	Dollars of economic activity; benefit-cost ratio	BBNP spending of $445.2 million in 3 years generated more than: • $1.3 billion in net economic activity (personal income, small business income, other proprietary income, intermediate purchases) • $129.4 million in net federal, state, and local tax revenues Estimated net benefit-cost ratio: 3.0.	Yes
Provide accountability and transparency in spending BBNP funds	Evidence of accountability and transparency	Grantees receiving ARRA funding submitted ARRA expenditure reports. Grant expenditure information was available to the public on *Recovery.gov.* BBNP DOE staff developed and maintained a program tracking database for periodic grantee reporting. Staff worked with grantees to increase the quantity and quality of reported data. Grantees had access to summary data. Evaluator-verified results will be publicly available.	Yes

Table ES-4: Attainment of BBNP Objectives

OBJECTIVES	METRICS	RESULTS	ATTAINED?	
			3-Year Verified	4-Year Unverified*
Upgrade more than 100,000 residential and commercial buildings to be more energy efficient	Number of upgrades	The evaluation verified the grantee-reported 99,071 upgrades for the 3-year evaluation. Grantees reported: • Unverified - 119,404 upgrades for the 4-year program period.	No 99%	Likely
Save consumers $65 million annually on their energy bills	Energy bill savings ($)	Verified energy savings for the 3-year evaluation period provide over $40 million in annual bill savings. Close to $700 million lifetime energy bill savings expected (estimated at fuel prices during the program period). Grantees reported: • $60 million in estimated annual bill savings during the 3-year evaluation period • $76 million in estimated annual bill savings through the 4-year program period	No 62%	Unlikely ~ 78% (based on 3-year evaluation findings)
Achieve 15% to 30% estimated energy savings from residential energy efficiency upgrades	Average energy upgrade savings (%)	Verified single-family residential savings: 15.1%. Grantees reported 22% estimated energy savings in single-family residential upgrades.	Yes	Yes
Create or retain 10,000 to 30,000 jobs	Net number of jobs	The evaluation estimated 10,191 net jobs resulting from BBNP during the 3-year evaluation period.	Yes	Yes
Leverage $1 to $3 billion in additional resources	Dollars leveraged	Evaluation interviews with financial institutions corroborated grantee-reported leveraged loan funds of at least $618 million. Grantees reported leveraged funds from other sources of about $750 million, for an estimated total leveraged funds of about $1.4 billion.	Inconclusive**	Likely

* Our evaluation did not verify fourth-year program achievements. We concluded that objectives that were met by Q3 2013 also were met by the end of Q3 2014. An assessment of “likely” indicates that the unverified data show a trend suggestive of achievement.

** The evaluation addressed financial leverage amounts only; it did not address other grantee-reported leveraged funds.

ENERGY, ENVIRONMENTAL, AND ECONOMIC IMPACTS

We verified source energy savings of 3,887,764 MMBtu gross and 3,534,131 MMBtu net through the third quarter of 2013 (Table ES-5). We estimated the measures installed through Q3 2013 will save 56,725,063 MMBtu over their lifetimes.

Although some grantees conducted agricultural and industrial upgrades, these projects were not included in the evaluation activities due to their small contribution to total program savings and a lack of data provided by grantees to the evaluation team. We also note that we estimated program lifetime savings – as well as the lifetime metrics of bill savings and carbon emission reductions – from the M&V project sample and extrapolated the calculation to the population. Thus, our estimates of lifetime savings and reductions do not have the same analytical rigor as the annual savings analysis.

Table ES-5: Verified Gross and Net Energy Savings, through Q3 2013

SECTOR	GROSS VERIFIED SOURCE SAVINGS (MMBtu)	NET VERIFIED SOURCE SAVINGS (MMBtu)	RELATIVE PRECISION (90% CONFIDENCE LEVEL)	NET LIFETIME SOURCE SAVINGS (MMBtu)	VERIFIED ENERGY SAVINGS AS A PROPORTION OF USAGE
Residential	2,084,120	1,960,024	6.9%	36,456,444	15.1%
Multifamily*	324,292	322,749	11.4%	6,003,132	13.8%
Commercial	1,479,352	1,251,359	6.4%	14,265,488	4.6%
Total	3,887,764	3,534,131	4.5%	56,725,063	11.0%

* Represents total units treated.

We estimated participants are saving $40 million annually from reduced energy bills (Table ES-6) based on verified net site savings through Q3 2013 and energy prices during the program period as reported by the U.S. Energy Information Administration (EIA). We estimated lifetime bill savings of $668 million based on the measure lifetime savings and the energy prices during the program period, as opposed to forecast prices. Again, the lifetime savings estimate lacks the analytical rigor of the annual estimate.

Table ES-6: Annual and Lifetime Bill Savings Associated with Verified Net Energy Savings, through Q3 2013

SECTOR	ANNUAL BILL SAVINGS	LIFETIME BILL SAVINGS
Residential	$ 25,074,800	$ 466,391,273
Multifamily	$ 4,128,644	$ 76,792,784
Commercial	$ 11,002,400	$ 125,427,356

Total	$ 40,205,844	$ 668,611,414

We estimated avoided carbon emissions (carbon dioxide equivalent, or CO_2e) of 478,568 metric tons annually for upgrades through Q3 2013 and 7,216,526 metric tons over the upgrade lifetimes (Table ES-7). The analysis entailed assumptions that make the resulting lifetime estimate less rigorous than annual estimate.

Table ES-7: Verified Annual and Lifetime Avoided Carbon Emissions (CO_2e), through Q3 2013

FUEL TYPE	ESTIMATED ANNUAL CO_2E AVOIDED (METRIC TONS)	ESTIMATED LIFETIME CO_2E AVOIDED (METRIC TONS)
Residential	207,721	3,863,613
Multifamily	36,842	685,254
Commercial	234,005	2,667,659
Total	478,568	7,216,526

Using an input-output macroeconomic model, we estimated the gross and net economic activity resulting from the $445.2 million expended by BBNP grantees through Q3 2013 (Table ES-8 and Table ES-9), for which ARRA funds provided 95% of the funding. The gross impacts indicate that the ARRA stimulus funds spent on BBNP contributed about $2 billion dollars and 13,000 jobs (full-time equivalent, FTE) to the economy that would not have occurred in the absence of the ARRA stimulus legislation, with a benefit-cost ratio of 4.7. The net impacts indicate that spending on BBNP specifically, rather than on typical federal spending as described by historical, non-defense outlays, contributed over $1.3 billion dollars and 10,000 jobs to the economy that would not have occurred in the absence of BBNP, with a benefit-cost ratio of 3.0.

Table ES-8: Estimated Gross and Net Economic Activity and Tax Revenues, through Q3 2013

IMPACT MEASURE	GROSS IMPACTS ($ MILLIONS)	NET IMPACTS ($ MILLIONS)
Economic Activity	**$2,097.1**	**$1,345.0**
Intermediate Purchases	$947.8	$769.8
Personal Income	$631.5	$230.2
Small Business Income	$141.9	$111.2
Other Property Income	$311.7	$194.7
Other	$64.2	$39.1
Tax Revenues	**$244.5**	**$129.4**
State and Local Taxes	$83.8	$48.6

IMPACT MEASURE	GROSS IMPACTS ($ MILLIONS)	NET IMPACTS ($ MILLIONS)
Federal Taxes	$160.7	$80.8

Table ES-9: Estimated Gross and Net Benefit-Cost Ration and Jobs Impact, through Q3 2013

IMPACT MEASURE	TOTAL GROSS IMPACTS	TOTAL NET IMPACTS
Benefit-Cost Ratio	4.71	3.02
Jobs (FTE)	13,331	10,191

IMPACT ASSESSMENT LESSONS LEARNED

The main objective of this impact evaluation was to determine the impacts of $508 million in BBNP spending that allocated resources to varied energy efficiency programs across the country. The challenges associated with this task, such as difficulty in acquiring grantee data, lack of quality control/assurance leading to inaccuracies of reported metrics, and the large scale and broad scope of grantee programs, affected the team's evaluation activities. While navigating these challenges, we learned many lessons that will help shape the future of similar program evaluations. Key among these lessons are:

- **Allow sufficient time to request and gather data from the grantees.** Grantees are busy, and unlike most utility-funded efficiency program managers, they are not equipped with the tools and databases to easily extract participant and project level information. In addition, grantees are frequently understaffed, so making clear and concise data requests are necessary to help speed up the response time and alleviate any concerns or questions that they may have regarding data needs.

- **Phone verifications had limited value.** Phone verifications are standard practice in many utility-funded impact evaluations. While the phone surveys were useful in verifying overall project participation and obtaining information on program influence, we determined during the preliminary evaluation that the phone verifications used for M&V often provided limited value. The majority of participants interviewed had difficulty remembering the specifics surrounding completed upgrades, and gathering key data on measures implemented. This is likely due to the long timespan (averaging one to two years) between measure installation and phone verifications. There also was confusion among participants regarding the measure funding source (BBNP or local utility program).

- **Onsite verifications were valuable.** While onsite surveys encounter some of the same issues with reliability as the phone surveys, the onsite surveys were valuable in obtaining a greater level of detail regarding project implementation than could be obtained during phone verifications and file review.

RECOMMENDATIONS

The grant cycle for BBNP has ended, and it is unlikely that in the foreseeable future DOE will fund a program on a scale similar to BBNP. Were DOE or another agency to fund a program like BBNP, we offer the following recommendations to foster greater consistency in program expectations, design, tracking, and reporting:

- Plan and develop a comprehensive and easy to use data tracking and reporting system available to grantees at time of funding award.
- Require grantees to ensure the consistency of project-level tracking values with overall quarterly report values.
- Require consistent documentation procedures across all grantees and programs.
- Require accountability for quality control practices across programs.
- Provide support to grantees that may demonstrate insufficient quality assurance/quality control and provide support to grantees that may demonstrate insufficient quality assurance/quality control.
- Consider a requirement of timely and accurate progress reports as a condition of funding payments.
- Compile a single final dataset to be used for reporting and evaluation purposes.

1. INTRODUCTION

The U.S. Department of Energy (DOE) administered the Better Buildings Neighborhood Program (BBNP) to support programs promoting whole building energy upgrades. BBNP distributed a total of $508 million to support hundreds of communities served by 41 grantees. DOE awarded funding of $1.4 million to $40 million per grantee through the competitive portions of the Energy Efficiency and Conservation Block Grant (EECBG) Program ($482 million in American Recovery and Reinvestment Act [ARRA, the Recovery Act] of 2009 funds) and the State Energy Program (SEP; $26 million). DOE awarded grants between May and October 2010 intended to provide funding over a three-year period ending September 30, 2013. In 2013, DOE offered an extension to ARRA-funded grantees with ongoing financing programs to operate through September 30, 2014, using BBNP funds exclusively for financing.

State and local governments received the grants and worked with nonprofits, building energy efficiency experts, contractor trade associations, financial institutions, utilities, and other organizations to develop community-based programs, incentives, and financing options for comprehensive energy saving upgrades. Each of the 41 grant-funded organizations, assisted by 24 subgrantees, targeted a unique combination of residential, multifamily, commercial, industrial, and agriculture sector buildings, depending on their objectives.

This report provides the impact findings from a comprehensive impact, process, and market effects evaluation of the original program period spanning fourth quarter (Q4) 2010 through third quarter (Q3) 2013. A team of four energy efficiency evaluation consulting firms conducted the comprehensive evaluation – Research Into Action, Inc. (lead contractor), Evergreen Economics, Nexant, Inc., and NMR Group, Inc. – which was managed by Lawrence Berkeley National Laboratory (LBNL) and supported by DOE. Nexant led the impact research, with principal support provided by Evergreen Economics and additional support provided by the other two firms. The study constitutes one report among a suite of six evaluation reports assessing BBNP.

1.1. STUDY OVERVIEW

To assess whether BBNP was successful in meeting its goals and objectives, this study developed independent, quantitative estimates of the impacts of the BBNP. These impacts include energy savings, cost savings, greenhouse gas emission reductions, economic impacts, and jobs created or maintained for projects installed during the three-year BBNP. Based on the investigation and findings, we provide lessons learned and recommendations to DOE and the grantees that wish to continue their programs after the grant funding has ended.

The impact evaluation comprised two broad activities to determine gross verified savings: 1) Measurement and Verification (M&V) of a sample of grantees and projects, using an ex-post analysis (actual savings based on post-retrofit conditions); and 2) billing regression analysis on projects from grantees with sufficient utility bill data. The impact evaluation also constructed an economic impact model of the U.S. economy and estimated the economic impacts of BBNP, including jobs, economic output, income (personal and business), and tax revenue that result from the program spending relative to a base case scenario where BBNP does not exist.

This report does not document or present grantee-specific findings and impacts, as such conclusions would need to be based on a much greater level of sampling, data collection, and overall effort. Table 1-1 presents the key metrics measured.

Table 1-1: Key Metrics

KEY METRIC	DESCRIPTION
Energy Saved (Number of Energy Units Saved) – by Project, by Program	Energy units include annual and lifetime kWh, kW, therms, gallons of oil, and MMBtus; the savings estimates are weather-normalized.
Energy Bill Savings – by Project, by Program	Energy bill savings include the value of annual and lifetime energy savings, demand reduction, and renewable energy generation at current customer costs.
Number of Houses/ Businesses Retrofitted	These retrofits are based on the tracking data provided from grantees and verified for a sample of projects.
Avoided greenhouse gas emissions	Quantified in metric tons of avoided carbon dioxide equivalent (CO_2e) emissions.
Number of Jobs Created/ Retained	Jobs created/retained is measured in full-time equivalent person-years of employment and is based on modeling the impacts against a base case scenario.
Benefit-cost ratio	The ratio of program economic output to program costs.
Economic Output	Output is estimated by modeling the impacts against a base case scenario.
Personal and Business Income	Income is estimated by modeling the impacts against a base case scenario.
Tax Revenue	Tax revenue is estimated by modeling the impacts against a base case scenario.

We conducted the impact evaluation of the three-year BBNP in two phases: a preliminary evaluation, which evaluated program activities between program start through Q2 2012 (Research Into Action, Evergreen Economics, Nexant, and NMR Group, 2013) and a final evaluation, which evaluated program activities between Q3 2012 and Q3 2013. We combined the findings from both evaluations to develop a verified energy savings estimate for the BBNP program.

1.2. BBNP DESCRIPTION

DOE administered the BBNP to support programs promoting whole building energy upgrades. BBNP distributed over $500 million to support hundreds of communities served by 41 grantees. While the federal government has issued periodic funding opportunities for energy efficiency, none has been on the scale of BBNP.

DOE issued two competitive funding opportunity announcements (FOAs) for BBNP grants. The first, drawing on EECBG funding, was issued in October 2009. The second, drawing on SEP funding, was issued

in April 2010. Awarded grants between May and October 2010 were intended to provide funding over a three-year period ending
September 30, 2013. (During the grant period, DOE determined that programs that included a BBNP-funded financing mechanism could continue to operate beyond the grant period using BBNP funds exclusively for financing.)

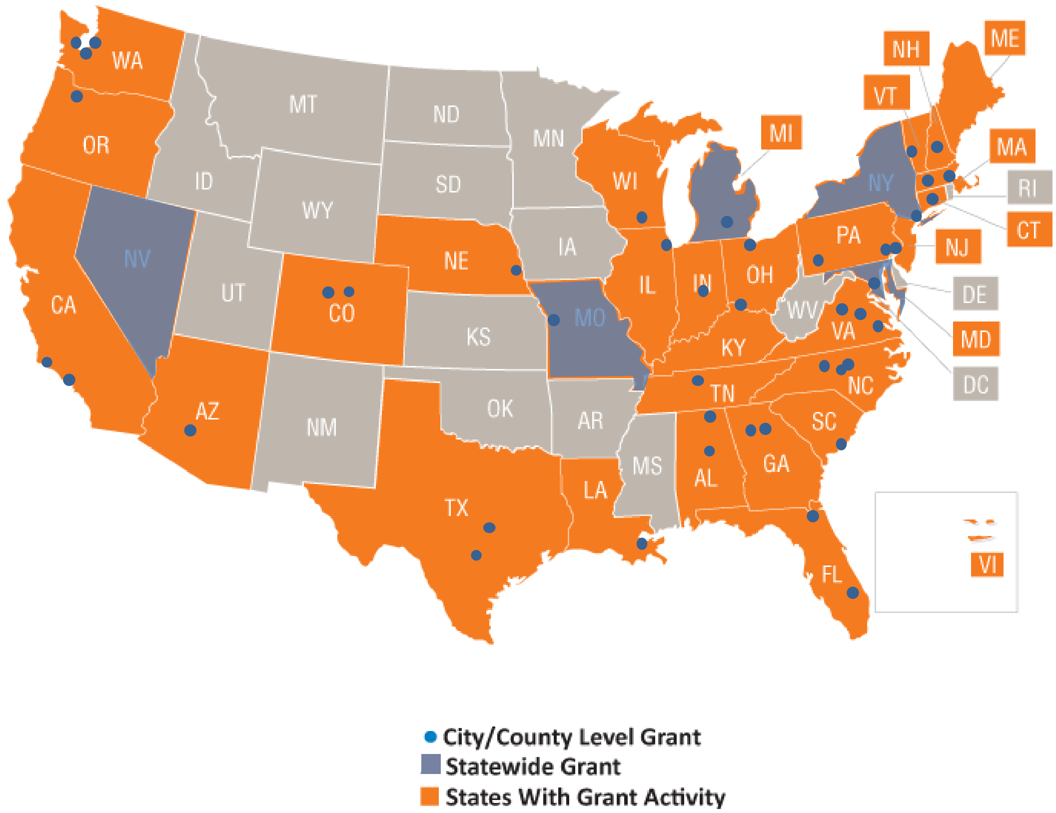
Each grant recipient proposed and implemented unique programs designed to address the energy efficiency needs, barriers, and opportunities within its jurisdiction. However, all of the recipients' programs were broadly designed around three common purposes: 1) to obtain high-quality retrofits resulting in significant energy improvements (retrofits also described as whole building or comprehensive); 2) to incorporate a viable strategy for program sustainability, which DOE defined as continuing beyond the grant period without additional federal funding; and 3) to fundamentally and permanently transform energy markets to make energy efficiency and renewable energy the options of first choice (DOE, 2009):

Through the EECBG FOA, DOE sought "innovative, 'game–changing' whole-building efficiency programs (DOE, 2009). DOE recognized that innovation is a form of experimentation and is not without risk of failure. The BBNP program at that national level was looking to identify the most effective approaches; DOE was not expecting every local BBNP-funded program to be equally, or even moderately, effective.

DOE provided BBNP grants to 41 recipients operating programs in 32 states and territories. The jurisdictions recipients served varied widely. Some recipients served only a single city or county, while others served entire states. One recipient, the Southeast Energy Efficiency Alliance (SEEA), funded sub-recipient (subgrantee) programs in five states and the U.S. Virgin Islands. The sizes of grants awarded through BBNP also varied, ranging from $1.3 million to $40 million.

Figure 1-1 shows the states with BBNP activity and illustrates whether the grant recipient represented the state or a city or county within the state. Appendix A provides tables listing the grantee awards in descending order by size and alphabetically by grantee.

Figure 1-1: BBNP Grantees by Location



1.3. BBNP GOALS AND OBJECTIVES

DOE designed BBNP to meet the three principal ARRA goals (Table 1-2), as well as seven objectives developed by DOE staff to guide the BBNP initiative (Table 1-3). Below, we identify which of the three types of evaluation (impact, process, or market effects) provide findings relevant to our assessment of goal and objective attainment. This study addresses the goals and objectives flagged in the tables as relating to the impact evaluation. For an investigation of the other goals and objectives noted in the tables, see the companion reports *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4), and *Market Effects of the Better Buildings Neighborhood Program* (Final Evaluation Volume 5).

Table 1-2: ARRA Goals

GOALS	EVALUATION TYPE		
	Impact	Process	Market Effects
Create new jobs and save existing ones	✓	✓	✓
Spur economic activity and invest in long-term growth	✓	✓	✓
Provide accountability and transparency in spending BBNP funds	✓	✓	

Table 1-3: BBNP Objectives

OBJECTIVES	EVALUATION TYPE		
	Impact	Process	Market Effects
Develop sustainable energy efficiency upgrade programs		✓	✓
Upgrade more than 100,000 residential and commercial buildings to be more energy efficient	✓		
Save consumers $65 million annually on their energy bills	✓		
Achieve 15% to 30% estimated energy savings from residential energy efficiency upgrades	✓		
Reduce the cost of energy efficiency program delivery by 20% or more		✓	
Create or retain 10,000 to 30,000 jobs	✓		
Leverage $1 to $3 billion in additional resources	✓		

1.4. PROGRAM TERMINOLOGY

In order to effectively communicate key details of the report and ensure consistency with the process and market evaluations, the following terminology will be used throughout. The BBNP will refer to the entire grant program encompassing both EECBG and SEP grants. *Grantees* will refer to the states, counties, cities, and organizations that were awarded the funds while *sub-grantees* are the organizations or local governments that received funding from the grantees. The grantees are operating a *program* with the awarded funding and may have sub-grantees operating programs as well. These programs encompass a variety of activities including contractor training programs, financing programs, rebate programs, energy assessments, etc. *Participants* are the businesses, residents, or contractors who take part in these programs. A collection of one or more energy upgrade measures that are implemented by a participant in a home or building is considered a *project*.

2. BETTER BUILDINGS NEIGHBORHOOD PROGRAM

This chapter provides program accomplishments for the three-year grant period (Q4 2010 through Q3 2013) *reported* by DOE's BBNP team from data provided the grantees. This section does *not* provide verified accomplishment data, which are presented in subsequent chapters.

DOE provided the evaluation team access to databases used by DOE for reporting purposes. These databases detailed the performance of the grantees from the time the grants were awarded in August 2010 through the third quarter of 2013 and are based on information reported directly by each grantee through DOE's Better Buildings Neighborhood Information System (BBNIS).

2.1. REPORTED PROGRAM ACCOMPLISHMENTS

This section provides program accomplishments *reported* by DOE's BBNP team from data provided the grantees. **These are unverified grantee data.** This section does *not* provide verified accomplishment data, which are presented in subsequent chapters.

2.1.1. REPORTED THROUGH Q3 2013 (THE EVALUATION PERIOD)

This section presents grantee-reported accomplishments from Q4 2010 through Q3 2013 (the evaluation period). DOE provided the evaluation team access to databases used by DOE for reporting purposes. These databases detailed the performance of the grantees from the time the grants were awarded in August 2010 through Q3 of 2013 and are based on information reported directly by each grantee through DOE's BBNIS.

All of the 41 grantees conducted whole home and/or building upgrades. Grantees reported (not verified) completing over 99,000 projects between Q4 2010 and Q3 2013, reportedly saving over 5,800,000 MMBtu annually of energy measured at the source (not site), at a reported cost of $76 per MMBtu of source energy saved (Table 2-1). In this report, source energy savings are used unless otherwise noted.

Table 2-1: BBNP Reported (Unverified) Progress Q4 2010 - Q3 2013*

METRIC	REPORTED ACHIEVEMENT
Grantees with Projects	41
Projects	99,071
Spending	$449 million
Total Reported Energy Savings (Source, MMBtus)	5,852,275
$/MMBtu Saved (Source)	$76

Source: DOE-provided extract of its Better Buildings Neighborhood Information System (BBNIS), a database of grantee-reported project level data.

* A few grantees reported projects completed prior to Q4 2010.

Grantees conducted upgrades in the residential, multifamily, commercial/industrial, and agricultural sectors
(Table 2-2).[1, 2, 3] The residential sector accounted for 75% of the projects, but only 51% of the savings. The commercial sector accounted for less than 4% of the projects, but nearly 38% of the savings.

Table 2-2: BBNP Reported (Unverified) Projects and Energy Savings Q4 2010 - Q3 2013*

SECTOR	NUMBER OF PROJECTS IMPLEMENTED	PERCENT OF TOTAL PROJECTS	TOTAL SOURCE ENERGY SAVINGS (MMBtu)	PERCENT OF PORTFOLIO SAVINGS
Residential	74,184	74.9%	2,975,346	50.8%
Multifamily	21,178	21.4%	603,432	10.3%
Commercial	3,546	3.6%	2,240,970	38.3%
Agriculture**	163	0.2%	32,526	0.6%
BBNP Total	99,071	100%	5,852,275	100%

Source: DOE-BBNIS.

* A few grantees reported projects completed prior to Q4 2010.

** Agriculture totals obtained from DOE email dated May 9, 2013, as they are not included in Project Level data.

Table 2-3 provides the average project savings for each of the four sectors.

Table 2-3: Average BBNP Reported (Unverified) Savings per Project by Sector

SECTOR	AVERAGE SOURCE SAVINGS PER PROJECT (MMBtu)
Residential	40
Multifamily (individual units)*	29
Commercial	632
Agriculture	200

1 Industrial projects were limited to 15 upgrades conducted by one grantee.

2 Table 2-2 outlines results as reported from the Project Level database. Throughout the course of the evaluation activities, DOE adjusted the reporting database to correct for errors in reported data from grantees. The information presented in this table represents reported values recorded as of September 2014.

3 Grantees reported savings from a number of different fuel types including electricity, natural gas, fuel oil, propane, kerosene, and wood. In order to convert the savings achieved from these different fuel types to site and source MMBtu savings, the team used the conversion factors found in Appendix I.

Source: DOE-BBNIS.

The overall savings reported by the grantees included savings from a variety of fuel types including electricity, natural gas, fuel oil, propane, kerosene, and wood. Natural gas and electricity savings were the most common sources of savings. Table 2-4 presents the reported savings per fuel type for each sector, presented as *site* savings in the specific fuel units, consistent with DOE's reporting.

Table 2-4: BBNP Reported (Unverified) Site Energy Savings through Q3 2013 by Fuel Type per Sector

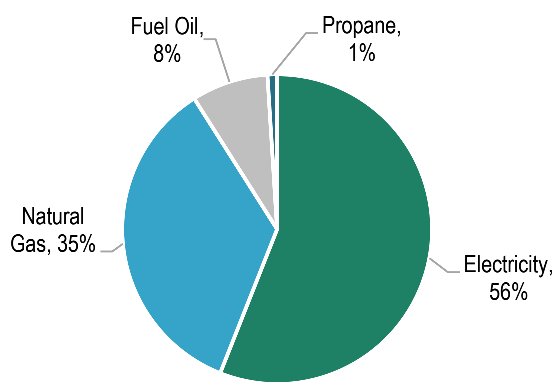
SECTOR	ELECTRICITY (KWH)	NATURAL GAS (THERMS)	FUEL OIL (GALLONS)	PROPANE (GALLONS)	KEROSENE (GALLONS)
Residential	87,510,900	13,698,543	2,648,021	213,362	5,723
Multifamily	20,681,620	2,498,801	539,016	4,051	—
Commercial	173,940,718	2,004,409	90,170	87,420	—
Agriculture*	2,405,535	13,778	3,607	229,779	—
Total	282,133,238	18,201,753	3,280,814	534,612	5,723

Source: DOE-BBNIS.

* Agriculture totals obtained from DOE email dated May 9, 2013, as they are not included in Project Level data.

Grantees reported savings from a number of different fuel types including electricity, natural gas, fuel oil, propane, kerosene, and wood. Electricity and natural gas savings were the most common fuel sources, comprising 92% of the overall reported (unverified) source MMBtu savings (Figure 2-1).

Figure 2-1: Percent of Total BBNP Reported (Unverified) MMBtu Savings by Fuel Type



Source: DOE-BBNIS.

Figure 2-2 and Figure 2-3 illustrate the two major fuel types saved (electricity and natural gas) by sector. As these figures illustrate, the commercial sector was reported to be responsible for a majority of the electricity (kWh) savings while the residential sector was responsible for the majority of reported natural gas (therms) savings.

Figure 2-2: Electricity Savings by Sector (kWh)

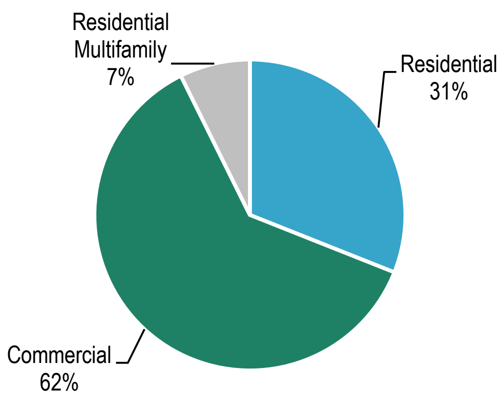
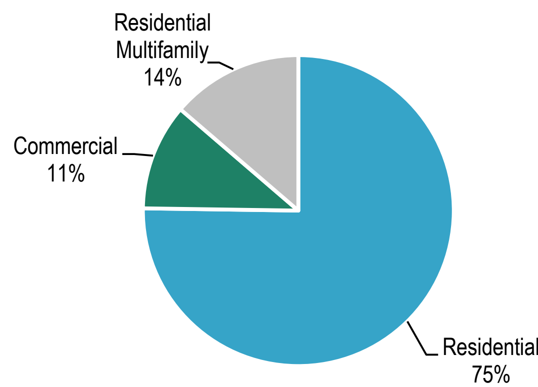
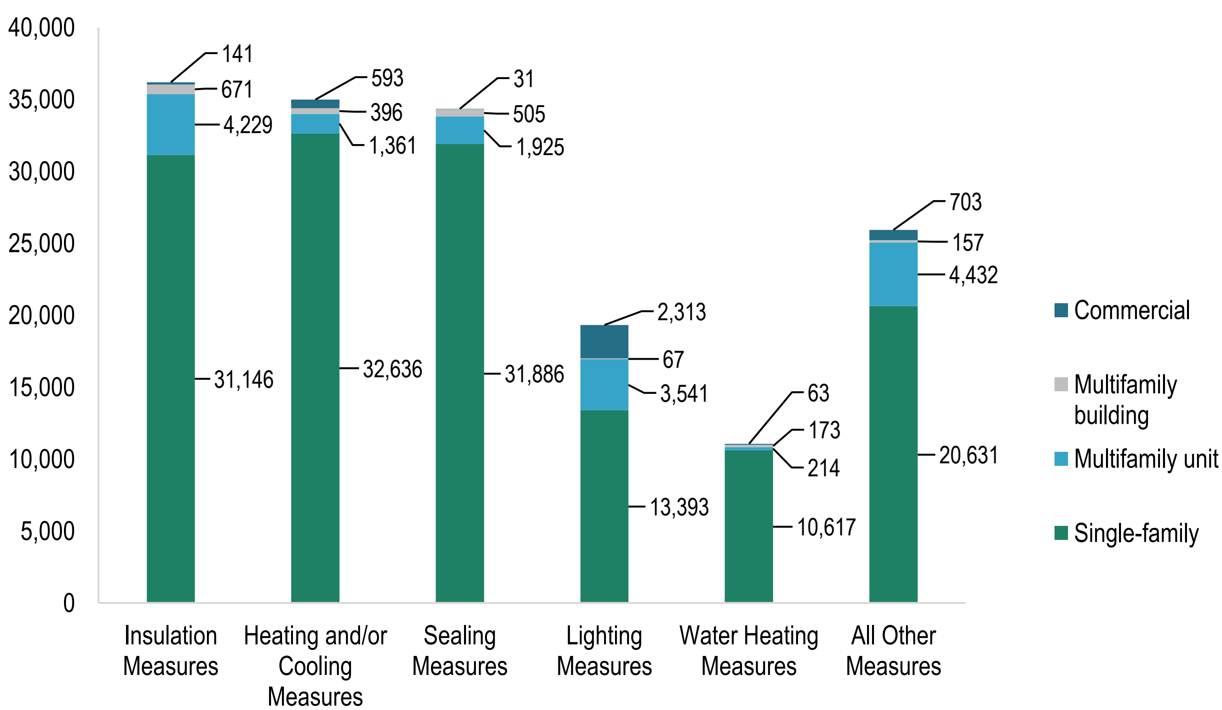


Figure 2-3: Natural Gas Savings by Sector (therms)



Upgrade customers most commonly installed heating and/or cooling systems, insulation, and air sealing measures; these measures comprised 91% of the overall reported (unverified) source MMBtu savings and 81% of installed measures (Figure 2-4).

Figure 2-4: BBNP Reported Installed Measure Counts



Source: DOE-BBNIS.

2.1.2. REPORTED THROUGH Q3 2014 (THE END OF THE EXTENSION PERIOD)

In 2013, DOE provided an extension to ARRA-funded grantees with ongoing financing programs to operate through Q3 2014. By the end of this period, grantees reported cumulative spending of $508 million and conducting 115,640 upgrades. The following tables summarize BBNP accomplishments over the four-year period from program start through Q3 2014, as reported to the evaluation team by BBNP staff.

Table 2-5: Summary of BBNP Reported Upgrade and Loan Accomplishments through Q3 2014

	RESIDENTIAL	COMMERCIAL*	TOTAL
Total Upgrades	115,640	3,764	119,404
Total Loans (count)	20,528	302	20,830
Total Loan Amounts ($)	$225,818,156	$27,929,303	$253,747,458

Source: BBNP staff, personal communication.

* Does not include 187 reported industrial and agricultural projects

Table 2-6: Count of BBNP Reported Residential Upgrades by Calendar Year

YEAR	ANNUAL	CUMULATIVE
2010	3,963	3,963
2011	16,779	20,742
2012	35,665	56,407
2013	44,785	101,192
2014	14,448	115,640

Source: BBNP staff, personal communication.

Table 2-7: Summary of BBNP Reported (Unverified) Energy Savings through Q3 2014

ELECTRICITY (KWH)	NATURAL GAS (THERMS)	HEATING OIL (GALLONS)	LPG (GALLONS)	TOTAL SOURCE MMBtu SAVED	TOTAL ENERGY BILL SAVINGS
320,086,742	21,757,373	6,072,183	781,570	7,117,675	$86,921,898

Source: BBNP staff, personal communication.

2.2. GRANTEE PROGRAMS

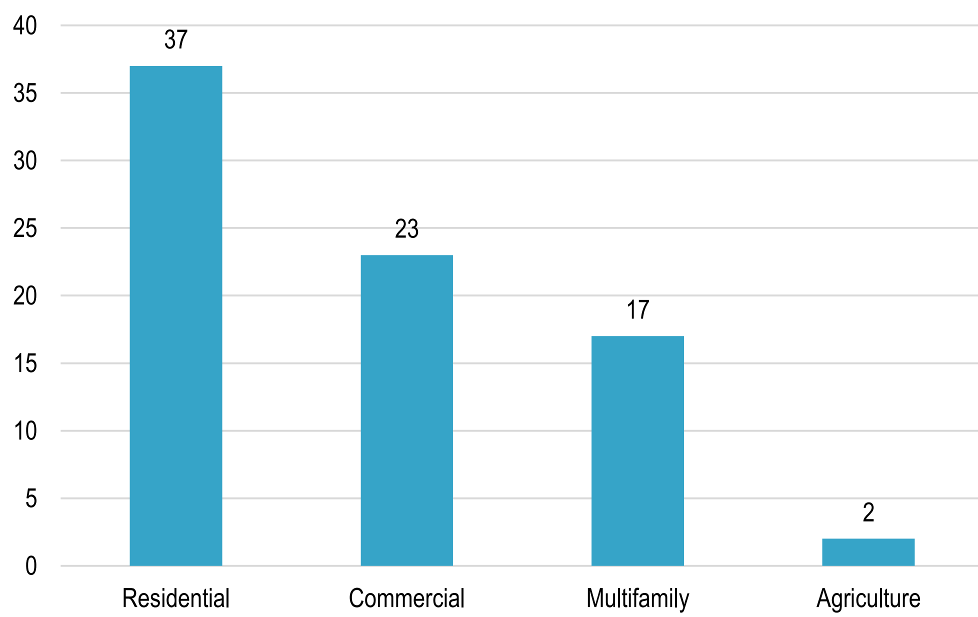
One of the unique aspects of this program was the freedom that the grantees had to design and implement programs that met the needs of their communities. While DOE provided guidance and expectations, the grantees were able to develop programs specific to their communities. A companion volume, *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4), describes the program variations in detail. This volume assesses the energy savings from upgrade projects completed through the programs, and the description of grantee programs relates to these upgrades.

Grantees offered a number of different types of financial incentives to promote energy efficiency in their communities, including rebates, direct installation of measures, and loans, including loans with interest rate buy-downs. Many grantees used one or a combination of these financial incentives, depending on such factors as their funding, community interest, and previous program offerings in the community.

Initially, DOE required that each project reported by a grantee meet a goal of 15% energy use reduction for the home or building undergoing the energy upgrade. However, in March 2012, DOE allowed grantees the option to meet the 15% energy use reduction goal on their entire portfolio of projects. This optional approach allowed the grantees to accept projects in the program that did not achieve 15% savings, as long as the portfolio of projects implemented through the grantee efforts achieved an overall average of 15% energy savings.

Grantees offered programs that focused either on one sector within their community or multiple sectors. Figure 2-5 illustrates the number of grantees offering various sector-based programs.

Figure 2-5: Grantee Sector Offerings



In the residential market, the grantees generally offered two participation options for energy upgrades:

1. **Whole Home** – Consisted of the installation of a specific combination of energy-saving measures that target whole home energy reduction with incentives based on the overall reduction in the house's energy consumption or on the specific combination of measures.
2. **Individual Improvements** – Included installation of one or more individual energy savings measures, with incentives provided per measure installed.

The commercial sector programs generally focused on offering incentives on individual measures, with lighting being the most common type of improvement noted in the M&V sample.

Multifamily programs were categorized in two different ways. Some programs were designed to improve individual units within a multifamily building, while others worked with entire multifamily complexes to improve the energy efficiency of the common spaces of the buildings. Table 2-8 outlines the various services and measures offered by the grantees.

Table 2-8: Technologies and Services Offered by Grantees Across the Four Sectors

TECHNOLOGY/SERVICES	RESIDENTIAL	MULTIFAMILY	COMMERCIAL	AGRICULTURE
Energy Audits	x	x	x	x
Energy Efficiency Advisors	x	x	x	
Contractor Training	x	x	x	
Air Sealing	x	x	x	
Insulation	x	x	x	
Lighting	x	x	x	x
Programmable Thermostats	x	x	x	
Water Heater	x	x	x	
Heating	x	x	x	x
Cooling	x	x	x	x
Washing Machine	x	x	x	
Refrigerator	x	x	x	
Freezer	x	x	x	
Farm Equipment				x
Solar Thermal/Electric	x	x	x	
Equipment Tune Ups	x	x	x	x
Energy Management Systems			x	x
Motor and Drives			x	

TECHNOLOGY/SERVICES	RESIDENTIAL	MULTIFAMILY	COMMERCIAL	AGRICULTURE
Ventilation			x	
Recommissioning			x	

2.3. PROGRAM REQUIREMENTS

The Better Buildings Neighborhood Program Grant Recipient Management Handbook outlines the program requirements and processes.[4]

The BBNP grants were awarded through three different funding streams over a six-month time period in 2010. The EECBG awards were made in April 2010, June 2010, and September 2010; they were originally scheduled to end three years later, between May 2013 and September 2013. The SEP awards were made in September and October 2010, with an end date of September 2013. A grant development team from DOE visited each grantee to develop the Statement of Project Objectives (SOPO).

Once the SOPO was completed, the grantee was encouraged to develop an implementation plan. The implementation plan could be developed by the grantee or the grantee could use the template provided by the BBNP team. The template was designed to help frame the details of the implementation plan by allowing grantees to report on marketing and outreach, financing, workforce development and contractor capacity, and data reporting. The implementation plans were due within three months after signing the SOPO.[5]

The implementation plans were considered a living document. Since grants are not contracts, there was no set deliverables defined by the implementation plan, and success was not measured against the implementation. Thus, grantees were able to adjust savings and project goals as they proceeded through the grant period.

In addition to the activities to meet the SOPO and implementation plan, grantees had obligations to follow federal regulations in their reporting. There were a number of specific reporting documents involving different options of program operation, but the key documents that we used for this report included:

- **DOE Performance Project Reports** – required quarterly of EECBG and SEP grantees. This was a narrative and a spend plan report used to capture key progress and planning data, including budgeted and actual spend amounts and progress made against project milestones.
- **Better Buildings Neighborhood Program Report** – required monthly for EECBG and SEP grantees for documenting the number of upgrades. The grantee submitted Microsoft Excel

4 *The Better Buildings Neighborhood Program Grant Recipient Management Handbook* was first published January 2011, v1.0, v1.2 was published April 2011, and v2.0 January 2012.

5 The Implementation Plan template had a due date of October 31, 2011. With some grantees receiving their awards in September, this date was not feasible; for those receiving them in June and April, it was.

datasets quarterly that provided details on the upgrades, the loans, the energy bills, and other information needed for the program to assess the effectiveness of the upgrades.

2.4. DATABASES AND DATA TRACKING PROCESSES

Both grantees and DOE took a number of steps in order to produce the reported metrics based on the achievements of the grantees. This section outlines the data calculation and tracking processes utilized to capture and report savings.

2.4.1. GRANTEE DATA REPORTING AND TRACKING

Grantees utilized deemed saving values, modeled savings values, or a combination of both to calculate the energy savings associated with projects implemented in their communities. The deemed approach involved the use of predetermined energy savings values for measures implemented for each project. The modeled approach involved the use of energy models that are built specifically to the project parameters (that is, building type, sq. ft., energy using systems, weather, etc.) in order to determine an energy savings estimate. While we often did not have access to the sources and inputs for these savings, we were able to determine which modeling software was commonly utilized by the grantees to calculate savings.

For those grantees using modeled savings, the following list shows the software programs employed, based on interviews conducted with the grantees:

- Conservation Services Group's (CSG) software
- Targeted Retrofit Energy Analysis Tool (TREAT)
- Beacon
- REM/Rate
- Energy Performance Score
- Performance Systems Development (PSD) Surveyor
- Auto Audit
- EnergyPro
- eQuest
- Weatherization Field Guide
- Helpdesk Expert Automation Tool (HEAT)
- Home Energy Renovation Opportunity (HERO)
- Home Energy Saver Pro
- Honeywell's software
- Optimizer

Grantees used internal databases specifically developed for their programs to track program performance. DOE did not require grantees to use any specific database for program tracking. The information captured within these databases was often more detailed than what was provided to DOE through the quarterly reports and often included information such as the specific measures implemented for each retrofit project, customer contacts, energy savings assumptions, etc. There was a wide range of internal tracking database systems used by the grantees:

- Snughome
- Energy Savvy
- Google Docs
- CSG
- Symbiotic
- PSD
- Longjump
- Neat
- Expression Engine
- Grantee developed

The evaluation team was often offered access to the tracking data systems to capture the necessary information for the analysis.

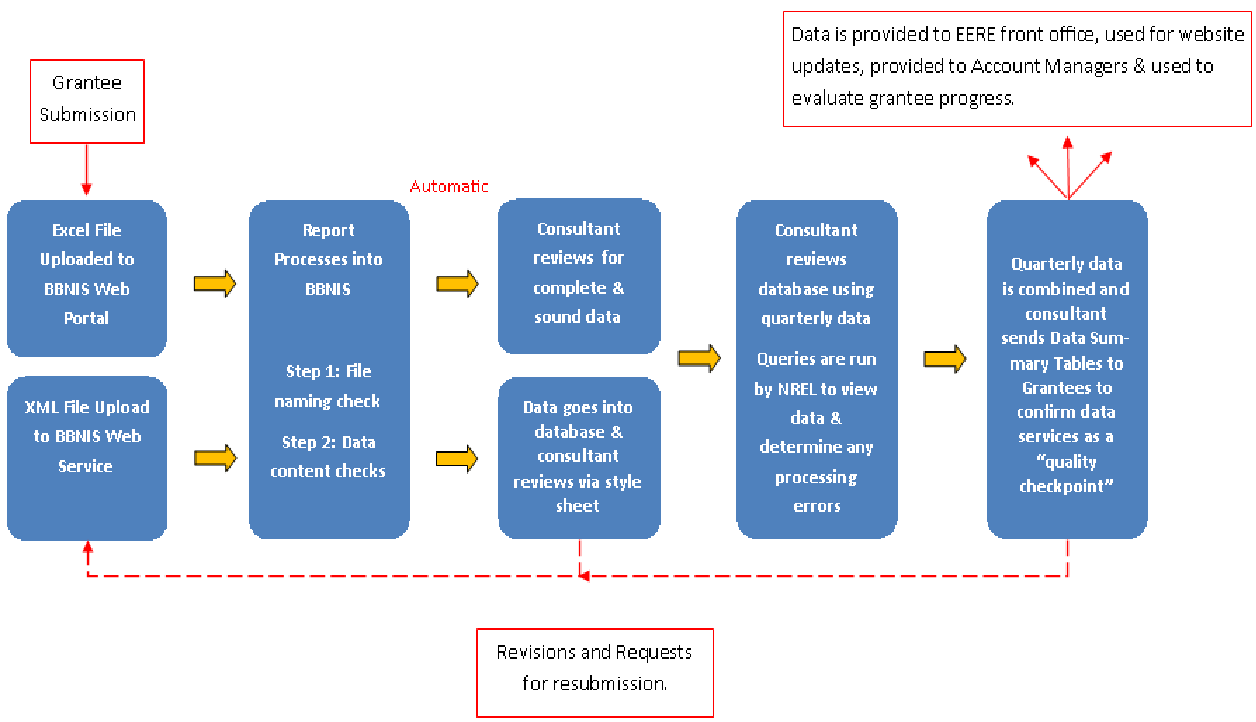
2.4.2. DOE REPORTING PROCESSES

DOE established websites and databases to manage and track the overall BBNP data. These tracking and informational tools were designed to serve specific functions for grantees, program managers, and the public, and included the following:

- **BBNIS.** Grantees used this site to upload program progress reports, and DOE used the site to quantify both program and individual project-level results.
- **Google Site.** This site was intended to allow grantees to share program information amongst themselves and DOE to gain an understanding of best practices and relevant program information.
- **Public-Facing Better Buildings website.** DOE used this site to share grantee project information with the public.

DOE required grantees to report program results quarterly to DOE through the BBNIS, using DOE-provided *Excel* or *XML* templates. This allowed DOE to track the performance of the grantees towards the outlined goals. DOE then summarized the individual quarterly reports into tracking spreadsheets and dashboards through the *Salesforce* site to use for reporting purposes. Figure 2-6 outlines the processes used by the grantees and DOE to report accomplishments from BBNP.

Figure 2-6: Grantee and DOE Reporting Process



Source: Figure provided courtesy of Navigant Consulting (2013)

This reporting process created a system of checks and balances to address erroneous reporting issues. However, as might be anticipated for a program of this scope and scale, issues occurred that impacted the reporting of the accomplishments. Throughout the course of the BBNP, DOE and its consultants targeted areas of concern and worked with the grantees to ensure better accuracy of their reporting.

3. METHODOLOGY

This chapter provides an overview of our evaluation methodology. It then provides additional discussion of our sampling approach, our method of extrapolating our impact evaluation findings to develop a verified savings estimate for the BBNP program overall, and additional metrics investigated. The chapter concludes with a discussion of evaluation challenges.

Appendix B provides supplementary methodological detail.

3.1. OVERVIEW

The impact evaluation comprised two broad activities to determine gross verified savings:

- **M&V** of a sample of grantees and projects
- **Billing regression analysis** on projects from grantees with sufficient utility bill data

We combined the results from both M&V and billing regression analysis and extrapolated to the population in order to determine the overall estimated energy savings for BBNP.

We used a sector based analysis (that is, residential, multifamily and commercial) that reviewed savings associated with individual projects but not the individual measures making up each project.

We quantified impact metrics for the entire three-year BBNP grant cycle based on findings from preliminary and final evaluations. The preliminary evaluation assessed a sample of projects reported between Quarter 4 (Q4) 2010 and Quarter 2 (Q2) 2012 (inclusive).[6] The final evaluation verified grantee reported activities and quantified metrics for a sample of projects reported between Quarter 3 (Q3) of 2012 and Quarter 3 (Q3) of 2013. We conducted the preliminary research and analysis from January 2013 through May 2013; we conducted the final research and analysis from December 2013 to October 2014.

Although the preliminary and final evaluations use consistent and, for many of the assessment activities, identical methodologies, our work plan for the final evaluation included refinements based on our preliminary evaluation experiences. This chapter describes primarily the methodology we used for the final evaluation activities, unless otherwise noted.

To conduct our analysis, we collected and analyzed data from the grantees and subgrantees as well as program participants. Table 3-1 summarizes our data collection methods.

6 The preliminary evaluation had multiple goals: 1) to provide impact results mid-way through the BBNP program cycle; 2) to refine the impact evaluation method for the final evaluation; 3) to support the process and market effect evaluation activities; and 4) develop initial conclusions and recommendations that might be implemented by the grantees to foster an effective final impact evaluation (Research Into Action, Evergreen Economics, Nexant, and NMR Group, 2013).

Table 3-1: Summary of Methods

EVALUATION METHOD	GRANTEE COUNT*	SAMPLED PROJECT COUNT
Preliminary Evaluation Activities		
Desk Review Only**	14	49
Phone Survey	22	205
Onsite Visit with Interview	17	65
Utility Billing Data	4	2,226
Final Evaluation Activities		
Desk Review Only**	14	256
Onsite Visit with Interview	16	103
Utility Billing Data	21	7,513

* Grantee counts represent overlap between evaluation methods.

** All samples received a desk review of supporting project documentation regardless of measurement rigor.

3.2. M&V

To determine the overall estimated BBNP gross energy savings, we used an ex-post analysis (actual savings based on post-retrofit conditions) in order to estimate the energy savings for each project in a representative sample selected to provide high confidence and precision. We determined gross verified energy savings through: 1) participant onsite inspections and surveys; 2) review of project files and documentation; and 3) engineering analysis of projects. We compared gross verified savings to reported savings to determine a realization rate for each sector.

3.3. BILLING REGRESSION ANALYSIS

We conducted a billing regression analysis to estimate realized energy savings at the project level. We reviewed all billing data that grantees provided to DOE and determined that 19 grantees had provided sufficient data to support regression analysis. We needed both participant billing (monthly electricity or natural gas consumption before and after program participation) and participant tracking data (for example, information on when measures were installed).

3.4. EXTRAPOLATION OF RESULTS TO OVERALL BBNP

We recognized that potential issues might exist when combining the results from the billing and M&V analyses. First, the two analysis methods used different baselines for some of the measures. The billing regression analysis inherently used a baseline of pre-project existing conditions as the baseline. This was due to the regression analysis comparing the energy use prior to the project implementation to the energy use after the project installation. However, the M&V analysis used either a codes and standards baseline or the pre-project existing conditions baseline depending on the measure installed and the amount of information available for each measure. The second issue involves participant spillover savings, which are energy savings due to measures installed by a program participant and likely due to the influence of the program but for which no program incentive was paid. The billing regression analysis would capture the savings due to participant spillover or other changes that would not be directly caused by the program, while the M&V activities would not.

To address these concerns, we overlapped the M&V and billing regression analysis sample frames for the final evaluation in order to determine an adjustment factor that could account for these issues and allow the M&V and billing analyses to be merged. The adjustment factor is a ratio we computed by directly comparing the estimated energy savings of projects examined by both analysis methodologies. This ratio is determined through a regression of participant fuel consumption against M&V savings estimates. For example, an adjustment factor of 70.1 percent indicates that the savings estimates estimated by the billing regression were found to be, on average, 70.1 percent of the M&V estimates. Appendix B contains a detailed description of the methodology and regression model used to estimate the adjustment factor. Table 3-2 summarizes the adjustment factors for each sector based on the performed regression models. We did not calculate an adjustment factor for multifamily projects due to an insufficient sample size. Therefore, we used the residential adjustment factor as a proxy value for the multifamily sector. We applied these adjustment factors to the billing regression realization rates (that is, computed the product of the two estimates), so that the billing regression findings are comparable with the M&V savings estimates, thereby, allowing for the calculation of one final realization rate for each sector.

Table 3-2: Billing Regression Adjustment Factors

SECTOR	ADJUSTMENT FACTOR (PERCENT)
Residential	70.1%
Multifamily	70.1%
Commercial	92.4%

3.5. OVERALL VERIFIED BBNP SAVINGS

In order to calculate the overall verified energy savings associated with BBNP, we extrapolated the sample findings to the population through the use of case weights and realization rates. Due to the intrinsic differences in baseline conditions between the M&V analysis and billing regression analysis, we developed an adjustment factor based on a subset of overlapping projects between each analysis (see section 3.4 above). This adjustment factor was applied to the savings estimates of the billing regression analysis to make the savings estimates comparable to the M&V savings estimates. We then calculated realizations rates for the M&V sample frame and the billing regression analysis sample frame separately. Finally, we combined the resulting realization rates and extrapolated to the entire BBNP.[7]

[7] According to the *California Evaluation Framework*, two statistically independent evaluation studies that provide statistically unbiased estimates of the savings of the program may be combined into a single estimate. If the two estimators, in this case

We combined the M&V realization rates for both the preliminary and final evaluations in order to determine an M&V realization rate representative of the entire evaluation timeframe. We calculated the combined M&V realization rate through a weighted average of the realization rates based on the total *ex ante* savings of all the grantees within each respective sampling frame. We could not calculate a weighted realization rate for the multifamily sector as no realization rate was calculated for this sector during the preliminary evaluation.

We also used the billing regression results to develop realization rates for the all sectors. We calculated these realization rates for each grantee that provided billing data and where robust billing regression models could be estimated. To develop a realization rate for the billing regression analysis sample, we calculated a weighted average of the grantee-level realization rates that were estimated using the billing regression, with *ex ante* savings used as the weights.

BBNP savings reported by DOE for the sample was adjusted to reflect the findings of the M&V and billing regression analysis activities.

We calculated the overall sector realization rate by taking a weighted average of the realization rates calculated for the M&V and the billing regression analyses. The team weighted these realization rates based on the total *ex ante* savings of all the grantees within each respective sampling frame. Once we determined the weighted average realization rate, we applied this value to the overall reported savings for the sector population to calculate a gross verified savings. We then calculated net verified savings for each sector by applying the NTG ratio to the sector level gross verified savings.

3.6. ADDITIONAL OVERALL BBNP METRICS

3.6.1. GREENHOUSE GAS EMISSION SAVINGS

We calculated and reported carbon dioxide (CO_2e) equivalent reductions based on verified net source savings for each year over the effective useful lifetime of the projects evaluated. We expressed the emission factor as mass per unit of energy (metric tons of CO_2e per MMBtu), which represents the characteristics of the emission sources displaced by reduced generation from conventional sources of electricity or reduced consumption of natural gas.

We sourced emission factors for electricity from the U.S. Environmental Protection Agency's (EPA) eGrid[8] dataset. Emission factors for average U.S. annual non-baseload output for carbon dioxide, methane, and nitrous oxide were used to calculate a CO_2e emissions factor. We used non-baseload output to calculate the emissions factor as energy efficiency programs are generally assumed not to

the realization rates from the M&V analysis and the billing regression analysis, are both unbiased estimators of a given parameter, then any weighted average of the two estimators also is an unbiased estimator. The error bound of the result is the square root of the reciprocal of the sum of the weights (TecMarket Works, 2004).

8 Emissions & Generation Resource Integrated Database, 9th edition Version 1.0 Year 2010 GHG Annual Output Emission Rates. The national-level emissions factor was used to convert total net electricity savings to avoided greenhouse gas (GHG) emissions.

affect baseload emissions.[9] The natural gas emissions factor used in the report represents a weighted national average emissions output for homes and businesses[10] for natural gas, heating oil, and propane and is weighted by the verified savings contribution of each fuel type in the BBNP.

3.6.2. LIFETIME ENERGY SAVINGS

The effective useful life (EUL) of retrofit equipment is an important consideration in the assessment of program effectiveness because the avoided energy, demand, and cost benefits continue to accrue over the lifetime of the measure. In order to calculate lifetime savings for the sample projects, we assigned individual project EULs based on the retrofit measure types implemented in the project, using values sourced from deemed savings databases, such as the Database for Energy Efficient Resources (DEER), Regional Technical Forum (RTF) data, and regional Technical Reference Manuals (TRMs).[11]

DOE did not report lifetime energy savings; therefore, we could not develop a realization rate for lifetime energy savings. Instead, we calculated lifetime savings for the entire sector populations by calculating a lifetime savings factor. This factor was calculated by dividing the sample lifetime savings by sample annual savings. We then multiplied this factor by the total verified annual savings to determine a verified lifetime savings. Thus, the lifetime savings estimates lack the analytical rigor of the annual estimates.

3.6.3. ESTIMATING ANNUAL AND LIFETIME BILL SAVINGS

For the three-year grant period ending in Q3 2013, BBNIS data provided energy savings by fuel type by sector, which we multiplied by the dollar per unit cost by fuel type by sector per U.S. Energy Information Agency (EIA), as shown in Table 3-3. For the period Q4 2013 to Q4 2014, DOE provided energy savings by fuel type. We assume the proportion of savings by sector for this period was the same as for the three-year grant period. EIA had cost data for 2014 for electricity and gas, which we used; we used the 2010 fuel oil and propane prices as EIA did not have these data for 2014. We estimated lifetime bill savings by extrapolating from the three-year bill savings; we multiplied the three-year bill savings by the ratio of lifetime energy savings divided by three-year energy savings.

Table 3-3: Energy Cost Prices

SECTOR	ELECTRIC $/KWH (2012) [a]	GAS $/THERM (2012) [b]	#2 FUEL OIL $/GALLON (2010) [c]	PROPANE $/GALLON (2010) [d]
Residential (applied to all BBNP single and multifamily savings)	$0.119	$1.065	$2.224	$2.798

9 As described by EPA on its Clean Energy Calculations and References website: *http://www.epa.gov/cleanenergy/energy-resources/refs.html*.

10 U.S. Energy Information Administration (EIA): Carbon Dioxide Emissions Coefficients.

11 DEER Database maintained by the California Public Utilities Commission and the California Energy Commission. Accessed 7/9/2012. *http://www.energy.ca.gov/deer/*.

Commercial (applied to all BBNP nonresidential savings)	$0.101	$0.810	$1.873	$2.358

[a] http://www.eia.gov/electricity/data

[b] http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm. Converted from MCF to Therms by multiplying MCF by 0.103.

[c] http://www.eia.gov/dnav/pet/pet_pri_dist_dcu_nus_a.htm. 2010 was the most recent available data.

[d] http://www.eia.gov/dnav/pet/pet_pri_prop_dcu_nus_a.htm. 2010 was the most recent available data.

3.6.4. LEVERAGED FUNDS

The Quarterly Program Report form grantees submitted to DOE asked them to report on leveraged funds by source. One reporting field, entitled "Other Federal Leveraged Funds," instructed grantees to "Please enter the total amount of other [that is, other than BBNP] Federal leveraged funds expended by your program during the most recent quarter. Other federal funds may include funds from EECBG and SEP, loans from U.S. Department of Housing and Urban Development (HUD), etc." The second reporting field, entitled "Non-federal Leveraged Funds," instructed grantees to "Please enter the total estimated amount of non-federal funds expended during the most recent quarter. This includes third-party, in-kind contributions, and the portion of the costs of a federally assisted project or program not borne by the federal government."

DOE also requested we use Wolf's (2008) methodology for defining leveraged funds (Wolf, 2008). Wolf specifies a definition for identifying leveraged funds that differs considerably from popular usage of the term and, indeed, is more stringent than any used by any of the DOE Energy Efficiency and Renewable Energy (EERE) programs we examined in the report; it results in fewer funding sources or monies qualifying as leveraging. We developed an in-depth interview guide (see Appendix L) and interviewed 15 grantees that reported leveraged funds, collectively comprising 78% of all funds grantees reported to DOE as leveraged. We analyzed the data according to Wolf's method (described in Appendix B, *Section B.10 Leveraging*).

Finally, grantees reported funds leveraged from the financial institutions with which they partnered to offer BBNP upgrade participants loans. We conducted interviews with 20 financial institution partners to corroborate these leveraged funds.[12]

3.7. NET-TO-GROSS METHODS

We conducted surveys to provide inputs to the net-to-gross (NTG) calculations with two groups: participating end users and participating and nonparticipating contractors. The larger contractor sample size for the residential sector gave us confidence in extrapolating contractor sample estimates to the population. Given the smaller contractor sample size for the commercial sector and no multifamily-specific contractor data, we extrapolated solely from the participating end user data to the commercial and multifamily populations.

[12] Chapter 8 of *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4) presents the findings of these interviews; Appendix L.5 of that volume provides the interview guide.

Residential: The final NTG estimate for the residential sector is based on both end user- and contractor-derived NTG estimates. Participating end user free-ridership informs the lower bound NTG estimates (that is, NTG with free-ridership), and contractor-derived estimates of free-ridership and spillover inform the upper bound NTG estimates (that is, NTG with free-ridership and spillover). The final residential NTG value is the mid-point between the lower and upper bounds (that is, the end user- and contractor-derived NTG estimates).

Commercial and Multifamily: The final NTG estimates for the commercial and multifamily sector are derived solely from participating end user free-ridership. While there are some indications of spillover from the commercial grantees, the sample size of surveyed contractors was too small to develop a reliable estimate.

See Appendix B and *Market Effects of the Better Buildings Neighborhood Program* (Final Evaluation Volume 5) for additional details on the NTG methodology.

3.7.1. LOWER BOUND NET-TO-GROSS RATIO ESTIMATES DERIVED FROM PARTICIPATING END USERS

Sampled commercial end users were those that completed an onsite verification survey as part of the M&V activities for the final evaluation; the onsite verification survey included the NTG questions. We sampled multifamily end users from a desk review and conducted the NTG survey over the phone. Sampled residential end users were those that completed an online survey that included process and NTG questions. Our survey questions sought information relating both to program influence (free-ridership) and spillover; however, we are able to provide numeric estimates of free-ridership only. (Our study methodology did not include estimation of energy savings associated with respondents' reported spillover activity, nor with verifying the spillover.) We compiled the free-ridership results for each project from two components, what the participant would likely have done in the absence of the program and the influence the participant states that the program had on the upgrade actions taken. For commercial and multifamily sectors (which were based on the M&V sample), we rolled up the per-project results to the stratum level within each sector. We multiplied the stratum-average free-ridership score by the stratum verified savings and summed the resulting stratum-net-savings to obtain a sector net savings. We calculated sector NTG as the ratio of the sector-net-savings divided by the sector-verified-savings. We calculated the residential lower bound NTG using an analogous approach, but used grantee-stratum case weights developed by multiplying the ratio of a grantee's total project count to total BBNP project count by the ratio of respondents in the grantee's stratum to total survey respondents.

3.7.2. UPPER BOUND NET-TO-GROSS RATIO ESTIMATES DERIVED FROM PARTICIPATING AND NONPARTICIPATING CONTRACTORS

We estimated the number of energy efficiency upgrades associated with the residential grantee programs included in this market assessment (see *Market Effects of the Better Buildings Neighborhood Program* [Final Evaluation Volume 5] for more details). This provided an estimate of the net impacts of the residential BBNP grantees for participating contractors (that is, the estimate includes both free-ridership and spillover) and an estimate of nonparticipant spillover for nonparticipating contractors. We estimated a NTG value for the residential grantees by combining the total estimated net number of energy efficiency upgrades from participating and nonparticipating contractors and dividing by the total number of BBNP-supported upgrades reported by participating contractors. We have not included the NTG ratio for the commercial grantees included in the market assessment because the estimate is based on a small sample.

We estimated net BBNP upgrades by asking contractors to estimate the number of energy efficiency upgrades they would have completed in the absence of BBNP activities. In addition, we used contractors' ratings of the impacts of BBNP on their business and the energy efficiency upgrade market as a consistency check of program influence on net upgrades, combining a four-question series into a scale. It is important to note that the estimate captures contractor activity only in the territories of the residential grantee programs included in the market assessment, all of which were chosen because of their success levels, and that the estimate did not apply to BBNP overall.[13] Therefore, we applied an adjustment to the residential NTG value, proportionate to the percent of BBNP residential upgrades accounted for by residential grantees included in market assessment, to develop an adjusted NTG value of 1.10 (see Appendix B for more details).[14] We are unable to provide NTG estimates for the multifamily and commercial sectors.

Table 3-4: Net-to-Gross Ratio Calculation Methods

SECTOR	LOWER BOUND NTG ESTIMATES DERIVED FROM PARTICIPATING END USERS (FREE-RIDERSHIP ONLY)	UPPER BOUND NTG ESTIMATES DERIVED FROM PARTICIPATING AND NONPARTICIPATING CONTRACTORS (FREE-RIDERSHIP AND SPILLOVER)	FINAL NTG ESTIMATE (MID-POINT OF LOWER AND UPPER BOUNDS)
Residential	0.78	1.10	0.94
Commercial	0.85	Not estimated	0.85

13 The market effects study investigated grantees with residential programs from each success grouping: most successful (six grantees), average (13 grantees), and least successful (one grantee) as well as the top five commercial grantee programs (based on BTUs of savings). Section 3.9 *Review of Independent Evaluations* provides our method for identifying grantee relative success.

14 It also is important to note that we could not directly estimate energy savings from any of the spillover upgrades because data on the type of equipment installed or replaced in these non-BBNP upgrades were not available. Further, the data were self-reported and were not corroborated by field studies.

Multifamily	0.99	Not estimated	0.99

3.8. ECONOMIC IMPACT ANALYSIS

We modeled the economic impacts of BBNP, including jobs, as well as estimates of economic output, income (personal and business), and tax revenue that result from the program spending relative to a base case scenario where BBNP does not exist. We intend the economic analysis to inform interested stakeholders and the public, as well as provide useful, action-oriented information to policymakers and program managers.

The economic analysis used information contained in the BBNP Quarterly Summary Reports (specifically, the Program Level data) to analyze the economic impact of the program offerings. This information included program outlays, energy bill savings, and measure spending (project costs). Where necessary, the data were supplemented with information from the detailed quarterly spreadsheets completed by program grantees.

Measuring the economic impacts estimated for BBNP was a complex process, as spending by grantees and program participants unfolded over time for over 40 separate grantee offerings. This analysis measured the short-term economic impacts approximated for BBNP. Short-term impacts are those associated with changes in business activity as a direct result of changes in spending (or final demand) by program administrators, program participants, and institutions that provide funding for energy efficiency programs.

The economic impacts were driven by changes (both positive and negative) in final demand, and were measured within a static input-output modeling framework that relies on data for an economy at a point in time and assumes that program spending does not affect the evolution of the economy. (This last event is what economists call a change in the “production possibilities frontier” of the economy.)

Energy efficiency programs may have longer lasting effects, and this was clearly the case for continued post-installation energy savings. However, we did not measure long-term, dynamic effects in this analysis, as it was unlikely that BBNP caused significant structural changes in the economy given the relatively small magnitude of energy savings achieved relative to the overall size of the national economy.

The economic modeling framework that best measures these short-term economic impacts is called input-output modeling. Input-output models involve mathematical representations of the economy that describe how different parts (or sectors) are linked to one another. We constructed an economic impact model of the U.S. economy using the IMPLAN (for IMpact Analysis for PLANning) modeling software.[15] IMPLAN has several features that make it particularly well suited for this analysis.

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15 IMPLAN (for IMpact Analysis for PLANning) was originally developed by the Forest Service of the U.S. Department of Agriculture in cooperation with the Federal Emergency Management Agency and the Bureau of Land Management of the U.S. Department of the Interior in 1993, and is currently licensed and distributed by the IMPLAN Group LLC.

Input-output analysis employs specific terminology to identify the different types of economic impacts. BBNP affected the economy *directly* through the purchase of goods and services. Under our program-centric approach, these direct impacts included jobs[16] and income for grantee staff that administer and manage energy efficiency programs, contractors who provide audit and retrofit services, and energy efficiency equipment manufacturers. Direct effects also included changes in spending or output resultant to the energy savings for participating households and businesses.

These direct changes in economic activity will, in turn, *indirectly* generate purchases of intermediate goods and services from other related sectors of the economy. Because these indirect purchases represent interactions among businesses, they are often referred to as "supply-chain" impacts.

In addition, the direct and indirect increases in employment increase income, which expands consumer spending and enhances overall economy purchasing power, thereby *inducing* further consumption- and investment-driven stimulus. These induced effects are often referred to as "consumption-driven" impacts. In this report, the indirect and induced impacts are grouped together and reported as "secondary" impacts.

The model includes the following elements: 1) It captures upgrade project costs – that is, both the incented and unincented portions of project costs are captured in BBNP-related spending; 2) It describes net verified project energy savings; 3) It reduces activity in the generation sector commensurate with project energy savings; and 4) It does not include leveraged funds, such as funds leveraged from financial institutions, on the assumption that these amounts are largely reflected in upgrade project costs.

Increasing the total inputs to compensate for leveraged resources would result in double counting the impacts derived from these moneys and therefore overestimate the economic impacts of BBNP

3.9. REVIEW OF INDEPENDENT EVALUATIONS

We identified 20 grantee-level program impact evaluations conducted by independent (also known as third party) evaluators. However, the majority of these documents were process evaluations, marketing evaluations, informational brochures, or memos regarding the program. We benchmarked six third party impact evaluations and identified one for inclusion in our evaluation of the BBNP.

16 The IMPLAN modeling software measures jobs as the annual average of monthly jobs in each industry (this is the same definition used by Quarterly Census of Employment and Wages [QCEW], U.S. Bureau of Labor Statistics [BLS], and U.S. Bureau of Economic Analysis [BEA] nationally). Thus, one job is equivalent to one person being employed for the duration of one year, two people being employed for half a year each, three people being employed for a third of a year each, etc. Furthermore, IMPLAN jobs include full-time, part-time, and temporary positions. For reporting purposes, all IMPLAN job estimates in this report have been converted to full-time equivalents (2,080 hours in a standard year) using the sector-level conversion spreadsheet available on IMPLAN Group's website. For more information please see: https://implan.com/index.php?view=document&alias=206-convert-implan-employment-to-fte-and-wage-and-salary-data-to-employee-compensation&category_slug=version-three-files&layout=default&option=com_docman&Itemid=1370

3.10. ASSESSING GRANTEE SUCCESS

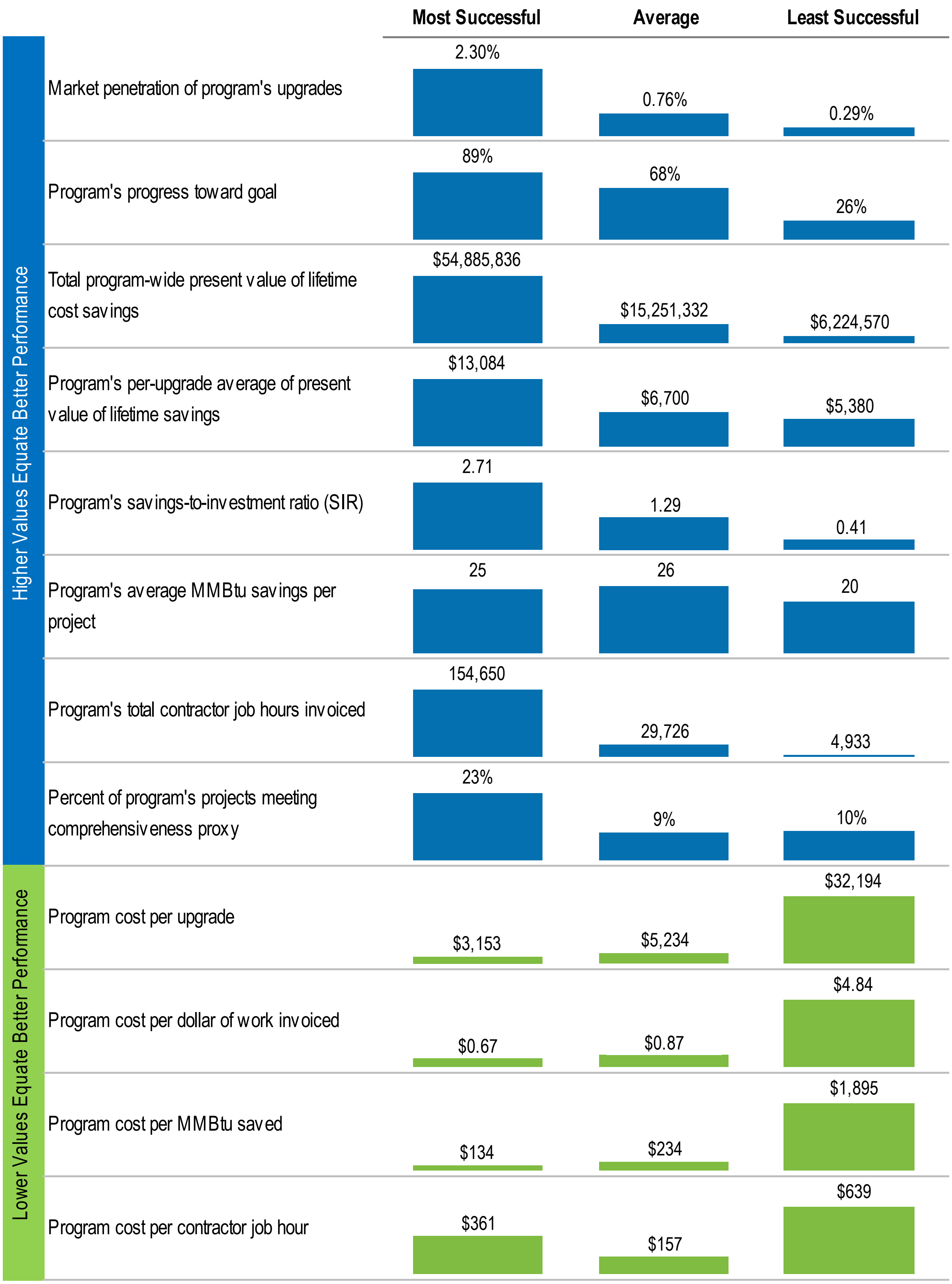
A primary goal of our evaluation was to identify factors that drove or inhibited success among grantees' and subgrantees' residential upgrade programs. To support the statistical investigation of effective approaches to delivering residential upgrade programs, *Drivers of Success in the Better Buildings Neighborhood Program – Statistical Process Evaluation* (Final Evaluation Volume 3) identified 12 diverse quantitative performance indicators, such as average MMBtu savings per project, program cost per upgrade, and progress toward upgrade goal. We then clustered grantees into groups based on their performance on the 12 metrics using grantee-reported residential activity data (Q4 2010 to Q3 2013). The analyses yielded three groups of grantees whose average performance on the 12 metrics were consistent with an interpretation of a most successful group, an average group, and a least successful group.

We emphasize here that the Volume 3 analysis used the grantee success clustering only to identify programmatic elements associated with stronger performance relative to other grantees, a research objective important to the DOE BBNP team. As we note elsewhere, grantee success during the three-year evaluation period was associated with the length of time programs took to reach optimal functioning; the most successful grantees reached the optimum point in their programs six months sooner than less successful grantees. However, we did not find that grantee success was driven by prior whole home program experience. Nonetheless, were the grantee programs to continue for ten years, we would expect program achievements to be higher in later years than in the initial years as grantees gained experience in their markets and adjusted their programs accordingly.

As we report in Volume 3, using both data that grantees reported to DOE in partial fulfillment of their grant requirements and data collected by our team, we conducted a series of statistical analyses to develop a quantitative definition of grantee success that corresponds to BBNP's multiple program objectives and to identify program features and characteristics that predict success.

Due to the greater availability of data for residential programs compared with multifamily and commercial programs, the Volume 3 success analysis focused exclusively on residential programs. Further, if a grant recipient had subgrantees that ran separate and distinct programs in mutually exclusive regions, we collected and analyzed data from each individual subgrantee to capture the full diversity of program models, outcomes, and market characteristics. A total of 54 grantees and subgrantees with residential programs were included in these analyses.

Figure 3-1: Performance Metric Cluster Means (n = 54)



First, we defined a broad range of potential measurements of program success based on theory and industry knowledge. From this list, we identified 12 quantitative performance metrics for which there were adequate data. We then conducted latent profile analysis (LPA) to cluster programs into groups that exhibited similar performance on the 12 performance metrics. LPA is an exploratory analytical technique, and our analyses sought to identify groups, or clusters, of grantees that differed meaningfully in their performance on 12 metrics of program success.

The LPA yielded three groups, and their average group values on the 12 performance metrics were consistent with an interpretation of a most successful cluster (n = 12), an average cluster (n = 35), and a least successful cluster
(n = 7). The most successful cluster generally performed best on each of the metrics, the least successful cluster generally performed worst on the metrics, and the average cluster demonstrated middling values on the performance metrics. Thus, the LPA revealed clusters of grantees that were more or less successful relative to one another. Figure 3-1, a copy of Figure 3-1 in Volume 3, demonstrates these tiered levels of grantee success by displaying the average cluster means for each of the 12 performance metrics.

Next, we identified grantee and program characteristics that may predict program success and compiled the corresponding data. This dataset also included exogenous variables that we deemed as critical control variables, such as weather metrics, average energy price, median income, and other variables that may affect energy use, savings, and participation rates. We used bivariate logistic regression models to explore whether any of the proposed predictor variables predicted membership in either the least successful cluster or the most successful cluster, respectively. We report the bivariate findings in companion volume *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4). Next, we ran multivariate regression models for each dependent variable (membership in the least successful cluster versus other and membership in the most successful cluster versus other) using the independent variables identified as meaningful predictors in the aforementioned bivariate models. We report the multivariate findings in Volume 3. Findings relevant to the savings and economic impacts are discussed throughout this volume. For additional information on the methods used to identify the grantee success clusters, see Volume 3.

3.11. SAMPLING

We selected unique sample frames for the M&V and the billing regression analysis assessments, as described in Table 3-5. As noted, the billing regression sample was dictated by the availability of sufficient grantee billing data required to conduct the billing regression analysis.

Table 3-5: Grantee Sample Frame by Evaluation Activity

EVALUATION ACTIVITY	NUMBER OF GRANTEES IN SAMPLE FRAME	NUMBER OF PROJECTS IN SAMPLE FRAME	REPORTED ENERGY SAVINGS IN SAMPLE FRAME (MMBtus)
M&V	30	41,541	3,026,023
Billing regression analysis	19	16,294	1,237,045

Total	49*	57,835	4,263,068

* Note: The total grantees listed in the sample include overlap between both the M&V and billing regression analysis sample frames. We designed such overlap to: 1) explore the differences of estimated savings when using M&V versus billing regression; 2) normalize those differences; and 3) merge the M&V and billing analyses to calculate an overall realization rate for the BBNP.

We designed the M&V sample to achieve a high level of confidence and precision in the verified gross and net savings for the overall BBNP. We designed the sample using a value of information (VOI) approach. A VOI approach balances cost and rigor, allocating the bulk of the M&V funds to areas with high impact and high uncertainty. Through this approach, our sample achieves an industry-standard level of measurement rigor while efficiently using onsite activities, providing the most cost-effective sample for the M&V activities.

The M&V sample was a random stratified sample for each sector selected across all sampled grantees based on the level of reported savings at the project level. We established strata boundaries using the Dalenius-Hodges method according to the size of the program energy savings within the residential and commercial sectors (Cochran, 1997).[17] We stratified the multifamily sector based on whether retrofits were conducted in individual units within the building or on the entire building itself.

We selected the confidence/precision targets for both the preliminary and final M&V activities based on the objectives outlined by DOE for the evaluation and determined a sample of ~375 projects for each evaluation was appropriate. However, our final executed sample differed from the planned sample due to difficulties in obtaining project data from grantees, which impacted recruitment and analysis efforts. For example, due to a lack of project data from one grantee, we used instead results from a third party evaluation conducted for the grantee that we reviewed and judged appropriate for use. We thus removed this grantee from the sample frame, which reduced the overall sample size for the affected sector and stratum.

Table 3-6 and Table 3-7 below summarize the sample and associated M&V activities for the preliminary and final evaluations, respectively. For additional information on the sampling stratification and sizing, see Appendix B.

Table 3-6: Preliminary Evaluation Proposed and Achieved M&V Sample Size by Sector

SECTOR	TOTAL NUMBER OF REPORTED PROJECTS (Q4 2010-Q2 2012)*	CV	PROPOSED SAMPLE SIZE	ACHIEVED SAMPLE SIZE	ACHIEVED SAMPLE BY SAMPLING RIGOR		
					Desk Review Only**	Phone Survey	Site Visit
Residential	23,461	1.2	237	217	16	154	47

[17] The Dalenius-Hodges methodology is used to determine optimal strata boundaries based on the cumulative root frequency method.

Multifamily	390		9	0	0	0	0
Commercial	1,534		139	102	33	51	18
Total	25,385		385	319	49	205	65

* A few grantees reported projects completed prior to Q4 2010.

** All samples received a desk review of supporting project documentation regardless of measurement rigor.

Table 3-7: Final Evaluation Proposed and Achieved M&V Sample Size by Sector

SECTOR	TOTAL NUMBER OF REPORTED PROJECTS (Q3 2012-Q3 2013)	CV	PROPOSED SAMPLE SIZE	ACHIEVED SAMPLE SIZE	ACHIEVED SAMPLE BY SAMPLING RIGOR		
					Desk Review Only*	Phone Survey	Site Visit
Residential	44,506	0.6	155	136	84	0	52
Multifamily	7,114	0.7	50	52	52	0	0
Commercial	2,018	0.9	170	171	120	0	51
Total	53,638		375	359	256	0	103

* All samples received a desk review of supporting project documentation regardless of measurement rigor.

3.12. LIMITATIONS AND CHALLENGES

Much of the $508 million in program funding across the country was provided to communities with limited or no prior experience with offering energy efficiency programs. This combination of significant scale and inexperienced grantees created challenges for DOE to manage and track the results of BBNP, which affected the evaluation efforts.

While these challenges presented risks to the validity of the study, we attempted to mitigate these risks based on lessons we learned from the preliminary evaluation.

3.12.1. SELF-REPORTED TRACKING DATA

All of the program data we examined were self-reported by grantees in the form of online data submissions managed by DOE staff, including grantees' corrections to previously submitted data. While our evaluation activities encompassed for sampled projects reviews of project documentation, phone surveys with program participants, onsite visits to project locations, and analysis of utility billing data, these activities are necessarily limited and do not result in fully validated program tracking data. We selected the evaluation samples based on the self-reported tracking data. Therefore, to the extent that data provided accurately represents the population of all grantee projects, our impact analysis results correctly estimate energy savings and economic impacts for those grantees providing data.

3.12.2. DIFFICULTY INTERPRETING GRANTEE DATA

The grantees were responsible for submitting metrics associated with project impacts and program operation on a quarterly basis to DOE, yet DOE did not specify or restrict data tracking methods that the grantees used to generate the data they uploaded to DOE's database. The variation in grantee data tracking and quality created a number of challenges to our understanding and interpretation of the data. The four main issues that came out of this challenge included:

1. **Quantification of Savings.** In order to calculate the estimated energy savings reported to DOE, grantees use a deemed approach, modeled approach, or a combination of both. The deemed approach involved the use of predetermined energy savings values for measures implemented for each project. The modeled approach involved the use of energy models that are built specifically to the project parameters (that is, building type, sq. ft., energy using systems, weather, etc.) in order to determine an energy savings estimate. However, the inputs that were used in these calculations were often not available to us. Consequently, we often had no insight into the methodology for the calculation of savings and, thus, could not easily identify potential reasons for discrepancies between verified savings and reported savings.

2. **Grantee Reporting.** Grantees had two options for reporting savings to DOE. These two reporting options resulted in DOE receiving very different levels of information. In addition, the level of detail that grantees provided on DOE reporting forms varied substantially. In response, DOE implemented a separate methodology to capture the required information. Section 3.3 provides further explanation.

3. **Project Tracking.** All of the grantees tracked project information differently and maintained varying levels of information regarding project implementation activities. Some maintained only tracking databases with a limited level of information, while others kept detailed project records complete with rebate applications or invoices. Therefore, we faced challenges when verifying measure specific details at some of the project sites.

4. **Billing Data.** As part of the grant specifications, grantees were tasked with the collection of billing data for all completed projects. However, this proved difficult for many of the grantees due to the challenges associated with obtaining utility bills from the utility provider. Thus, only half of all grantees were able to collect utility bills and even fewer had sufficient billing data to support our billing regression analysis to verify savings.

3.12.3. INACCURACIES OF DOE REPORTED METRICS

DOE depended on quarterly reporting from the grantees in order to determine the energy savings, bill savings, and number of implemented projects across all the grantees. However, during the course of both the preliminary and final evaluations, we uncovered reporting issues that resulted in inaccuracies in the reported savings and project totals.

DOE populated its internal database with program level data submitted by the grantees each quarter. DOE used these data to *track* a grantee's program progress. DOE also used the grantee program-level data to populate the "Program Level" database in the DOE Quarterly Summary Reports used by DOE to *report* progress. Grantees also reported individual project data, which was uploaded to a "Project Level" database to track and outline every project and the savings associated with each project. Theoretically, the sum of the project level reporting should equal the program level reporting in terms of project savings and project counts; however, during the evaluation activities, we found that they most often do not equal.

There appeared to be a number of reasons for the discrepancy:

1. **Grantee reporting errors.** There were cases of grantees reporting project details in the wrong fields, projects with missing data, double counting, or projects listed under the wrong sector.
2. **DOE database upload inconsistencies.** DOE uploaded the grantee project data into the Project Level database. However, inconsistencies occurred during the upload process that created differences between what was reported and what was uploaded.
3. **Fuel conversion errors.** Grantees occasionally did not report fuel savings in the units requested by DOE, which led to conversion and reporting errors in the database.
4. **Inconsistencies in reporting of direct install projects.** Many of the grantees offered direct install measures that were implemented at a residence during the course of an energy audit. These measures included water saving devices, pipe wrap, programmable thermostats, etc. Some grantees included participants who only received direct install measures as projects in their reporting, while other grantees did not include them as projects, but did include savings from the direct install measures into the total program level savings.

3.12.4. DELAYED OR LACK OF GRANTEE RESPONSIVENESS

We worked closely with each sampled grantee in order to obtain the project-level data needed to conduct the evaluation. Grantees often were slow to respond to our data requests, and some grantees simply did not respond to our inquiries. We learned quickly that concerns grantees had regarding the privacy of their participants constituted the main reason for their hesitation. After we outlined the numerous procedures, we employed to ensure the confidentiality of the data received, including secure file transfer protocol (FTP) sites and confidentiality agreements, most of the sampled grantees provided us with the requested information.

3.12.5. LIMITED VALUE OF PARTICIPANT PHONE VERIFICATION SURVEYS

The use of phone surveys of program participants in order to verify the installation of measures is a common evaluation practice. As part of the approach for the preliminary evaluation activities, we implemented phone surveys at approximately 300 residences. While the phone surveys were useful in verifying overall project participation and obtaining information on program influence, we found that specific measure details installed as part of the project often could not be obtained through the phone surveys. In many cases, substantial time had passed between project implementation and phone survey. This affected participants' ability to remember details of the measures that they implemented, and even more so, of the baseline condition that existed prior to implementation. Additionally, contacts were often uncertain whether BBNP funded the measures that they implemented, as many had participated in multiple funding programs or implemented measures at different points over the time period. Based on this experience, we did not use phone surveys for the final evaluation and, instead, increased the sample size for onsite visits.

3.12.6. LARGE SCOPE AND BROAD SCALE OF GRANTEE PROGRAMS

Generally, impact evaluations of efficiency programs involve analyzing a specified set of measures across the territory of one utility and developing verified savings based on these known conditions. However, BBNP’s large scope and broad scale of the programmatic offerings created challenges in establishing a consistent methodology for verifying energy savings. There was a wide variety of measures offered by each of the grantees, and the scope of implementation of these measures within each grantee’s region was often unknown before the analysis commenced for the evaluation. Additionally, grantees used varying methodologies/algorithms to calculate the savings associated with the measures in a wide range of climatic conditions in the various grantee regions.

3.12.7. LIMITED BILLING DATA AVAILABLE

The historical billing data used in the billing regressions throughout this report were solely provided at the discretion of the grantees. Data request attempts were met with limited success. As such, only to the extent that the sample of data provided accurately represents the population of all grantee projects, our models’ results correctly estimate energy savings for those grantees providing data.

3.12.8. LACK OF INCREMENTAL MEASURE COST

The measure spending figures reported by the grantees included limited measure information as many fields were marked as optional. Therefore, incremental costs could not be disentangled from total measure costs, which were one of the costs modeled in the economic impact analysis. As total measure costs of efficiency measures are equal to the cost of a standard replacement plus an incremental efficiency cost, the net impacts of measure spending are overstated. For example, an incandescent bulb can be replaced by an equivalent $1 incandescent or an efficient $4 compact fluorescent lamp (CFL) bulb. In either case a replacement is purchased, therefore, in net terms; the efficient scenario should only model the incremental measure cost of $3.

4. FINDINGS

4.1. ENERGY IMPACT ESTIMATES

This section provides our findings for:

1. Gross verified source energy savings,
1. Average site energy savings as a proportion of baseline energy use,
2. Annual bill savings,
3. Net verified source energy savings,
4. Net lifetime source energy savings, and
5. Verified site energy savings by fuel type and sector.

Based on the analysis, BBNP residential, commercial, and multifamily sectors achieved gross verified savings of 3,887,764 source MMBtus with 90% confidence and 3.5% precision of the results (Table 4-1). We calculated realization rates of 70% for the residential sector, 66% for the commercial sector, and 54% for the multifamily sector, and 67% realization overall. The agriculture sector was not included in this analysis due to lack of project activity and available data. Therefore, verified savings were not calculated for this particular sector.

Table 4-1: Reported and Gross Verified Source Savings, through Q3 2013

SECTOR	REPORTED PROJECTS	REPORTED SOURCE SAVINGS (MMBtu)	REALIZATION RATE (PERCENT)	GROSS VERIFIED SOURCE SAVINGS (MMBtu)	RELATIVE PRECISION*
Residential	74,184	2,975,346	70.0%	2,084,120	4.4%
Multifamily	21,178	603,432	53.7%	324,292	6.4%
Commercial	3,546	2,240,970	66.0%	1,479,352	12.4%
Agricultural**	163	32,526	—	—	—
Total	99,071	5,852,275	—	3,887,764	3.5%

* 90% confidence level

** The agricultural sector was not included in the evaluation activities due to a small amount of activity and a lack of data provided by grantees to the evaluation team. Therefore, verified savings totals do not include savings from this sector.

On average, BBNP achieved 15% residential energy savings, 14% multifamily energy savings, and 5% commercial energy savings (Table 4-2).[18]

Table 4-2: Average Site Energy Savings as Proportion of Baseline Energy Use

SECTOR	AVERAGE ENERGY SAVINGS
Residential	15.1%
Multifamily	13.8%
Commercial	4.6%
Total	10.9%

Annual energy bill savings associated with gross verified savings are $40 million for energy savings through Q3 2013 and an additional roughly $11 million for unverified savings in the year four (Table 4-3).[19] We estimated about $669 million in lifetime bill savings associated with gross verified savings through Q3 2013. We estimated these savings by extrapolating from the three-year bill savings[20]; the lifetime estimate is less precise than the annual estimate.

Table 4-3: Annual Bill Savings Associated with Reported and Verified Energy Savings

	ANNUAL BILL SAVINGS ASSOCIATED WITH…	
	…Reported Energy Savings	…Verified Energy Savings
Through Q3 2013	$59.7 million	$40.2 million
Q4 2013 through Q3 2014	$16.6 million	~ $11 million

Table 4-4 below outlines the overall net verified source savings for the residential and commercial sectors. We calculated the net verified source savings by applying the net-to-gross ratios obtained from an analysis of free-ridership- and spillover-related questions in surveys administered to samples of contractors and BBNP participants. Overall, we estimated the BBNP program achieved a net verified energy savings of 3,534,131 source MMBtus with 90% confidence and 4.5% precision of the results.

18 Estimated by applying the estimated sector realization rates to information in an email from D. Hoffmeyer January 27, 2015 that stated 21.61%, 25.56%, and 6.94% reported savings by residential, multifamily, and nonresidential sectors respectively.

19 As we have not verified the year-four energy savings, we derived our reported value of $11 million year-four bill savings by multiplying the reported savings value ($16.6) by the savings realization rate through Q3 2013 (that is, 40.2/59.7 = 67%).

20 We multiplied the three-year bill savings by the ratio of lifetime energy savings divided by three-year energy savings.

Table 4-4: Net Verified Source Savings, through Q3 2013

SECTOR*	GROSS VERIFIED SOURCE SAVINGS (MMBtu)	NET-TO-GROSS RATIO	NET VERIFIED SOURCE SAVINGS (MMBtu)**	RELATIVE PRECISION***
Residential	2,084,120	0.94	1,960,024	6.9%
Multifamily	324,292	0.99	322,749	11.4%
Commercial	1,479,352	0.85	1,251,359	6.4%
Total	3,887,764	—	3,534,131	4.5%

* As the team did not evaluate the agricultural sector, these totals are not included in this table.

** MMBtu calculated using NTG estimate calculated to three significant digits.

*** 90% confidence level

We estimate nearly 57 million MMBtu in net verified lifetime savings (Table 4-5). Note that while residential savings comprise about 55% of total savings (54% of gross and 55% of net), they comprise 64% of lifetime savings, due to longer average measure lives. (We calculated lifetime savings for every project in the sample; the reliability of our program estimate is predicated on the assumption that the measure mix offered by the grantees is fairly consistent.)[21]

Table 4-5: Net Lifetime Source Energy Savings, through Q3 2013

SECTOR*	NET ANNUAL SOURCE SAVINGS (MMBtu)	LIFETIME SAVINGS FACTOR (YEARS)	NET LIFETIME SOURCE SAVINGS (MMBtu)
Residential	1,960,024	18.6	36,456,444
Multifamily	322,749	18.6	6,003,132
Commercial	1,251,359	11.4	14,265,488
Total	3,534,131	—	56,725,063

* As the team did not evaluate the agricultural sector; its savings are not included in this table.

We analyzed site savings by fuel type (Table 4-6). The table omits reported fuel oil and propane savings, as we did not calculate realization rates for these fuels do to reporting and sampling issues.[22]

21 Because lifetime savings were not reported by grantees, we could not calculate a realization rate for the program. Therefore, we calculated the average ratio of verified lifetime to annual savings for each sample project, by sector, and applied it across the population of the residential and commercial sectors to estimate lifetime savings.

22 Fuel type reporting varied significantly for fuel oil and propane with significant underestimation (often zero reported savings) and overestimation of these fuel types resulting in a lack of overall precision. In addition, the sampling strategy did not include stratification by fuel type, and sample sizes of projects selected with fuel oil and propane savings were small.

Table 4-6: Reported and Verified Site Energy Savings by Fuel Type and Sector, through Q3 2013

FUEL TYPE	FUEL UNITS	REPORTED ANNUAL SAVINGS (UNITS BY FUEL TYPE)	REALIZATION RATE (PERCENT)*	GROSS VERIFIED ANNUAL SAVINGS (UNITS BY FUEL TYPE)	NET-TO-GROSS RATIO*	NET VERIFIED ANNUAL SAVINGS (UNITS BY FUEL TYPE)	RELATIVE PRECISION **
Residential Sector							
Electricity	kWh	87,510,900	58.7%	51,376,035	0.94	48,316,911	8.4%
Natural Gas	Therm	13,698,543	74.3%	10,172,606	0.94	9,566,891	8.4%
Commercial Sector							
Electricity	kWh	173,940,718	64.5%	112,167,930	0.85	94,880,945	11.2%
Natural Gas	Therm	2,004,409	66.1%	1,324,910	0.85	1,120,719	25.8%
Multifamily Sector							
Electricity	kWh	20,681,620	69.3%	16,328,515	0.99	16,250,808	28.1%
Natural Gas	Therm	2,498,801	42.5%	1,368,339	0.99	1,361,827	18.3%

* NTG ratios were not calculated by fuel-type and therefore the sector-level NTG ratio was used for this analysis.

** 90% confidence level

4.2. ENVIRONMENTAL IMPACT ESTIMATES

We calculated avoided greenhouse gas emissions in carbon dioxide equivalent (CO_2e), based on the net verified source energy savings (both annual and lifetime; Table 4-16). As with the other lifetime metrics we present, the lifetime savings estimate lacks the analytical rigor of the annual estimate. Note that while residential sector annual savings are about 55% of total savings (as reported previously), they generate about 43% of the annual avoided greenhouse gas emissions, due to the measures comprising the sector savings. The residential measures primarily saved heating energy, specifically relatively less-carbon-emitting natural gas; the commercial measures primarily saved lighting energy – electricity generated by relatively higher-carbon-emitting power plants, including coal-fired plants.

Table 4-7: Net Verified Annual and Lifetime Avoided CO_2e, through Q3 2013

FUEL TYPE	ESTIMATED ANNUAL CO_2E AVOIDED (METRIC TONS)	ESTIMATED LIFETIME CO_2E AVOIDED (METRIC TONS)
Residential	207,721	3,863,613

Multifamily	36,842	685,254
Commercial	234,005	2,667,659
Total	478,568	7,216,526

4.3. ECONOMIC IMPACT ESTIMATES

Using an input-output macroeconomic model, we estimated the gross and net economic activity resulting from the $445.2 million expended by BBNP grantees through Q3 2013 (Table 4-8 and Table 4-9), for which ARRA funds provided 95% of the funding. The gross impacts indicate that the ARRA stimulus funds spent on BBNP contributed about $2 billion dollars and 13,000 jobs (full-time equivalent, FTE) to the economy that would not have occurred in the absence of the ARRA stimulus legislation, with a benefit-cost ratio of 4.7. The net impacts indicate that spending on BBNP specifically, rather than on typical federal spending as described by historical, non-defense outlays, contributed over $1.3 billion dollars and 10,000 jobs to the economy that would not have occurred in the absence of BBNP, with a benefit-cost ratio of 3.0.

Table 4-8: Estimated Gross and Net Economic Activity and Tax Revenues, through Q3 2013

IMPACT MEASURE	GROSS IMPACTS ($ MILLIONS)	NET IMPACTS ($ MILLIONS)	NET/GROSS RATIO
Economic Activity	**$2,097.1**	**$1,345.0**	**64%**
Intermediate Purchases	$947.8	$769.8	81%
Personal Income	$631.5	$230.2	36%
Small Business Income	$141.9	$111.2	78%
Other Property Income	$311.7	$194.7	62%
Other	$64.2	$39.1	61%
Tax Revenues	**$244.5**	**$129.4**	**53%**
State and Local Taxes	$83.8	$48.6	58%
Federal Taxes	$160.7	$80.8	50%

Table 4-9: Estimated Gross and Net Benefit-Cost Ratio and Jobs Impact, through Q3 2013

IMPACT MEASURE	GROSS IMPACTS	NET IMPACTS	NET/GROSS RATIO
Benefit-Cost Ratio	4.71	3.02	59%
Jobs (FTE)	13,331	10,191	76%

4.4. LEVERAGED FUNDS ESTIMATES

Finally, we developed lower and upper bound estimates of grantees' leveraged funds (Table 4-10).

Table 4-10: Leveraged Funds, through Q3 2013

TYPE	REPORTED ($ MILLION)	LOWER-BOUND ESTIMATE ($ MILLION)	UPPER-BOUND ESTIMATE ($ MILLION)
Financial Institution Funds Leveraged	$618	$618	$800
Other Funds Leveraged	$750	$19	$750+
Total	$1,368	$637	$1,550

4.5. M&V ADDITIONAL FINDINGS

This section presents the findings from the M&V analysis conducted on the sample of residential, commercial, and multifamily projects across the grantees. Specifically, we present the realization rates calculated in the final evaluation as well as the preliminary evaluation, followed by the overall combined M&V realizations rates. Table 4-11 and Table 4-12 present the realization rates for final and preliminary evaluations at the sector level, respectively.

Table 4-11: M&V Realization Rate by Sector for Q1 2010 – Q2 2012

SECTOR	REALIZATION RATE (PERCENT)	CONFIDENCE INTERVAL AT 90%
Residential	83%	77%-86%
Multifamily	—	—
Commercial	106%	93%-119%

Table 4-12: M&V Realization Rate by Sector for Q3 2012 - Q3 2013

SECTOR	REALIZATION RATE (PERCENT)	CONFIDENCE INTERVAL AT 90%
Residential	82%	75%-89%
Multifamily	95%	86%-104%
Commercial	83%	76%-90%

We combined the final and preliminary realization rates in order to derive an overall M&V realization rate that is representative of the entire evaluation timeframe. We combined the realization rates using weights derived from the total reported savings within the final and preliminary sample frames. Table 4-13 presents the combined realization rates by sector.

Table 4-13: Combined Preliminary and Final M&V Realization Rates for Verified Source Savings

SECTOR	REALIZATION RATE FOR Q3 2010 - Q2 2012	REALIZATION RATE FOR Q3 2012 - Q3 2013	WEIGHT FOR Q3 2010 - Q2 2012	WEIGHT FOR Q3 2012 - Q3 2013	COMBINED M&V REALIZATION RATE	CONFIDENCE INTERVAL AT 90%
Residential	83%	82%	0.46	0.54	82%	77%-87%
Multifamily	N/A	95%	0.00	1.00	95%	86%-104%
Commercial	106%	83%	0..32	0.68	90%	83%-97%

The following tables provide the combined M&V realization rates for fuel types by sector. We did not report realization rates for the other fuel types (that is, fuel oil, propane, wood), due to the limited number of projects within the sample. In addition, there appeared to be reporting issues from some of the grantees with these other fuel types that created calculation issues (that is, no savings reported for projects that actually achieved savings).

Table 4-14: Residential Combined M&V Realization Rates by Fuel Type

FUEL TYPE	REALIZATION RATE FOR Q3 2012 - Q3 2013	REALIZATION RATE FOR Q4 2010 - Q2 2012*	WEIGHT FOR Q3 2012 - Q3 2013	WEIGHT FOR Q4 2010 - Q2 2012*	COMBINED M&V REALIZATION RATE	CONFIDENCE INTERVAL AT 90%
Electricity	60%	56%	.60	.40	59%	51%-67%
Natural Gas	89%	85%	.49	.51	87%	78%-96%

* A few grantees reported projects completed prior to Q4 2010.

Table 4-15: Commercial Combined M&V Realization Rates by Fuel Type

FUEL TYPE	REALIZATION RATE FOR Q3 2012 - Q3 2013	REALIZATION RATE FOR Q4 2010 - Q2 2012*	WEIGHT FOR Q3 2012 - Q3 2013	WEIGHT FOR Q4 2010 - Q2 2012*	COMBINED M&V REALIZATION RATE	CONFIDENCE INTERVAL AT 90%
Electricity	84%	104%	.68	.32	91%	84%-98%
Natural Gas	60%	89%	.73	.27	68%	47%-89%

* A few grantees reported projects completed prior to Q4 2010.

Table 4-16: Multifamily Combined M&V Realization Rates by Fuel Type

FUEL TYPE	REALIZATION RATE FOR Q3 2012 - Q3 2013	REALIZATION RATE FOR Q4 2010 - Q2 2012*	WEIGHT FOR Q3 2012 - Q3 2013	WEIGHT FOR Q4 2010 - Q2 2012*	COMBINED M&V REALIZATION RATE	CONFIDENCE INTERVAL AT 90%
Electricity	81%	N/A	1.0	0.0	81%	69%-93%
Natural Gas	108%	N/A	1.0	0.0	108%	87%-129%

* A few grantees reported projects completed prior to Q4 2010.

4.5.1. M&V SAMPLE EXTRAPOLATION

We extrapolated the M&V sample results to the population using the sector level realization rates. Following the protocol outlined by the California Evaluation Framework, as described in Section 3 and Appendix B, we calculated case weights and applied the weights to sampled projects by strata. We divided the weighted verified savings by the weighted reported savings to determine the sector realization rate. We applied the realization rate to the sector's population of reported savings to determine the verified gross savings for the sector. An error bound at 90% confidence was calculated to generate the relative precision for the verified gross savings value.

4.5.2. FACTORS CONTRIBUTING TO REALIZATION RATE ESTIMATE

Over the course of the M&V activities, we uncovered projects with significant differences between the reported values and the gross verified findings. The following describes our understanding of the main reasons for some of the largest discrepancies:

1. **No reported savings.** During the preliminary evaluation, we discovered that some grantees did not report savings for their projects despite our verification of project savings. For the final evaluation, we designed the sample to try to reduce the number of projects with zero reported savings; however, the final evaluation sample had approximately 6% of electricity savings reported as zero and 3% of natural gas savings reported as zero. This issue in the reported data effectively increased the observed realization rates for these fuel types.

2. **Measures installed and not reported.** We encountered grantee projects with incomplete measure reporting. This reduced the amount of savings below what the grantee should have credited for these projects. For some projects, the grantee only reported the energy savings associated with one measure, but our review of their documentation and our participant surveys revealed that numerous measures were actually implemented. This in turn increased realization rates.

3. **More measures reported than verified.** Conversely, there also were cases of measures reported as installed, where the M&V activities verified that they were not installed. This often occurred where *recommended* measures from an audit were counted as installed. This over-reporting effectively decreased realization rates.

4. **Overstatement of savings.** In a few cases, we identified issues where the energy savings being reported by the grantee was more energy than was actually consumed by a typical customer. This over-reporting also decreased realization rates. This over-reporting likely was due to energy modeling issues, but because the models could not be calibrated or the inputs verified, it was difficult to know the exact reasons. Additionally, savings may have been overstated due to inaccurate deemed savings applied to project measures.

5. **Heat pump installations.** We encountered projects that resulted in the replacement of a primary heating system, such as a natural gas furnace or resistance heater, with heat pumps. Project documentation usually calculated savings as the displaced energy consumption of the previous system; however, documentation was often lacking regarding the energy consumption of the new heat pump especially for the potential new cooling load provided by the heat pump.

6. **Fuel type reporting issues.** There were cases where grantees reported fuel type savings incorrectly, either by listing the wrong fuel type or listing the wrong units (that is, MMBtu instead of kWh).

4.6. BILLING REGRESSION ANALYSIS FINDINGS

This section presents the results from the billing regression models and the resulting savings estimates for the grantees included in the billing regression analysis. Table 4-19 presents the sector level model results for both the electric and gas models with additional detail provided in B.10.

4.6.1. FINAL MODEL SPECIFICATION RESULTS

In general, our model results were consistent with expectations. Most coefficients had statistically significant estimates and were of expected magnitude. The variable of interest was *Post*, which represented the change in consumption in the post-retrofit installation period and, therefore, was a reflection of energy savings resulting from the program and other factors. As shown in Table 4-17, the point estimate of -76.27 in the residential electric model indicates energy savings of about 76 kWh per month or 8.1% of pre-retrofit monthly electricity consumption holding all other terms constant. The point estimate of -274.36 in the commercial electric model indicates energy savings of around 274 kWh per month or 12.1% of pre-retrofit monthly/annual electricity consumption holding all other terms constant. These models were only free of bias to the extent that billing histories not suitable for the analyses were any different from those included.

Table 4-17: Electricity Billing Regression Model Output

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
(β_1) Post	-76.2730	1.8493	-41.2445	0.00%	(-79.898, -72.648)
(β_2) HDD	0.3288	0.0068	48.5984	0.00%	(0.316, 0.342)
(β_3) CDD	1.7811	0.0130	137.2140	0.00%	(1.756, 1.807)
(β_4) January	58.2920	4.8647	11.9827	0.00%	(48.757, 67.827)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
(β_5) February	-28.8830	4.7329	-6.1026	0.00%	(-38.159, -19.607)
(β_6) March	-65.8100	4.5505	-14.4619	0.00%	(-74.729, -56.891)
(β_7) April	-119.3200	4.7674	-25.0275	0.00%	(-128.664, -109.976)
(β_8) May	-130.5300	5.2786	-24.7291	0.00%	(-140.876, -120.184)
(β_9) June	-112.6100	6.7272	-16.7390	0.00%	(-125.795, -99.425)
(β_{10}) July	-90.8750	8.2524	-11.0119	0.00%	(-107.05, -74.7)
(β_{11}) August	-97.8950	8.5936	-11.3916	0.00%	(-114.738, -81.052)
(β_{12}) September	-132.0000	7.8255	-16.8686	0.00%	(-147.338, -116.662)
(β_{13}) October	-130.0100	6.1036	-21.3013	0.00%	(-141.973, -118.047)
(β_{14}) November	-99.4510	4.9763	-19.9850	0.00%	(-109.205, -89.697)

Continued…

We saw similar results from the gas model. As in the electric model, the variable *Post* reflected the change in consumption in the post-retrofit installation period and, therefore, can be interpreted as an estimate of savings resulting from the program. In this case, the estimate of -8.30 indicated that residential participants saved over 8 therms per month or 12.4% monthly/annually holding all other terms constant. The point estimate of -9.16 in the commercial natural gas model indicates energy savings of around 9 therms per month or 10.3% monthly/annually holding all other terms constant. B.10 provides additional detail on our electric and gas billing models.

Table 4-18: Natural Gas Billing Regression Model Output

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
(β_1) Post	-8.2989	0.1678	-49.4444	0.00%	(-8.628, -7.97)
(β_2) HDD	0.1088	0.0006	177.8291	0.00%	(0.108, 0.11)
(β_3) January	9.3653	0.4242	22.0786	0.00%	(8.534, 10.197)
(β_4) February	3.9816	0.4149	9.5957	0.00%	(3.168, 4.795)
(β_5) March	-3.7755	0.3898	-9.6852	0.00%	(-4.539, -3.011)
(β_6) April	-20.3374	0.4082	-49.8206	0.00%	(-21.138, -19.537)
(β_7) May	-28.3123	0.4452	-63.5943	0.00%	(-29.185, -27.44)
(β_8) June	-27.1407	0.5284	-51.3667	0.00%	(-28.176, -26.105)
(β_9) July	-22.3499	0.5884	-37.9820	0.00%	(-23.503, -21.197)
(β_{10}) August	-21.9704	0.5908	-37.1859	0.00%	(-23.128, -20.812)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
(β_{11}) September	-24.1872	0.5780	-41.8438	0.00%	(-25.32, -23.054)
(β_{12}) October	-26.0158	0.5055	-51.4608	0.00%	(-27.007, -25.025)
(β_{13}) November	-15.4198	0.4363	-35.3435	0.00%	(-16.275, -14.565)

Table 4-19 presents a summary of our model statistics and results for the entire sample of projects with available billing data. On average, we found that BBNP participants had:

- Monthly electricity consumption equal to approximately 939 kWh in residential buildings and 2,266 kWh in commercial buildings
- Monthly gas consumption equal to approximately 67 therms in residential buildings and 89 therms in commercial buildings

The billing regression models found that, on average:

- Participants installing electric measures reduced their consumption by 8.1% in residential buildings and 12.1% in commercial buildings
- Natural gas participants reduced consumption by 12.4% in residential buildings and 10.3% in commercial buildings

While these results were reasonable estimates of savings, they do fall short of the program goal of achieving a minimum of 15% savings. These estimates translated to an average annual electricity savings of 915 kWh in residential buildings and 3,292 kWh in commercial, and average annual natural gas savings of 99.6 therms in residential buildings and 109.9 therms in commercial.

Table 4-19: Electricity and Natural Gas Billing Regression Model Summary

MODEL SUMMARY	ELECTRICITY		NATURAL GAS	
	Residential	Nonresidential	Residential	Nonresidential
Average Monthly Normalized Fuel Usage	938.61	2,266.20	66.74	89.30
Average Post-Retrofit Billing Months	17.0	19.7	17.5	19.9
Average Pre-Retrofit Billing Months	24.5	35.6	30.1	28.6
Adjusted R-Squared Statistic	0.25	0.25	0.74	0.57
Average Monthly Savings (% of usage)	8.13%	12.11%	12.44%	10.25%

See B.10 for a description of the energy savings estimates for each of the 19 grantees in the billing regression analysis sample expressed as a share of consumption for residential buildings, and for the three grantees in the billing regression analysis sample with commercial buildings.

4.6.2. BILLING REGRESSION ANALYSIS REALIZATION RATES

Based on the regression analysis, we estimated realization rates for each sector and fuel type. As discussed above, we used billing data from Q1 2010 through Q3 2013 for the final evaluation. Table 4-20 presents the combined billing regression analysis realization rates by sector in MMBtus. Additional detail on the billing regression analysis realization rates is provided in Table 4-21 through Table 4-23.

Table 4-20: Billing Regression Analysis Realization Rate by Sector for Q1 2010 – Q3 2013

SECTOR	REALIZATION RATE (PERCENT)	CONFIDENCE INTERVAL AT 90%
Residential	52%	48%-56%
Multifamily	21%	19%-23%
Commercial	42%	24%-60%

The billing regression analysis realization rates are defined as the ratio of fuel savings estimated by the billing regression models relative to grantee reported ex-ante savings. Given that the billing regressions consistently yielded savings equal to approximately 10 percent of pre-retrofit fuel consumption, a realization rate of 50 percent, for example, implies that claimed savings (as a percentage) was equal to approximately 20 percent. Therefore, a realization rate lower than 100 percent implies that the ex-ante savings estimated by the grantees are higher than observed savings.

The following tables present the billing regression analysis realizations rates by fuel type for each sector, as well as relative precision for each estimate at the 90 percent confidence level. For example, the residential electricity realization rate of 59 percent with a relative precision of 7.1 percent indicates that the realization rate at the 90 percent confidence interval is 59 percent ± 7.1 percent of 59 percent, that is, ± 4.2 percent.

Table 4-21: Billing Regression Analysis Residential Realization Rate by Fuel Type

FUEL TYPE	REALIZATION RATE (PERCENT)	CONFIDENCE INTERVAL AT 90%
Electricity	59%	55%-63%
Natural Gas	47%	43%-51%

Table 4-22: Billing Regression Analysis Commercial Realization Rate by Fuel Type

FUEL TYPE	REALIZATION RATE (PERCENT)	CONFIDENCE INTERVAL AT 90%
Electricity	21%	12%-30%

Natural Gas	42%	20%-64%

Table 4-23: Billing Regression Analysis Multifamily Realization Rate by Fuel Type

FUEL TYPE	REALIZATION RATE (PERCENT)	CONFIDENCE INTERVAL AT 90%
Electricity	42%	36%-48%
Natural Gas	21%	19%-23%

4.7. ESTIMATING BBNP ENERGY AND OTHER SAVINGS

We leveraged the analyses from the M&V activities and billing regression to calculate the overall energy impacts of the BBNP program. The following sections describe how the M&V and billing analyses were combined and extrapolated to the population as well as how the BBNP NTG ratio was determined and applied in the impact evaluation.

4.7.1. COMBINING THE M&V AND BILLING REGRESSION ANALYSIS FINDINGS

The next step in the analysis was to combine the findings from the M&V and billing analyses and extrapolate the combined findings to the population. As described in Section 3 and B.10, we weighted the individual realization rates from the M&V and billing analyses based on the proportion of reported savings analyzed by the M&V and billing analyses. The tables below present these weighted realization rates and the overall combined realization rate for each sector.

For the residential sector, we incorporated the results of one-third party evaluation into the realization rate analysis. This third party evaluation evaluated programs that were funded by BBNP, and it demonstrated usage of impact evaluation best practices in line with the level of rigor that we used for the BBNP evaluation and closely matched our BBNP impact evaluation timeframe. The weight for the third party evaluation realization rate was calculated in the same approach used to calculate the M&V and billing weights. We were unable to identify third party evaluations that were appropriate to inform the commercial or multifamily sectors.

Table 4-24: Residential Combined Realization Rate

ANALYSIS	REALIZATION RATE	WEIGHT	COMBINED REALIZATION RATE
M&V	82%	.58	70%
Billing	52%	.34	
3rd Party Evaluation	60%	.08	

Table 4-25: Commercial Combined Realization Rate

ANALYSIS	REALIZATION RATE	WEIGHT	COMBINED REALIZATION RATE
M&V	90%	.65	66%
Billing	21%	.35	

Table 4-26: Multifamily Combined Realization Rate

ANALYSIS	REALIZATION RATE	WEIGHT	COMBINED REALIZATION RATE
M&V	81%	.50	54%
Billing	26%	.50	

4.7.2. EXTRAPOLATING TO THE BBNP POPULATION

Table 4-27 below presents how the combined realization rates were applied to the population reported savings in order to extrapolate the gross verified savings for the residential, commercial, and multifamily sectors.

Table 4-27: Reported and Gross Verified Source Savings, Q1 2010 – Q3 2013

SECTOR	REPORTED SOURCE SAVINGS (MMBtu)	COMBINED REALIZATION RATE (PERCENT)	GROSS VERIFIED SOURCE SAVINGS (MMBtu)
Residential	2,975,346	70%	2,084,120
Multifamily	603,432	54%	324,292
Commercial	2,240,970	66%	1,479,352
Total	5,852,275	67%	3,887,764

4.7.3. CONFIDENCE AND PRECISION

We calculated confidence and precision statistics for the sampling error of the M&V and billing regression analysis studies, and they are presented in Table 4-28. See B.10 for a description on how relative precision was calculated.

Table 4-28: Confidence, Precision, and Error Bound by Sector for Gross Verified Savings

SECTOR	CONFIDENCE	RELATIVE PRECISION	ERROR BOUND (MMBtus)
Residential	90%	4.4%	90,143

Multifamily	90%	12.4%	39,619
Commercial	90%	6.4%	95,121
Total	90%	3.5%	136,907

The multifamily analysis likely had a larger relative precision due to the fact that it was only analyzed in the final evaluation and, therefore, we had fewer data points to use in its analysis.

4.7.4. NET-TO-GROSS ANALYSIS FINDINGS

We conducted free-ridership surveys on a sample of participating end users from BBNP programs in an attempt to understand how (and how much) BBNP influenced their participation. Additionally, we conducted surveys with participating and nonparticipating contractors to collect data on free-ridership and spillover for the residential sector. Using this self-report method for free-ridership and spillover estimation, we estimate residential NTG to be 0.94, multifamily to be 0.99, and commercial NTG to be 0.85 (Table 4-29). We applied these net-to-gross ratios to the sector level gross verified savings to determine the sector-level net verified savings.

Table 4-29: Sector Net-To-Gross Estimates

SECTOR	NET-TO-GROSS RATIO	RELATIVE PRECISION
Residential	0.94	6.9%
Multifamily	0.99	11.4%
Commercial	0.85	6.4%

A discussion on spillover calculations is included in B.10.

4.8. ENVIRONMENTAL IMPACT ANALYSIS ADDITIONAL FINDINGS

We calculated avoided greenhouse gas emissions in carbon dioxide equivalent (CO_2e), based on the net verified source energy savings (both annual and lifetime). Table 4-30, Table 4-31, and Table 4-34 present the findings for the residential, commercial, and agricultural sectors for electricity and natural gas. (The net source savings values in the avoided CO_2e tables are referenced from the individual fuel savings for each sector. Each of these calculations uses the sector-level realization rate presented in Table 4-1, in Section 4.1, above. Again, the lifetime savings estimate lacks the analytical rigor of the annual estimate.)

Table 4-30: Residential Sector Net Verified and Lifetime Avoided CO_2e through Q3 2013

FUEL TYPE	ANNUAL NET SOURCE SAVINGS (MMBtu)	CO_2E CONVERSION FACTOR (METRIC TONS/ MMBtu)	ESTIMATED ANNUAL CO_2E AVOIDED (METRIC TONS)	LIFETIME SAVINGS FACTOR	ESTIMATED LIFETIME CO_2E AVOIDED (METRIC TONS)
Electricity	661,908	0.2029	134,319	18.6	2,498,330
Natural Gas	1,298,115	0.0565	73,402	18.6	1,365,283
Total	1,960,024	—	207,721	—	3,863,613

Table 4-31: Commercial Sector Net Verified and Lifetime Avoided CO_2e through Q3 2013

FUEL TYPE	ANNUAL NET SOURCE SAVINGS (MMBtu)	CO_2E CONVERSION FACTOR (METRIC TONS/ MMBtu)	ESTIMATED ANNUAL CO_2E AVOIDED (METRIC TONS)	LIFETIME SAVINGS FACTOR	ESTIMATED LIFETIME CO_2E AVOIDED (METRIC TONS)
Electricity	1,115,216	0.2029	226,307	11.4	2,579,899
Natural Gas	136,143	0.0565	7,698	11.4	87,760
Total	1,251,359	—	234,005	—	2,667,659

Table 4-32: Agricultural Sector Net Verified and Lifetime Avoided CO_2e through Q3 2013

FUEL TYPE	ANNUAL NET SOURCE SAVINGS (MMBtu)	CO_2E CONVERSION FACTOR (METRIC TONS/ MMBtu)	ESTIMATED ANNUAL CO_2E AVOIDED (METRIC TONS)	LIFETIME SAVINGS FACTOR	ESTIMATED LIFETIME CO_2E AVOIDED (METRIC TONS)
Electricity	127,009	0.2029	25,773	18.6	479,385
Natural Gas	195,741	0.0565	11,068	18.6	205,869
Total	322,749	—	36,842	—	685,254

4.9. ECONOMIC IMPACT ANALYSIS ADDITIONAL FINDINGS

This analysis finds that BBNP supported an increased number of jobs, economic output, personal income, and tax revenue from the Q1 2010 to Q3 2013 program period. On a gross basis, BBNP is linked to nearly $2.1 billion in economic activity, including $631.5 million in personal income, 13,333 full-time equivalent jobs, $83.8 million in state and local tax revenues, and $160.7 million in federal tax revenues between Q1 2010 and Q3 2013. In total, on a net basis, BBNP is linked to over $1.3 billion in economic activity, including $230.2 million in personal income, 10,191 full-time equivalent jobs, $48.6 million in state and local tax revenues, and $80.8 million in federal tax revenues between Q1 2010 and Q3 2013. Net impacts reflect economic benefits over and above what would have occurred had BBNP not existed.

4.9.1. GROSS ECONOMIC IMPACTS

The economic impacts approximated for BBNP were based on program outlays and measure spending on efficiency upgrades and energy savings of program participants. Table 4-33 summarizes the main inputs, as they were gathered or calculated from the Quarterly Summary Reports and detailed quarterly spreadsheets submitted by BBNP grantees. Between Q1 2010 and Q3 2013, spending by BBNP grantees or program participants on measures totaled $579.3 million on a net basis (that is, sector-level net-to-gross ratios were applied to total program spending figures). This figure includes BBNP program funding and customer spending on energy efficiency measures not covered by program incentives. In addition, the energy efficiency measures installed by program participants will generate an estimated $41.4 million in net energy bill savings annually.

Table 4-33: Summary of BBNP Spending and Energy Savings Used for Economic Impact Modeling ($ millions)

QUARTER / YEAR	M&O OUTLAYS	OTHER OUTLAYS		AUDIT SPENDING	MEASURE SPENDING	TOTAL SPENDING	ANNUAL NET ENERGY BILL SAVINGS
		Incentives	Program Delivery				
Q1 2010	$2.1	$6.7	$5.4	$3.3	$23.9	$41.4	$2.3
Q1 2011	$4.3	$6.7	$5.5	$3.2	$26.3	$46.0	$1.6
Q2 2011	$6.4	$14.4	$11.7	$3.1	$19.9	$55.5	$1.7
Q3 2011	$6.7	$14.8	$12.0	$4.4	$37.2	$75.1	$2.5
Q4 2011	$6.7	$17.7	$14.3	$5.6	$44.1	$88.4	$2.6
Q1 2012	$12.9	$13.1	$10.7	$8.0	$44.4	$89.1	$3.3
Q2 2012	$6.4	$14.0	$11.3	$5.7	$47.6	$85.0	$3.0
Q3 2012	$5.4	$12.4	$10.0	$5.2	$57.0	$90.0	$3.6
Q4 2012	$5.4	$14.0	$11.3	$5.8	$69.5	$106.0	$5.5
Q1 2013	$3.7	$9.4	$7.6	$7.1	$79.7	$107.5	$5.9
Q2 2013	$5.7	$11.3	$9.1	$7.8	$63.5	$97.4	$4.3
Q3 2013	$5.3	$7.6	$6.2	$5.5	$66.2	$90.8	$5.1
Total All Quarters	$71.0	$142.1	$115.1	$64.7	$579.3	$972.2	$41.4

Source: As reported or calculated using data provided in BBNP Quarterly Summary Reports and detailed quarterly spreadsheets submitted by BBNP grantees.

BBNP spending and energy savings shown in Table 4-33 directly supported sales, income, and jobs in each quarter. Table 4-34 reports the gross direct economic impacts for each quarter (that is, direct impacts without adjustments for counterfactual spending). (Note that while it makes sense to sum the dollar impacts across the quarters, as shown in the table, it does not make sense to sum the job impacts across the quarters, as subsequently discussed.)

Table 4-34: BBNP Gross Direct Economic Impacts, by Quarter[23]

QUARTER / YEAR	OUTPUT ($ MILLIONS)	PERSONAL INCOME ($ MILLIONS)	JOBS (QUARTER-YEAR EQUIVALENT)
Q1 2010	$32.6	$10.1	883
Q1 2011	$36.1	$11.6	965
Q2 2011	$39.0	$15.2	1,143
Q3 2011	$55.8	$20.0	1,543
Q4 2011	$64.6	$23.4	1,783
Q1 2012	$70.2	$24.8	2,067
Q2 2012	$64.2	$21.7	1,719
Q3 2012	$70.4	$22.9	1,829
Q4 2012	$81.8	$25.7	2,131
Q1 2013	$85.2	$25.8	2,151
Q2 2013	$76.1	$24.6	2,057
Q3 2013	$71.4	$22.6	1,943
Total All Quarters	$747.4	$248.4	NA

Source: BBNP Quarterly Summary Report and detailed grantee quarterly spreadsheet information modeled in IMPLAN.

The gross direct impacts reported in Table 4-34 highlight the following:

1. The direct economic activity (output) approximated for BBNP was significant ($747.7 million) but modestly lower than total BBNP spending ($972.2 million), primarily due to imports of energy efficiency equipment.

23 Direct output represents the amount of economic activity resultant to BBNP program spending and participant spending on energy efficiency measures. Jobs reflect the number of grantee staff, subcontractors, and other program contractors employed due to BBNP. Moreover, direct personal income reflects the wages that these same individuals earn.

2. In addition to changes in direct output, BBNP was linked to $248.4 million in direct income for BBNP grantee staff, subcontractors, and others, as well as private contractors providing services on audits and efficiency upgrades.

3. BBNP also supported temporary employment. The direct job impacts reported in Table 4-34 reflects full-time equivalent employment lasting the duration of the quarter. Some of the workers employed by BBNP spending had full time BBNP work; others worked part-time on work supported by BBNP spending. Some workers may be employed in BBNP activities for multiple quarters, perhaps as long as the duration of the program, while other workers may be employed by BBNP spending for a single quarter. The job effects figures reported in Table 4-34 are quarterly direct job impacts and need to be averaged over the year to obtain annual impacts.

Table 4-35 reports the gross economic impacts, by type, associated BBNP spending and energy savings between Q1 2010 and Q3 2013. To be consistent with the secondary job impacts, the table reports direct job impacts for the period in FTEs.

Table 4-35: BBNP Gross Direct Economic Impacts, by Type, through Q3 2013

IMPACT MEASURE	DIRECT	SECONDARY	TOTAL
Output ($ millions)	$747.5	$1,349.6	$2,097.1
Personal Income ($ millions)	$248.5	$383.0	$631.5
Jobs (FTEs)	5,054	8,280	13,333
State and Local Taxes ($ millions)	$15.6	$68.2	$83.8
Federal Taxes ($ millions)	$60.2	$100.5	$160.7

Source: BBNP Quarterly Summary Report and detailed grantee quarterly spreadsheet information modeled in IMPLAN.

In total, on a gross basis, BBNP is linked to nearly $2.1 billion in economic activity, including $631.5 million in personal income, 13,333 jobs, $83.8 million in state and local tax revenues, and $160.7 million in federal tax revenues between Q1 2010 and Q3 2013. These impacts include:

- **Direct** impacts of $747.5 million in economic activity, including $248.5 million in personal income and 5,054 jobs. In addition, this economic activity directly generated $15.6 million in state and local tax and fee revenues, and $60.2 million in federal tax and fee revenues.
- **Secondary** impacts associated with supply-chain and consumption-driven spending linked to BBNP consisting of nearly $1.3 billion in output,[24] including $383 million in personal income and

[24] The Output metric that IMPLAN reports is equal to the sum of intermediate purchases (purchases of products consumed in production) and Value Added. Value Added is equal to gross domestic product (GDP), and can be broken down into 4 subcomponents, which include Employee Compensation (that is, "Personal Income"), Proprietor Income (that is, "Small Business Income"), Other Property Income (OPI), and Indirect Business Taxes.

8,280 jobs. This secondary spending and activity is associated with $68.2 million and $100.5 million in tax and fee revenues for state and local, and federal governments, respectively.

As the preceding discussion indicates, spending associated with BBNP will have secondary impacts that benefit workers and business owners in other non-participating sectors of the economy. All of the impact measures described in Table 4-34 can be summarized across direct and secondary impact categories using mathematical formulae to measure and explain what economists refer to as the "multiplier effect." In essence, economic multipliers provide a shorthand way to better understand the linkages between program and other sectors of the economy (that is, the larger the economic multipliers, the greater the interdependence between a company's operations and the rest of the economy). On a gross basis, BBNP has the following multipliers:[25]

- **Output multiplier is 2.8.** This means that every million dollars in direct output (BBNP purchases captured by U.S. businesses) was linked to another $1.8 million in output for firms in other sectors of the economy. Since both direct and secondary output are counted in an economic impact analysis, this indicates a total output increase of $2.8 million or a total output multiplier of 2.8 (the secondary output multiplier is equal to 1.8).
- **Personal income multiplier is 2.5.** Thus, every million dollars in direct personal income approximated for BBNP was linked to another $1.5 million in personal income elsewhere in the U.S. economy.
- **Job multiplier is 2.6.** This showed that every 10 jobs support another 16 jobs elsewhere in the economy.

Furthermore, the secondary impacts displayed in Table 4-35 were strongly positive and always greater than the direct impact for each impact measure. This is most likely due to a comparatively higher percentage of the intermediate goods and services purchased being produced domestically rather than abroad.

4.9.2. NET ECONOMIC IMPACTS

BBNP was funded primarily through the Recovery Act. The funds used to support BBNP resulted in increased economic activity (collectively known as gross impacts) as program staff were employed to administer the program, participants purchased energy efficient measures, and participants experienced energy savings and lower energy bills. However, the U.S. government could have used this Recovery Act funding to support federal government programs other than BBNP. Thus, we needed to take into account this foregone federal government spending on nondefense programs as the counterfactual scenario. The difference between the gross impacts and the counterfactual scenario are the net impacts. These *net economic impacts* reflect economic benefits owing to BBNP (that is benefits that would not have occurred in the absence of the program), based on our estimate of the program's net-to-gross ratio. The total gross and net impacts estimated for BBNP are reported in Table 4-36.

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[25] This analysis reports Type SAM multipliers. SAM stands for *Social Accounting Matrix*. A Type SAM multiplier is calculated by dividing the sum of direct, indirect, and induced impacts by the direct impacts.

Table 4-36: BBNP Total Economic Impacts, Gross and Net, through Q3 2013 ($ millions)

IMPACT MEASURE	TOTAL GROSS IMPACTS	TOTAL NET IMPACTS	NET/GROSS RATIO
Output	$2,097.1	$1,345.0	64%
Personal Income	$631.5	$230.2	36%
Jobs (FTEs)	13,333	10,191	76%
State and Local Taxes	$83.8	$48.6	58%
Federal Taxes	$160.7	$80.8	50%

Source: BBNP Quarterly Summary Report and detailed grantee quarterly spreadsheet information modeled in IMPLAN.

As shown in Table 4-36, depending on the impact measure, the net impacts were about 40% to 60% less than the gross impacts, but the net impacts were still strongly positive. This was due to BBNP spending and resulting energy savings having a larger multiplier effect than federal government spending on all other nondefense programs (in aggregate).

A further disaggregation of the net economic impacts reported in Table 4-36 is shown in Table 4-37.

Table 4-37: BBNP Net Direct Economic Impacts, Federal Non-Defense Spending Counterfactual, by Type, through Q3 2013

IMPACT MEASURE	DIRECT	SECONDARY	TOTAL
Output ($ millions)	$421.5	$923.5	$1,345.0
Personal Income ($ millions)	($19.2)	$249.4	$230.2
Jobs (FTEs)	3,879	6,312	10,191
State and Local Taxes ($ millions)	$3.6	$45.0	$48.6
Federal Taxes ($ millions)	$9.5	$71.3	$80.8

Source: BBNP Quarterly Summary Report and detailed grantee quarterly spreadsheet information modeled in IMPLAN.

In total, on a net basis, BBNP is linked to over $1.3 billion in economic activity, including $249.4 million in personal income, 10,191 jobs, $48.6 million in state and local tax revenues, and $80.8 million in federal tax revenues between Q1 2010 and Q3 2013. These impacts include:

- **Direct** impacts of $421.5 million in economic activity, including 3,879 jobs. In addition, this economic activity directly generated $3.7 million in state and local tax and fee revenues, and $9.5 million in federal tax and fee revenues.
- **Secondary** impacts associated with supply-chain and consumption-driven spending linked to BBNP consisting of nearly $923.5 million in output, including 6,312 jobs. This secondary spending and activity is associated with $45 million and $71.3 million in tax and fee revenues for state and local, and federal governments, respectively.

As shown in Table 4-37, the secondary net impacts were strongly positive and always greater than the direct impact for each impact measure. This was likely due to the importation of goods not manufactured domestically in the direct impacts and a large federal government spending multiplier effect (in aggregate) in the secondary impacts.

Alternate Base Case Scenario/s

As the ARRA funds used to support BBNP were ultimately financed by tax revenue, the team modeled net impacts with an alternate counterfactual scenario where the moneys used to fund the program were instead re-distributed to taxpayers and spent according to historical spending patterns. Accordingly, the total net impacts estimated for BBNP are reported in Table 4-38.

Table 4-38: BBNP Net Economic Impacts, Taxpayer Rebate Counterfactual, by Type, through Q3 2013

IMPACT MEASURE	DIRECT	SECONDARY	TOTAL
Output ($ millions)	$747.5	$637.6	$1,385.1
Personal Income ($ millions)	$248.5	$149.6	$398.1
Jobs (FTEs)	5,053	4,136	9,189
State and Local Taxes ($ millions)	$12.5	$27.6	$40.1
Federal Taxes ($ millions)	$58.0	$45.8	$103.8

Source: BBNP Quarterly Summary Report and detailed grantee quarterly spreadsheet information modeled in IMPLAN.

Utilizing this alternate counterfactual, the team found that the direct net impacts were universally greater than in the previous model that model where BBNP funds were spent on other federal nonmilitary spending. Conversely, the secondary impacts were unanimously less than those listed in Table 4-37. The differences in economic impacts were largely twofold. First, household income counts as an induced or secondary effect. Second, households import relatively more goods and services on a per dollar basis when compared to federal nonmilitary spending and as such, the economic multipliers associated with spending by the federal government were larger than those associated with households.

Sensitivity Analysis

Input-output models are fundamentally linear in nature. As such, a ten percent change in any input will necessarily result in a ten percent change in all economic impact measures associated with that particular input; however, total economic impacts will change by an amount equal to or less than ten percent depending on the weight of the input relative to all other inputs. Table 4-39 and Table 4-40 note the effect of a ten percent change in each major outlay category and energy savings on each impact measure. A positive sensitivity implies that an increase in the input results in an increase in the overall model. A negative sensitivity implies that an increase in the input results in a decrease in the overall model.

Table 4-39: BBNP Gross Impact Measure Sensitivity to 10% Increase in Inputs/Outlays

IMPACT MEASURE	INPUTS/OUTLAYS					ENERGY SAVINGS
	M&O	Other	Audit	Residential Measure	Commercial Measure	
Output	0.9%	1.7%	0.8%	4.8%	1.7%	0.6%
Personal Income	1.0%	2.2%	1.0%	3.9%	1.7%	0.6%
Jobs	1.0%	1.9%	1.0%	4.1%	1.5%	0.6%
State and Local Taxes	0.8%	1.8%	0.8%	4.8%	1.8%	0.7%
Federal Taxes	0.9%	2.1%	0.9%	4.4%	1.7%	0.5%

Source: BBNP Quarterly Summary Report and detailed grantee quarterly spreadsheet information modeled in IMPLAN.

As net impacts are defined as the sum of gross impacts less counterfactual impacts, a positive sensitivity indicates that the counterfactual has less influence on an impact measure than do the gross impacts (that is, the change in gross impacts is greater than the change in counterfactual impacts). Analogously, a negative sensitivity indicates that the change in the counterfactual is greater than the change in the gross impacts. Though these individual relationships between each input and each impact measure are important to note, the aggregate effect of the inputs should also be considered.

Table 4-40: BBNP Net Impact Measure Sensitivity to 10% Increase in Inputs/Outlays

IMPACT MEASURE	INPUTS/OUTLAYS					ENERGY SAVINGS
	M&O	Other	Audit	Residential Measure	Commercial Measure	
Output	0.4%	-0.7%	1.3%	7.5%	2.7%	0.9%
Personal Income	-0.1%	-4.0%	2.6%	10.6%	4.6%	1.6%
Jobs	0.8%	0.7%	1.3%	5.4%	2.0%	0.8%
State and Local Taxes	0.6%	-0.6%	1.4%	7.8%	2.9%	1.4%
Federal Taxes	0.4%	-1.5%	1.9%	8.4%	3.2%	1.1%

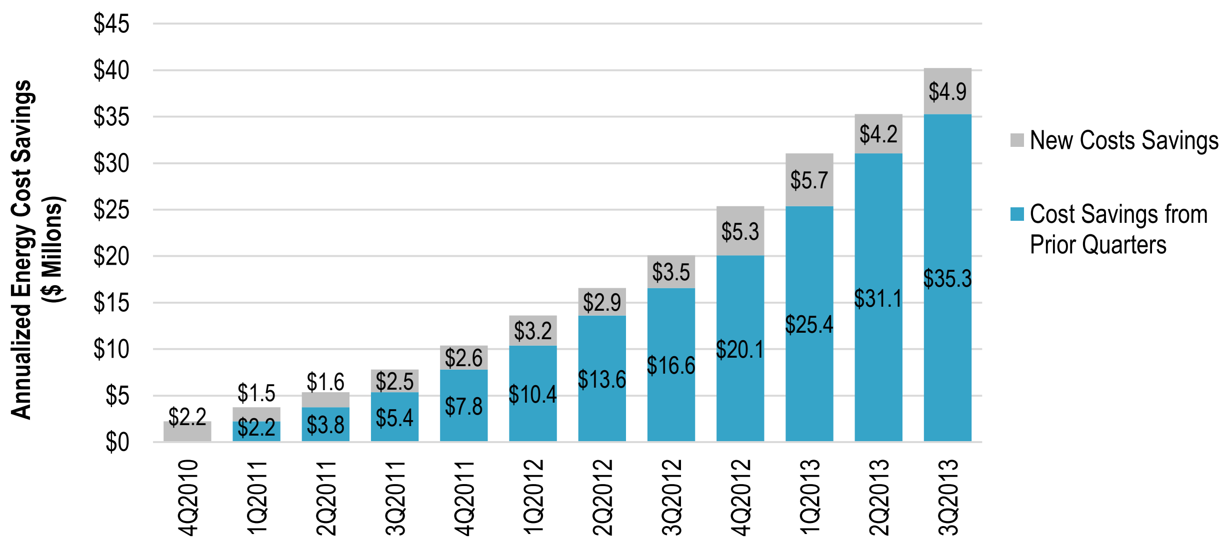
Source: BBNP Quarterly Summary Report and detailed grantee quarterly spreadsheet information modeled in IMPLAN.

4.9.3. NET ECONOMIC IMPACT OF ENERGY BILL SAVINGS IN POST INSTALLATION YEARS

Efficiency upgrades occurred over roughly the same time period that equipment and program costs were incurred.

Figure 4-1 shows the cumulative estimated annualized bill savings, by quarter, for efficiency upgrades completed between Q1 2010 and Q3 2013. These data are based on grantee-reported bill savings estimates, per the BBNIS. By the end of the twelve-quarter time period, it is estimated that efficiency upgrades will lower energy costs by $41.5 million annually.

Figure 4-1: Cumulative Estimated Annualized Energy Bill Savings of Efficiency Upgrades, by Quarter



Source: BBNP Quarterly Summary Reports

As Figure 4-1 illustrates, the energy savings from the installed measures extend into future years as most measures have expected useful lives (EULs) of multiple years. These bill savings continue to benefit the economy as households spend less on electricity and more on other consumer products, and businesses were able to produce goods and services more efficiently. As a consequence, the net effects from a given program quarter or year, when equipment and program spending occurs, only capture a fraction of the overall benefit of these programs

Table 4-41 below shows the net economic impacts associated with the estimated energy bill savings from efficiency measures installed between Q1 2010 and Q3 2013. These estimates were calculated using the input-output model to estimate the economic impacts of reduced energy costs while setting all other costs (that is, equipment purchases and program implementation costs) equal to zero. To isolate the impact of the energy bill savings, also we assumed that there was no loss of utility revenues resulting from the measures installed and that utilities (and others) would be able to sell the unused power (fuel) to other customers. This forms the basis of energy efficiency benefits in future post-installation years based solely on the reduced energy costs to the economy and excludes any additional benefits due to the spending on these programs and measures.[26]

[26] Future net energy savings were not adjusted to account for the EULs of installed measures.

Table 4-41: Net Economic Impacts Due to Annualized Energy Bill Savings Alone ($ millions)

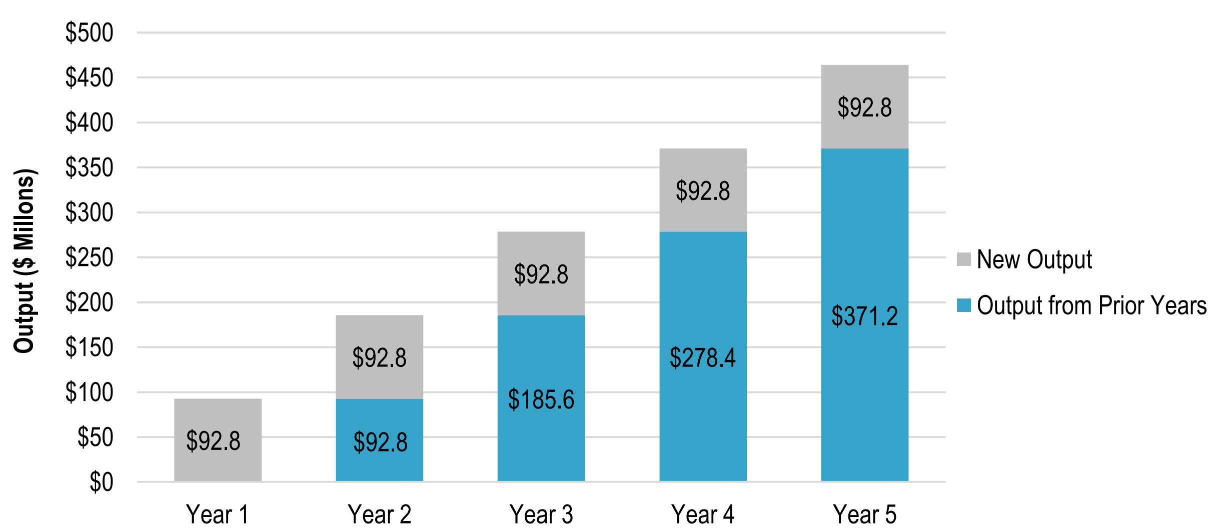
IMPACT MEASURE	ANNUAL NET IMPACTS (MILLIONS)
Output	$92.8
Personal Income	$29.6
Jobs	661
State and Local Taxes	$5.4
Federal Taxes	$7.5

Source: BBNP Quarterly Summary Report and detailed grantee quarterly spreadsheet information modeled in IMPLAN

As shown in Table 4-41, the $40.1 million in estimated annual energy savings associated with efficiency upgrades between Q1 2010 and Q3 2013 is linked to $92.8 million in economic output, including $29.6 million in personal income, and 661 jobs annually. These estimated annual energy savings and net economic impacts form the basis of annual energy savings and economic impacts in future post-installation years. However, both energy savings and net economic impacts will decline in future years depending on the EULs for measures installed between Q1 2010 and Q3 2013.

Figure 4-2 shows the cumulative effect for the economic activity (output) in subsequent post-installation years that results from efficiency upgrades accomplished between Q1 2010 and Q3 2013. In the first year, economic output will increase an additional $92.8 million based on energy bill savings achieved in that year. The energy bill savings will continue in future years and generate additional economic impacts. By the end of the fifth year, output will have increased by $464 million due to the efficiency upgrades accomplished between Q1 2010 and Q3 2013.

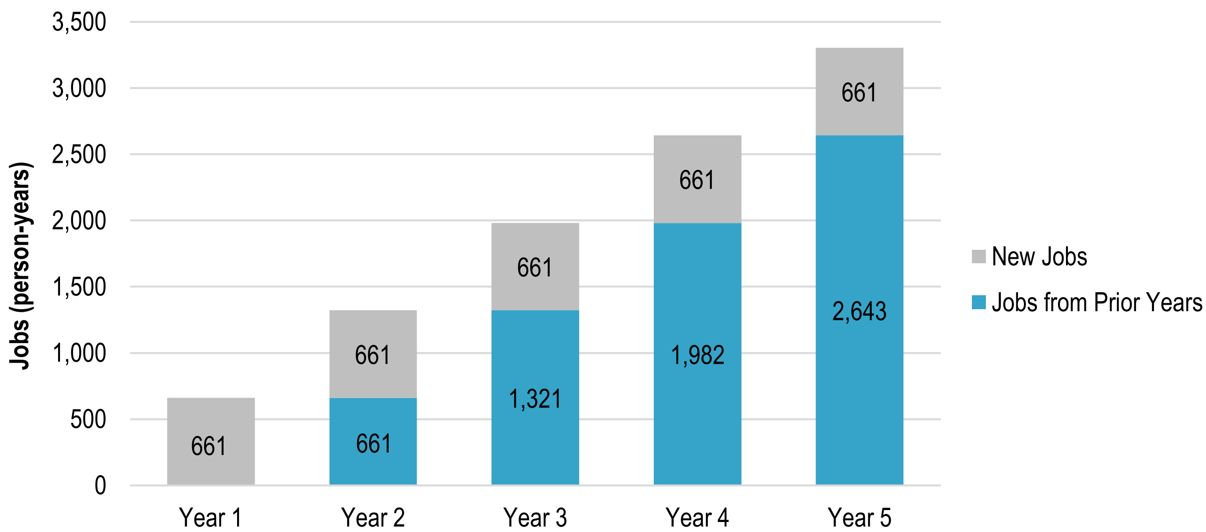
Figure 4-2: Cumulative Output Effects in Post-Installation Years (Five-Year Period)



Source: Evergreen Economics using BBNP data and IMPLAN.

If energy bill savings can be sustained over time, then the employment impacts should persist as well, at least in the short term. The energy savings associated with BBNP efficiency upgrades between Q1 2010 and Q3 2013, will have sustained 3,304 jobs over the following five-year period.

Figure 4-3: Cumulative Job Effects in Post-Installation Years (Five-Year Period)



Source: Evergreen Economics using BBNP data and IMPLAN.

This analysis finds that BBNP supported an increased number of jobs, economic output, personal income, and tax revenue during the evaluation period, Q1 2010 to Q3 2013; we expect additional economic impacts to occur in the post-installation period.

Table 4-42: BBNP Total Economic Impacts, Program and Future Year ($ millions)

IMPACT MEASURE	PROGRAM PERIOD NET IMPACTS (Q1 2010 – Q3 2013)*	FUTURE YEAR NET IMPACTS (Q4 2013 – Q3 2018)
Output	$1,345.0	$464.0
Personal Income	$230.2	$147.8
Jobs	10,191	3,303
State and Local Taxes	$48.6	$26.8
Federal Taxes	$80.8	$37.7

* From Table 4-37.

Source: BBNP Quarterly Summary Report and detailed grantee quarterly spreadsheet information modeled in IMPLAN

4.9.4. BENEFIT-COST RATIO

We compared the economic benefits of the program to program costs through Q3 2013. Total economic benefits are defined as the sum of net economic output and tax revenues. As is noted in Table 4-43, our analysis found that BBNP had a net benefit-cost ratio of 3.31 (that is, for every program dollar spent, 3.31 dollars were generated in economic benefits).

Table 4-43: Benefit-Cost Ratio, through Q3 2013

PROGRAM EXPENDITURES ($ MILLIONS)	GROSS ECONOMIC BENEFITS ($ MILLIONS)	GROSS BENEFIT-COST RATIO	NET ECONOMIC BENEFITS ($ MILLIONS)	NET BENEFIT-COST RATIO
$445.2	$2,097.1	4.71	$1,345.0	3.02

4.10. LEVERAGED RESOURCES

In the BBNP FOA, DOE articulated a relatively broad definition of leveraging that included “building owner contributions, partner contributions, in-kind contributions, project revenues, other federal funds (including other DOE funds), and state funds” (DOE, 2009). Drawing from each of these sources, grantees differed in the elements they included in their reporting of leveraged funds.[27] In this section, we distinguish between funds from financial institutions and other leveraged funds reported by grantees as we assess the degree to which grantees leveraged funds exclusive of other federal funds.

4.10.1. FINANCIAL INSTITUTION FUNDS

In this subsection, we assess the degree to which grantees leveraged the funds of their financial partners.

Grantees leveraged loan capital from their financial partners when they established loan loss reserves and interest rate buy-downs to increase the amount of attractive loan capital available from financial partners. According to grantee reporting, grantees allocated a total of $74.6 million to loan loss reserves and $10.4 million to interest rate buy-downs.[28]

27 The Quarterly Program Report form grantees submitted to DOE asked them to, “Please enter the total amount of other Federal leveraged funds expended by your program during the most recent quarter. Other federal funds may include funds from EECBG and SEP, loans from U.S. Department of Housing and Urban Development (HUD), etc.” and “Please enter the total estimated amount of non-federal funds expended during the most recent quarter. This includes third-party, in-kind contributions, and the portion of the costs of a federally assisted project or program not borne by the federal government.”

28 See Table 8-2 in *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4).

Table 4-44: Types of Financing Support Grantees Provided

TYPE OF FINANCING SUPPORT	SECTOR	NUMBER OF GRANTEES PROVIDING	TOTAL SPENDING
Loan Loss Reserve	Commercial (n = 19)	13	$36,704,152
	Residential (n = 30)	17	$30,154,770
	Multi-sector	3	$7,790,688
	Total (n = 36)	**27**	**$74,649,610**
Revolving Loan Fund	Commercial (n = 19)	13	$39,180,788
	Residential (n = 30)	16	$28,554,673
	Total (n = 36)	**22**	**$67,735,461**
Interest Rate Buy Down	**Total (n = 36)**	**15***	**$10,399,460**

* Reported data did not differentiate interest rate buy down spending by sector.

Source: *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4), Table 8-2.

Grantees further reported they leveraged financial loan funds of about $618 million. Our interviews with contacts at partnering financial institutions corroborate this figure as a lower-bound estimate of leveraged financial institution funds.[29]

We found a number of occurrences of missing data in the grantees' reports of leverage financial resources (that is, missing data for grantees also reporting they had established loan loss reserves and interest rate buy-downs). Thus, we conducted the following analysis to estimate an upper-bound estimate of leveraged financial institution funds.

Grantees using loan loss reserves most often placed 5% or 10% of each loan in reserve, making between 10 and 20 times the value of the grantee's contribution available for program lending.[30] A loan loss reserve likely leveraged approximately five times the grantee's contribution in loan capital.[31] Assuming grantees leveraged ten times their spending on loan loss reserves and five times their spending on

29 Chapter 8 of Volume 4 presents the findings of these interviews. The interview data provide support for the reported amounts; the interview data are insufficient to confirm or verify the amounts.

30 Each $1 placed in a reserve fund with a coverage ratio of 5%, would support $20 of lending; each $1 placed in a reserve fund of 10% would support $10 of lending. Concepts adapted from Zimring 2014. Data on amounts grantees placed in loan loss reserves from grantee interviews.

31 For example, the difference in interest a financial institution would receive on a 10-year, $10,000 loan at 2% interest as opposed to 7% interest is approximately $2,900. Grantees may not have compensated financial institutions for this full value to account for the benefit to the financial institution of receiving the interest income as a lump sum.

interest rate buy-downs, grantees leveraged up to approximately $800 million in lending capacity.[32] This is an upper-bound estimate, since some grantees used both loan loss reserves and interest rate buy-downs on the same pools of loan capital.

4.10.2. OTHER LEVERAGED FUNDS

In this subsection, we assess the degree to which grantees leveraged funds from other sources (federal and non-federal exclusive of financial institution partners).

Table 4-46 summarizes all the leveraged funds – both federal and non-federal – that grantees reported to DOE, as recorded in the BBNIS. Over the grant period, grantees reported spending more than $98 million in federal funds excluding their BBNP grants, as well as $655 million in non-federal funds (shown subsequently in Table 4-46), for a total of about $753 million.[33]

Table 4-45: Reported Leveraged Funds (Federal and Non-federal)

TOTAL	AVERAGE	TOTAL
Total	$28,370,016	$753,170,655
Small Award Grantees ($5M or less)	$3,352,071	$67,041,415
Medium Award Grantees (more than $5M to less than $20M)	$20,425,073	$265,525,952
Large Award Grantees ($20M or more)	$52,575,411	$420,603,287

Source: Research Into Action, analysis of BBNIS data.

We did not explore with grantees who provided these reported total funds and how the funds were used. However, we explored these questions for a subset of the reported funds that appeared to satisfy Wolf's definition of leveraging.[34] Our estimates on non-federal leveraged funds from this research therefore represent a lower bound of other leveraged funds.

As described in Section 3.6.4, we interviewed the 15 grantees reporting the largest quantities of *non-federal* leveraged funds – $546 million in total – an amount equal to 83% of the $655 million in leveraged funds reported by all grantees. Table 4-45 provides the non-federal leveraged funds *reported* by the interviewed grantees ($546 million) and the spending of leveraged funds we estimated for these 15 grantees using the Wolf method - $16 million. For nearly half (7 of 16) of the interviewed grantees, we could not identify any funds that met Wolf's leverage definition.[35] The table extrapolates from the

32 DOE did not request grantees to report funds leveraged from financial institutions, thus we estimated the amount of leveraged funds using the approach described.

33 The data describe program expenditures by any party – the grantee or its partners.

34 See Appendix B-11.

35 Since this assessment began, EERE has initiated a project with the aim of operationalizing a calculation tool for the consistent estimation of leveraged resources across EERE programs. Originally intended to follow the strict definition postulated by Wolf, early implementation activities, involving in-depth interviews with additional stakeholders (including the authors of this report)

interview findings to all grantees, estimating leveraged funds meeting the Wolf definition to be $19 million. These Wolf-defined estimated values for leveraged funds represent a conservative lower bound.

Table 4-46: Non-Federal Leveraged Funds Reported and Those Meeting Wolf's More Conservative Definition

METRIC	INTERVIEWED GRANTEES (N=15)	ALL GRANTEES (N=41)
Total Reported Spending of Non-federal Leveraged Funds	$546 million	$655 million
Percent of All Reported Spending of Non-federal Leveraged Funds	83%	100%
Spending of Leveraged Funds that Met Wolf's Definition	$16 million	$19 million*

Source: Extract of DOE's BBNIS data through Quarter 1 2013.

* Estimate based on proportion of spending reported by interviewed grantees.

The largest portion of the funds meeting Wolf's leverage definition came from new funding that had become available from local governments to support the grantees' efforts (Table 4-47). One grantee in particular reported receiving more than $7 million in a new allocation of Regional Greenhouse Gas Initiative funding as a result of the program's success. Capital raised by grantees from third-party investors (other than financial institution partners) to support loan programs they operated directly as revolving loan funds also contributed a notable portion of the funds that met Wolf's definition of leveraging.[36] Staff time spent working on BBNP-funded programs that was not compensated by the BBNP grant was one of the most frequently mentioned sources of leveraging (5 of 15 grantees), but these grantees were not able to quantify its value.

Table 4-47: Sources of Leveraged Funds Meeting Wolf's Definition

SOURCE OF LEVERAGED FUNDS	LEVERAGED FUNDING AMOUNT	PROPORTION OF ALL LEVERAGED FUNDS
New local government funds	$7,429,000	46%
Loan capital supporting revolving loan funds directly managed by BBNP grantee program	$6,127,492	38%
New utility incentives	$1,164,000	7%

have led to a revision of the Wolf definition. The revised definition of leveraged funds came too late to inform the approach used in this report, which hewed to the stricter definition of Wolf.

36 Loan capital provided by a grantee's financial institution partner does not qualify as leveraging under Wolf's definition because these loans are an output of grantees' financial institution recruiting and management activities, rather than activities of the program itself. However, third party capital that grantees lend directly contributes to the program activity of making loans and thus qualifies under Wolf's definition.

Partner staff time	$860,000	5%
Outside grants	$565,000	3%
Total	$16,145,492	100%

Interview findings suggest that the non-federal leveraged funds grantees reported that did not meet Wolf's definition primarily corresponded with the following: [37]

- Existing utility incentives
- Upgrade costs paid by participants
- Loan capital provided by financial partners
- Existing local government funds

4.10.3. SUMMARY

Based on the analysis described in the preceding section, we developed lower and upper bound estimates of grantees' leveraged funds, as shown in Table 4-48. Grantee-reported leveraged funds of $1,368 million lie within the estimated bounds, which range from $637 million to $1,550 million.

Table 4-48: Leveraged Funds, through Q3 2013

TYPE	REPORTED ($ MILLION)	LOWER-BOUND ESTIMATE ($ MILLION)	UPPER-BOUND ESTIMATE ($ MILLION)
Financial Institution Funds Leveraged	$618	$618	$800
Other Funds Leveraged	$750	$19	$750+
Total	$1,368	$637	$1,550

37 Rather than asking grantees to account for all of the non-federal leveraged funds they reported, we described the key components of Wolf's leveraging definition and asked grantees to identify any leveraged funds that might qualify. Our interview then probed to ensure that each identified source met Wolf's definition. Data on non-qualifying funds grantees reported as leveraged are based on information grantees volunteered in open-ended responses and were not collected systematically. Thus, our ability to draw conclusions from these data is limited.

5. LESSONS LEARNED, CONCLUSIONS, AND RECOMMENDATIONS

The chapter provides the lessons learned as part of the preliminary and final evaluation activities, our conclusions, and our recommendations for improving future design, implementation, and evaluations of similar programs.

5.1. LESSONS LEARNED

We believe the final impact evaluation was an overall success, and many lessons were learned along the way. As discussed, we faced multiple challenges during both the planning and implementation of the impact evaluation. While navigating these challenges, we identified lessons learned that will help shape the future of similar program evaluations. We offer the following lessons, organized as lessons learned during interactions with grantees, learned during sampling execution, and learned during the overall evaluation activities.

5.1.1. GRANTEE INTERACTION

We had multiple and varied interactions with each grantee, including interviews, data requests, and discussions to augment our understanding of their program offerings and structure. We draw several lessons from these interactions.

- **Allow sufficient time to request and gather data from the Grantees.** We made data requests to almost 30 grantees for the preliminary evaluation. This process to submit requests and receive data required four months to complete. This timeframe was reduced during the final evaluation process, as grantees understood our needs and the format of the data required. Regardless, future evaluations should understand that grantees are busy and, unlike most utility companies, they are not equipped with the tools and databases to easily extract participant and project-level information. It is necessary to give them sufficient time to gather requested data.
- **Give clear and concise data requests.** Grantees are busy and frequently understaffed. In addition, many of these grantees have little experience with evaluations. Making clear and concise data requests that include specific information required by the team for analysis (including invoices, audit reports, project applications, etc.) help to speed up the response time and alleviate any concerns or questions that they may have regarding data needs.
- **Know when to stop asking.** When requesting data from multiple grantees, many of whom are not already experienced in the area of program evaluation, it is necessary to be patient yet persuasive regarding the importance of the data requests. It also is necessary to know when to stop asking for more data and move forward with what has been provided.

5.1.2. SAMPLING

The sampling strategy contributes substantially to the accuracy and usefulness of the impact evaluation results. The following lessons summarize our experience.

- **Use proper sampling techniques.** When seeking to examine savings across multiple and diverse programs such as those offered through BBNP, the team needed to examine the effectiveness of the sampling and the level of rigor employed on the sample. Budget and time constraints put limits on the ability to sample at a high level of rigor across all the grantees. The team designed the sampling strategy with the knowledge that the programs were very diverse and that the reporting procedures were varied and not always consistent. Therefore, the sampling parameters that were used to determine the sample sizes took this known uncertainty and potential range of error into account.

- **Be flexible.** The initial sampling strategy was informed by preliminary grantee interviews and the review of available data at a certain point in time. After the team fully analyzed the data that were provided by the grantees, changes were made in the sampling design and approach. Additionally, grantees provided periodic project updates which adjusted savings and project counts throughout the evaluation activities. The team had to analyze these adjustments to determine the impact on the validity of the sample.

5.1.3. EVALUATION ACTIVITIES

We utilized several levels of rigor when determining gross verified savings. We typically followed standard practices as seen in most utility-funded evaluation activities, but found that approaches that may work for a utility-funded program may not necessarily be as successful for a program with the large scale, scope, and diversity of BBNP.

- **Phone verifications had limited value.** Phone verifications are standard practice in many utility-funded impact evaluations. While the phone surveys were useful in verifying overall project participation and obtaining information on program influence, we determined during the preliminary evaluation that the phone verifications used for M&V often provided limited value. The majority of participants interviewed had difficulty remembering the specifics surrounding completed upgrades, and gathering key data on measures implemented. This was likely due to the long timespan (averaging one to two years) between measure installation and phone verifications. There also was confusion among participants regarding the measure funding source (BBNP or local utility program).
- **Onsite verifications were valuable.** While the phone surveys proved challenging, the onsite surveys were valuable in obtaining a greater level of detail regarding project implementation than could be obtained during phone verifications. We do note that onsite verification also has limitations such as the inability to confirm baseline equipment or restricted access to upgraded measures (for example, insulation). However, for the purposes of the BBNP evaluation, we found the onsite data to be more reliable and useful than the phone survey data.
- **Reasons for variances in the data were multifaceted.** There was no one reason for the discrepancies between the reporting databases used by the grantees and DOE. Both parties were faced with multiple challenges while attempting to develop accurate reports of program progress. We interacted frequently with DOE and the grantees to understand the underlying issues effecting the data.

5.1.4. REPORTING INFRASTRUCTURE

DOE funded BBNP with the objective of creating jobs, saving energy, and setting the foundation for future similar programs. It is difficult for a program of this breadth and depth to create a centralized, consistent, and easy-to-use system for individual program tracking and reporting. However, one key lesson learned as a result of this evaluation is the importance of the design and enforcement of proper reporting processes. The design of proper reporting processes and concise yet all-inclusive data capturing procedures is crucial to the success of any program of this scale and magnitude. In addition, this lesson can be carried into energy efficiency program design, both for utility-funded structures and for nonutility structures, such as those that exist in BBNP. Designing a reporting structure that captures the basic data effectively and accurately is essential to a successful program both in the near term and the long term. Clear reporting procedures lead to a better understanding of the program effects both in the context of energy savings and the proper use of resources. This, in turn, helps lead to better program design in the future and greater program success. Additionally, some level of enforcement regarding the proper reporting would encourage accountability.

5.2. CONCLUSIONS

5.2.1. GOAL AND OBJECTIVE ATTAINMENT

By the end of the three-year evaluation period (Q4 2010 to Q3 2013), BBNP had met the three ARRA goals, as shown in Table 5-1. The table presents, among other findings, our findings of net jobs, net economic activity, and net benefit-cost ratio. For the economic metrics, the term “net” signifies BBNP’s contribution to these outcomes above and beyond the outcomes that would have occurred had the BBNP funding been spent according to historical non-defense federal spending patterns.

Table 5-1: Attainment of ARRA Goals, through Q3 2013

GOALS	METRICS	RESULTS	ATTAINED?
Create new jobs and save existing ones	Number of jobs created and retained	The evaluation estimated 10,191 net jobs resulted from BBNP during the 3-year evaluation period.	Yes
Spur economic activity and invest in long-term growth	Dollars of economic activity; benefit-cost ratio	BBNP spending of $445.2 million in 3 years generated more than: • $1.3 billion in net economic activity (personal income, small business income, other proprietary income, intermediate purchases) • $129.4 million in net federal, state, and local tax revenues Estimated net benefit-cost ratio: 3.0.	Yes
Provide accountability and transparency in spending BBNP funds	Evidence of accountability and transparency	Grantees receiving ARRA funding submitted ARRA expenditure reports. Grant expenditure information was available to the public on *Recovery.gov.* BBNP DOE staff developed and maintained a program tracking database for periodic grantee reporting. Staff worked with grantees to increase the quantity and quality of reported data. Grantees had access to summary data. Evaluator-verified results will be publicly available.	Yes

By the end of the three-year evaluation period, BBNP met two of the five impact-related BBNP objectives (Table 5-2). Unverified program-reported accomplishments for Q4 2013 through Q3 2014 suggest the program likely was successful in meeting four of the five objectives by the end of the four-year program period. These findings indicate that BBNP met its objectives to spur energy efficiency upgrade activity, achieve energy savings, and create or maintain jobs.

Table 5-2: Attainment of BBNP Objectives

OBJECTIVES	METRICS	RESULTS	ATTAINED? 3-Year Verified	ATTAINED? 4-Year Unverified*
Upgrade more than 100,000 residential and commercial buildings to be more energy efficient	Number of upgrades	The evaluation verified the grantee-reported 99,071 upgrades for the 3-year evaluation. Grantees reported: • Unverified - 119,404 upgrades for the 4-year program period.	No 99%	Likely
Save consumers $65 million annually on their energy bills	Energy bill savings ($)	Verified energy savings for the 3-year evaluation period provide over $40 million in annual bill savings. Close to $700 million lifetime energy bill savings expected (estimated at fuel prices during the program period). Grantees reported: • $60 million in estimated annual bill savings during the 3-year evaluation period • $76 million in estimated annual bill savings through the 4-year program period	No 62%	Unlikely ~ 78% (based on 3-year evaluation findings)
Achieve 15% to 30% estimated energy savings from residential energy efficiency upgrades	Average energy upgrade savings (%)	Verified single-family residential savings: 15.1%. Grantees reported 22% estimated energy savings in single-family residential upgrades.	Yes	Yes
Create or retain 10,000 to 30,000 jobs	Net number of jobs	The evaluation estimated 10,191 net jobs resulting from BBNP during the 3-year evaluation period.	Yes	Yes
Leverage $1 to $3 billion in additional resources	Dollars leveraged	Evaluation interviews with financial institutions corroborated grantee-reported leveraged loan funds of at least $618 million. Grantees reported leveraged funds from other sources of about $750 million, for an estimated total leveraged funds of about $1.4 billion.	Inconclusive**	Likely

* Our evaluation did not verify fourth-year program achievements. We concluded that objectives that were met by Q3 2013 also were met by the end of Q3 2014. An assessment of "likely" indicates that the unverified data show a trend suggestive of achievement.

** The evaluation addressed financial leverage amounts only; it did not address other grantee-reported leveraged funds. See *Leveraged Resources* for more information.

5.2.2. IMPACT ASSESSMENT LESSONS LEARNED

The main objective of this impact evaluation was to determine the impacts of $508 million in BBNP spending that allocated resources to varied energy efficiency programs across the country. The challenges associated with this task, such as difficulty in acquiring grantee data, lack of quality control/assurance leading to inaccuracies of reported metrics, and the large scale and broad scope of grantee programs, affected the team's evaluation activities. While navigating these challenges, we learned many lessons that will help shape the future of similar program evaluations. Key among these lessons are:

- **Allow sufficient time to request and gather data from the grantees.** Grantees are busy, and unlike most utility-funded efficiency program managers, they are not equipped with the tools and databases to easily extract participant and project level information. In addition, grantees are frequently understaffed, so making clear and concise data requests are necessary to help speed up the response time and alleviate any concerns or questions that they may have regarding data needs.
- **Phone verifications had limited value.** Phone verifications are standard practice in many utility-funded impact evaluations. While the phone surveys were useful in verifying overall project participation and obtaining information on program influence, we determined during the preliminary evaluation that the phone verifications used for M&V often provided limited value. The majority of participants interviewed had difficulty remembering the specifics surrounding completed upgrades, and gathering key data on measures implemented. This is likely due to the long timespan (averaging one to two years) between measure installation and phone verifications. There also was confusion among participants regarding the measure funding source (BBNP or local utility program).
- **Onsite verifications were valuable.** While onsite surveys encounter some of the same issues with reliability as the phone surveys, the onsite surveys were valuable in obtaining a greater level of detail regarding project implementation than could be obtained during phone verifications and file review.

5.3. RECOMMENDATIONS

The grant cycle for BBNP has ended, and it is unclear whether or not, in the foreseeable future, DOE will fund a program on a scale similar to BBNP. Were DOE or another agency to fund a program like BBNP, we offer the following recommendations to foster greater consistency in program expectations, design, tracking, and reporting:

- **Plan and develop a comprehensive and easy to use data tracking and reporting system available to grantees at time of funding award.** Due to the size of the funding pool and the speed at which it needed to be issued, there was a limited focus on program evaluation and reporting needs when BBNP was designed and launched. The resulting tracking and reporting processes were cumbersome, inconsistent, and frustrating for both grantees and DOE. It is critical that for any future programs, consideration be given to the data tracking and reporting needs for both a successful and streamlined program, but also for the needs of data verification and program evaluation.

- **Require grantees to ensure the consistency of project-level tracking values with overall report totals.** One of the main reasons the Project Level data did not match the Program Level data was that there was no process where grantees matched the individual savings totals from each project to the total savings achieved for the reporting period. This inherently created an opportunity for discrepancies.
- **Require consistent documentation procedures across all grantees and programs.** Grantees had varying information on projects implemented through their programs. Future program design should outline documentation procedures and needs for measure-level, project-level, and program-level reporting.
- **Require accountability for quality control practices across programs and provide support to grantees that may demonstrate insufficient quality assurance/ quality control.** We found a lack of data regarding the reported measures installed at project sites. This is a complex issue and relies on accurate and comprehensive grantee data collection and reporting. In the interest of understanding measure-specific implementation data, there should be more scrutiny on this level of information received.
- **Consider a requirement of timely and accurate reports as a condition of funding payments.** While most grantees have complied with stipulations regarding reporting, it appeared that some grantees did not take the time to accurately report their savings. For future programs, DOE could assess whether they should consider a potential model for paying out funding over time as grantees meet certain reporting requirements.
- **Compile a single final dataset to be used for reporting and evaluation purposes to ensure consistency of results across reporting activities.** The program manager should assure data quality by the conclusion of the evaluation period and a single final dataset issued to the evaluation team to avoid evaluation inefficiencies.

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APPENDICES

APPENDIX A. GRANTEE AWARDS

Table A-1 provides a list of grantees sorted alphabetically. Table A-2 identifies the grantees in decreasing order of grant award.

Table A-1: BBNP Grant Recipients

GRANTEE NAME	TOTAL GRANTED
ADECA, AL (SEP)	$3,013,751
Austin, TX	$10,000,000
Boulder County, CO	$25,000,000
Camden, NJ	$5,000,000
Chicago Metro Agency for Planning	$25,000,000
Commonwealth of MA (SEP)	$2,587,976
Connecticut Innovations, Inc.	$4,171,214
CSG, Bainbridge Island, WA	$4,884,614
Eagle County, CO	$4,916,126
Fayette County, PA	$4,100,018
Greater Cincinnati Energy Alliance	$17,000,000
Greensboro, NC	$5,000,000
Indianapolis, IN	$10,000,000
Kansas City, MO	$20,000,000
Los Angeles County, CA	$30,000,000
Lowell, MA	$5,000,000
New York State Energy Research and Development Authority (NYSERDA)	$40,000,000
Omaha, NE	$10,000,000
Philadelphia, PA	$25,000,000
Phoenix, AZ	$25,000,000
Portland, OR	$20,000,000
Rutland, VT	$4,487,588
San Antonio, TX	$10,000,000
Santa Barbara County, CA	$2,401,309

Continued…

GRANTEE NAME	TOTAL GRANTED
Seattle, WA	$20,000,000
Southeast Energy Efficiency Alliance (SEEA)	$20,000,000
St. Lucie County, FL	$2,941,500
State of Maine	$30,000,000
State of Maine (SEP)	$4,538,571
State of Maryland	$20,000,000
State of Michigan	$30,000,000
State of Michigan (SEP)	$4,994,245
State of Missouri	$5,000,000
State of Nevada (SEP)	$5,000,000
State of New Hampshire	$10,000,000
Toledo-Lucas Co. Port Authority (OH)	$15,000,000
Town of Bedford, NY	$1,267,874
Town of University Park, MD	$1,425,000
VDMME, VA (SEP)	$2,886,500
WDC, WA (SEP)	$2,587,500
Wisconsin Energy Efficiency Project	$20,000,000
Total	$508,203,786

Table A-2: BBNP Recipient Grant Recipients in Decreasing Order of Grant Amounts

GRANTEE NAME	TOTAL GRANTED
NYSERDA	$40,000,000
Los Angeles County, CA	$30,000,000
State of Maine	$30,000,000
State of Michigan	$30,000,000
Boulder County, CO	$25,000,000
Chicago Metro Agency for Planning	$25,000,000
Philadelphia, PA	$25,000,000
Phoenix, AZ	$25,000,000

Continued…

GRANTEE NAME	TOTAL GRANTED
Kansas City, MO	$20,000,000
State of Maryland	$20,000,000
Portland, OR	$20,000,000
Seattle, WA	$20,000,000
Southeast Energy Efficiency Alliance	$20,000,000
Wisconsin Energy Efficiency Project	$20,000,000
Greater Cincinnati Energy Alliance	$17,000,000
Toledo-Lucas Co. Port Authority (OH)	$15,000,000
Austin, TX	$10,000,000
Indianapolis, IN	$10,000,000
State of New Hampshire	$10,000,000
Omaha, NE	$10,000,000
San Antonio, TX	$10,000,000
Camden, NJ	$5,000,000
Greensboro, NC	$5,000,000
Lowell, MA	$5,000,000
State of Missouri	$5,000,000
State of Nevada (SEP)	$5,000,000
State of Michigan (SEP)	$4,994,245
Eagle County, CO	$4,916,126
CSG, Bainbridge Island, WA	$4,884,614
State of Maine (SEP)	$4,538,571
Rutland, VT	$4,487,588
Connecticut Innovations, Inc.	$4,171,214
Fayette County, PA	$4,100,018
ADECA, AL (SEP)	$3,013,751
St. Lucie County, FL	$2,941,500
VDMME, VA (SEP)	$2,886,500
Commonwealth of MA (SEP)	$2,587,976

Continued…

GRANTEE NAME	TOTAL GRANTED
WDC, WA (SEP)	$2,587,500
Santa Barbara County, CA	$2,401,309
Town of University Park, MD	$1,425,000
Town of Bedford, NY	$1,267,874
Total	$508,203,786

APPENDIX B. IMPACT EVALUATION METHODOLOGY SUPPLEMENT

B.1. OVERVIEW

Impact evaluations of efficiency programs seek to quantify the gross and net energy savings that have been realized by projects enrolled in a program.

The team utilized a sector based analysis (that is, residential, multifamily and commercial) that reviewed savings associated with individual projects, not the individual measures making up each project.

Because it was not cost-effective to complete analysis and onsite inspections on a census of the programs and the program projects, savings were only verified for a representative sample of projects. We also conducted a billing regression analysis to estimate realized energy savings at the project level. The scale of this billing regression analysis depended on the availability of sufficient pre- and post-installation utility billing data for a large enough sample of end-use customers to support a regression model. Finally, we employed multiple approaches to develop an estimate of net savings, the proportion of reported savings that were actually caused by the program. This work allows U.S. Department of Energy (DOE) to report its best estimate for the energy savings actually achieved by the Better Buildings Neighborhood Program (BBNP) program, based on Measurement and Verification (M&V), billing regression, and net savings analyses that use detailed data collected about actual retrofit activities, energy use, and decision-making based on representative samples of program projects and market participants.

Finally, the final impact evaluation estimated the economic impacts of BBNP. These impacts included jobs, as well as estimates of economic output, income (personal and business), and tax revenue that resulted from the program spending relative to a base case scenario where BBNP did not exist.

B.1.1. COMPONENTS OF THE RESEARCH

The impact evaluation for BBNP encompassed the following activities, each of which is outlined in greater detail throughout this section:

- Develop Sample Approach
- Design the M&V Sample
- Conduct M&V
- Conduct Billing regression analysis Regression
- Review of Independent Evaluations
- Net-to-Gross (NTG) Analysis
- Extrapolation of Results to Overall BBNP Level
- Calculate Additional Metrics

- Economic Impacts Analysis

The impact evaluation team relied on their collective experiences conducting evaluations, along with information gathered from externally published protocols and guidelines for reference and guidance throughout the evaluation project. Secondary sources included:

- The 2004 California Evaluation Framework (TecMarket Works, 2004).
- Model Energy-Efficiency Program Impact Evaluation Guide (Schiller Consulting, 2007).
- Uniform Methods Project[38]
- Impact Evaluation Framework for Technology Deployment Programs (Reed, Jordan, and Vine, 2007).
- Conference papers available through the International Energy Program Evaluation Conference (IEPEC)[39]
- "An Evaluation Approach for Assessing Program Performance from the State Energy Program"[40]
- International Performance Measurement and Verification Protocol (IPMVP®)[41]

B.1.2. TIMING OF EVALUATION ACTIVITIES

The preliminary evaluation commenced February 2012, and the results of the preliminary evaluation were presented in July of 2013. The final evaluation activities commenced in summer 2013 with the development of the draft Final Evaluation Plan. The Plan was submitted in September for review and comment by DOE and a peer review group consisting of experts in the energy efficiency evaluation field. Based on feedback from DOE, we finalized the Evaluation Plan in November 2013 (Research Into Action, Evergreen Economics, Nexant, Inc., and NMR Group, Inc., 2013). Following DOE approval of the Plan, the impact evaluation activities commenced with the sampling process, data collection, billing regression analysis, verification activities, and the economic analysis. Table B-1 provides a summary of the major activities and deliverables associated with both the preliminary and final impact evaluation.

Table B-1: Summary of Major Final Impact Evaluation Project Deliverables

ACTIVITIES AND DELIVERABLES	DATE
Preliminary Evaluation Kick-Off	February 2012
Grantee Interviews	July – August 2012
Preliminary Evaluation Plan	January 2013

38 For a full copy of the Uniform Methods Project protocols see: *http://www1.eere.energy.gov/deployment/ump.html*

39 See: *www.iepec.org*.

40 Written in collaboration by TecMarket Works, NYSERDA, Megdal & Associates, Edward Vine, and Marty Kushler.

41 2010. *International Performance Measurement and Verification Protocol*. Efficiency Valuation Organization (EVO®).

ACTIVITIES AND DELIVERABLES	DATE
Preliminary Evaluation Findings and Report	July 2013
Final Evaluation Plan	November 2013
Final Evaluation Report	June 2015

We used two major approaches for determining gross savings: utility bill regression analysis and M&V on a sample of grantee projects. Table B-2 outlines the specific tasks and timelines associated with these approaches.

Table B-2: Schedule of Major Evaluation Activities

IMPACT EVALUATION ACTIVITIES	DATE
Preliminary Evaluation	
Database and Project File Review	January - March 2013
Billing Data Requests	February 2013
Grantee Data Requests	February - March 2013
Participant Verification Phone Surveys	March - April 2013
Onsite Verification Surveys	April 2013
Billing regression analysis	March - May 2013
Economic Analysis	March - May 2013
M&V Analysis	May 2013
Report Writing	May - June 2013
Final Evaluation	
Database and Project File Review	December 2013 – January 2014
Billing Data Requests	October 2013 – May 2014
Onsite Verification Surveys	February – April 2014
Grantee Data Requests	February – July 2014
Billing regression analysis	October 2014
Economic Analysis	October 2014
M&V Analysis	August – October 2014
Report Writing	November 2014 – June 2015

B.1.3. RELATIONSHIP TO PRELIMINARY EVALUATION METHODOLOGY

We conducted two impact evaluations as part of this Project; the preliminary evaluation that measured impacts through the second quarter of 2012, and the final evaluation that continued the impact evaluation activities through Q3 2013 The goal of the preliminary evaluation was to not only provide impact results mid-way through the BBNP program cycle, support the process evaluation activities, and to coordinate with other evaluation activities, but also to inform us about methods that worked and processes that might be implemented by the grantees to allow for an effective final impact evaluation. The final impact evaluation focused on verifying the sample of grantee reported activities after Q2 2012 as well as leveraging results from the preliminary evaluation in order to quantify impact metrics for the entire grant cycle of the BBNP.

B.2. SAMPLING METHODS

The evaluation of BBNP is unique due to the program's significant scope, size, and reporting methodology. As discussed, grantees collected and reported a wide range of information, and the team worked to design a flexible methodology that handled the variety of information that was available. The sampling methods employed for the impact evaluation took into account the two distinct activities utilized to determine gross verified savings:

- **M&V** of a sample of grantees and projects
- **Billing regression analysis** on projects from grantees with sufficient utility bill data

Ultimately, the results from both activities were combined and extrapolated to the population in order to determine the overall estimated energy savings for BBNP. Details regarding the methodology for combining and extrapolating the results are provided later in this section.

B.2.1. OVERVIEW OF M&V AND REGRESSION SAMPLING APPROACHES

Unique sample frames were selected for each evaluation activity. The billing regression sample was based on the availability of sufficient grantee billing data required to conduct the billing regression analysis. Table 3-1 outlines the sample frame for the preliminary and final evaluation by evaluation activity.

B.2.2. OVERLAP OF M&V AND REGRESSION SAMPLES

For the final evaluation, the team overlapped sampled grantees between the M&V and billing regression analysis sample frames. The intention of this overlap was to understand the differences on estimated savings when using M&V versus billing regression, normalize those differences, and merge the M&V and billing analyses to calculate an overall realization rate for the BBNP. Further discussion on the adjustments we made in order to merge the M&V and billing analyses is provided in Appendix B, Section B.7.3.

B.2.3. M&V SAMPLE

The sampling provided a high level of project verification coupled with an efficient use of onsite activities to achieve an industry-standard level of measurement rigor. Verification of energy savings and influence/ spillover surveys conducted throughout the preliminary and final M&V activities included participant telephone surveys (conducted only for the preliminary evaluation), detailed desk review and analysis, and onsite inspections (conducted on a smaller subset of the sample population).

Sample Parameters

Three key parameters were established for an effective sample design of the M&V population:

- Confidence
- Precision
- Coefficient of Variance (Cv)

Confidence and Precision

The industry standard confidence and precision levels for energy efficiency program evaluations is 90% confidence, with 10% precision. The sampling strategy was designed to meet 90/10 confidence and precision at the overall BBNP level.

Coefficient of Variance

The greater the deviation of the observed value from the reported value, the greater is the variance in the sample pool. A greater variance in the sample pool indicates poor correlation between ex ante and ex-post savings and the potential need to sample more data points in order to reduce the error ratios in the sample pools. If a greater variance is expected in the reported impacts, the Cv is set at a higher value at the beginning of the sampling process, resulting in a larger sample pool.[42]

During planning for the preliminary evaluation, we determined that there was a strong likelihood for a larger deviation in reported savings. In order to address this issue, the Cv used for setting the sample size was set at 1.2 for the entire BBNP during the preliminary evaluation. Utility evaluations generally use a Cv of .5 for the majority of evaluations, as their programs are generally focused on specific measures and have established standardized reporting and measurement procedures. By establishing a higher Cv, we acknowledged the challenges listed below and selected a larger sample size to account for the perceived higher variability in the reported results.

- Grantee’s challenges with reporting project savings
- Errors in the reporting documents
- DOE’s challenges in capturing data in different formats
- Changes in reporting requirements since the programs began
- Lack of grantee experience managing energy efficiency programs

[42] The Cv is an estimate of the variability of the population in relation to the mean. Populations with assumed higher Cv indicates a larger sample size will be necessary in order to achieve the desired confidence and precision due to variability in the reported findings.

The evaluation revised its Cv for the final evaluation sampling by setting sector-level Cv assumptions based on the findings from the preliminary evaluation.

Sample Size

The sample size (*n*) was calculated based on the following formula, assuming an infinite population size (which essentially is the case for BBNP):

$$n = \frac{C_v^2 Z^2}{P^2}$$

- Where:

  n = sample size for an infinite program population

  Cv = Coefficient of variance by sector

  P = Precision = 10%

  Z = *Z*-Statistic based on 90% confidence = 1.645

Using the above formula and parameter inputs, the team determined that a sample size of 375 projects was desired for the final evaluation activities. This was slightly less than our proposed sample size of 385 projects for the preliminary evaluation. Table 3-4 and Table 3-5 illustrate the proposed sample sizes by sector and separately for the preliminary and final evaluation.

Stratification

With the M&V sample frame determined, we first stratified BBNP projects into strata based on the key sectors receiving services from the grantees: residential (single-family homes), multifamily, and commercial. This stratification allowed for the grouping of similar project types that increase the homogeneity within each sector stratum and reduce the expected variation in the verified results. Stratification occurred at the project level as opposed to the measure level due to the lack of detail provided in the reporting databases regarding measures implemented for each project.

An objective in many sampling approaches is to focus on areas with high impact. Therefore, we allocated samples to each sector stratum based on the magnitude of the reported savings for each sector in the sampling frame. Additionally, a subset of 120 projects of the sample population was selected for onsite verification activities during the final evaluation.

Once program evaluation activities commenced, the final executed sample was not identical to the planned sample for both the preliminary and final evaluations. This was due to difficulties in obtaining project data from grantees, which impacted recruitment and analysis efforts. For example, the lack of data collected from one specific grantee was fulfilled by third party evaluation results that we deemed appropriate for use. In turn, this grantee was removed from the sample frame and consequently reduced the overall sample size for the grantee's given sector and stratum. Table B-3 and Table B-4 summarize the final *actual* sample and associated M&V activities for the preliminary and final evaluations, respectively.

Table B-3: Actual M&V Sampling by Sector for Preliminary Evaluation

STRATA	TOTAL ACTUAL SAMPLE (NUMBER OF PROJECTS)	ACTUAL DESK ANALYSIS ONLY (NUMBER OF PROJECTS)	DESK ANALYSIS W/ TELEPHONE SURVEY VERIFICATION METHOD (NUMBER OF PROJECTS)	ONSITE ANALYSIS VERIFICATION METHOD – SUBSET OF SAMPLE (NUMBER OF PROJECTS)
Residential	217	16	154	47
Multifamily	0	0	—	—
Commercial	102	33	51	18
Totals	319	49	205	65

Table B-4: Actual M&V Sampling by Sector for Final Evaluation

STRATA	TOTAL ACTUAL SAMPLE (NUMBER OF PROJECTS)	ACTUAL DESK ANALYSIS ONLY (NUMBER OF PROJECTS)	ONSITE ANALYSIS VERIFICATION METHOD – SUBSET OF SAMPLE (NUMBER OF PROJECTS)
Residential	136	84	52
Multifamily	52	52	—
Commercial	171	120	51
Totals	359	256	103

The next step was to allocate the sector sample size to the populations within each sector. Due to the differing characteristics between each sector, the team used two different allocation methods. The details below provide the actual allocation of samples achieved by the team as opposed to the planned number of samples. The change from planned sample to the actual sample created risks such as noncoverage (populations not included in sample frame) and nonresponse (population members refuse participation) to the validity of the findings. However, the team sought to reduce the risks through the methodologies outlined below. Note that the sections below identify the allocation of sampling for the final evaluation only; the allocation of sampling for the preliminary evaluation can be found in the Preliminary Energy Savings Impact Evaluation Report (Research Into Action, Evergreen Economics, Nexant, and NMR Group, 2013).

Residential Stratification

The team used the Dalenius-Hodges method to create strata boundaries according to the size of the grantee energy savings within the residential stratum (Cochran, 1997).[43] This method created three substrata within the residential stratum: *small*, *medium*, and *large*.

To guide the process of allocating the residential sample among the substrata, our goal was to balance impact with perceived uncertainty to minimize the overall error in our final impact estimate. To accomplish this goal, the Neyman allocation method was used to allocate the sample to each of the three stratum created by the Dalenius-Hodges methodology (Cochran, 1997).[44] The results of this allocation method are outlined in Table B-5.

Table B-5: Residential M&V Sample Design by Substrata (Q3 2012 – Q3 2013)

GRANTEES WITHIN EACH RESIDENTIAL SUB - STRATA	REPORTED SOURCE ENERGY SAVED (MMBtu)*	REPORTED NUMBER OF PROJECTS*	ACTUAL SAMPLE SIZE (NUMBER OF PROJECTS)
Small			
Grantee-MVR 1	1298	51	22
Grantee-MVR 2	2,572	112	
Grantee-MVR 3	2,658	117	
Grantee-MVR 4	3,944	41	
Grantee-MVR 5	4,393	138	
Grantee-MVR 6	6,282	109	
Grantee-MVR 7	7,601	247	
Grantee-MVR 8	6,773	296	
Grantee-MVR 9	9,178	226	
Grantee-MVR 10	10,364	231	
Grantee-MVR 11	12,294	221	
Grantee-MVR 12	14,782	385	
Grantee-MVR 13	21,596	431	
Continued…			
Grantee-MVR 14	24,666	383	

43 The Dalenius-Hodges methodology is used to determine optimal strata boundaries based on the cumulative root frequency method.

44 Neyman allocation is a sample allocation method that is most often used with Dalenius-Hodges. It allocates sample size to strata based on product of stratum size and uncertainty in order to maximize survey precision, given a fixed sample size.

GRANTEES WITHIN EACH RESIDENTIAL SUB - STRATA	REPORTED SOURCE ENERGY SAVED (MMBtu)*	REPORTED NUMBER OF PROJECTS*	ACTUAL SAMPLE SIZE (NUMBER OF PROJECTS)
Grantee-MVR 15	25,377	505	
Grantee-MVR 16	25,696	627	
Grantee-MVR 17	27,538	959	
Grantee-MVR 18	28,429	304	
Grantee-MVR 19	30,033	957	
Grantee-MVR 20	34,079	725	
Medium			
Grantee-MVR 21	35,314	444	
Grantee-MVR 22	35,275	378	
Grantee-MVR 23	37,707	1,398	
Grantee-MVR 24	48,705	1,160	
Grantee-MVR 25	49,371	1,363	
Grantee-MVR 26	51,627	1,037	
Grantee-MVR 27	58,071	1,373	60
Grantee-MVR 28	59,138	1,296	
Grantee-MVR 29	61,633	1,601	
Grantee-MVR 30	63,870	1,540	
Grantee-MVR 31	66,897	2,347	
Grantee-MVR 32	69,945	3,861	
Grantee-MVR 33	80,814	1,467	
Large			
Grantee-MVR 34	92,414	1,312	
Grantee-MVR 35	111,181	6,723	54
Grantee-MVR 36	172,994	3,480	
Grantee-MVR 37	281,720	6,577	
Total	1,386,068	34,718	136

* Project and Savings total from Project Level data, September 2014

The samples within each small, medium, and large substratum were then randomly selected from the population of projects within each stratum. Random selection within the stratum allowed for the allocation of samples across the entire sample frame of the grantees within that stratum. Additional projects were then selected from the grantees receiving the initial sample allocation as alternates if the initial sample projects could not be verified due to lack of grantee response, lack of interested participant, or insufficient data. This helped reduce the risk of noncoverage error by not only ensuring enough alternates were selected but also that they would be allocated to similar type grantees within each stratum.

Onsite Selection

As mentioned above, the additional level of rigor of onsite verification visits were prescribed for a subset of the sample projects within 13 grantees. Projects selected for onsite visits were randomly selected from the medium and large strata, as these projects had greater energy impacts relative to projects in the small stratum.

Final Residential M&V Sample (Table B-6) shows the final list of grantees, the sample sizes and level of rigor employed for the residential sector. In a few cases, grantees had to either be removed from the sample due to unresponsiveness or a lack of adequate data. The project samples selected from these grantees were then
re-allocated to other grantees within the same stratum using the alternates previously selected.

Table B-6: Final Residential M&V Sample

GRANTEES WITHIN RESIDENTIAL SUBSTRATA	TOTAL SAMPLE	DESK ANALYSIS ONLY	ONSITE VISITS
Grantee-MVR 2	1	1	
Grantee-MVR 8	1	1	
Grantee-MVR 9	3	3	
Grantee-MVR 11	1	1	
Grantee-MVR 12	2	2	
Grantee-MVR 14	2	2	
Grantee-MVR 15	3	3	
Grantee-MVR 16	3	3	
Grantee-MVR 17	1	1	
Grantee-MVR 19	1	1	
Grantee-MVR 20	4	2	2
Grantee-MVR 21	3	3	
Grantee-MVR 22	2	1	1
Grantee-MVR 23	2	2	

Continued…

GRANTEES WITHIN RESIDENTIAL SUBSTRATA	TOTAL SAMPLE	DESK ANALYSIS ONLY	ONSITE VISITS
Grantee-MVR 24	5	2	3
Grantee-MVR 25	7	4	3
Grantee-MVR 26	3		3
Grantee-MVR 27	2	2	
Grantee-MVR 28	4	1	3
Grantee-MVR 29	5	2	3
Grantee-MVR 30	4	1	3
Grantee-MVR 31	6	2	4
Grantee-MVR 32	14	7	7
Grantee-MVR 33	3		3
Grantee-MVR 36	18	12	6
Grantee-MVR 37	36	25	11
Total	136	84	52

Commercial Stratification

For the commercial sector, the team used a very similar stratification method to the residential sector. The team used the Dalenius-Hodges method to create strata boundaries according to the size of the project energy savings within the commercial sector. This method created two strata: small and large. The Neyman allocation method was used to allocate the sample to each of the two strata. The results of this allocation method are outlined in Table B-7.

Table B-7: Commercial Sample Design by Strata (Q3 2012 - Q3 2013)

GRANTEES WITHIN EACH COMMERCIAL SUBSTRATA	REPORTED SOURCE ENERGY SAVED (MMBtu)*	REPORTED NUMBER OF PROJECTS*	SAMPLE SIZE (NUMBER OF PROJECTS)
Small			
Grantee-MVC 1	0	5	
Grantee-MVC 2	1,538	41	
Grantee-MVC 3	1,845	9	59
Grantee-MVC 4	5,408	5	
Grantee-MVC 5	7,748	6	

Continued…

GRANTEES WITHIN EACH COMMERCIAL SUBSTRATA	REPORTED SOURCE ENERGY SAVED (MMBtu)*	REPORTED NUMBER OF PROJECTS*	SAMPLE SIZE (NUMBER OF PROJECTS)
Grantee-MVC 6	11,391	106	
Grantee-MVC 7	12, 763	9	
Grantee-MVC 8	14,887	3	
Grantee-MVC 9	20,050	48	
Grantee-MVC 10	21,809	17	
Grantee-MVC 11	23,290	11	
Grantee-MVC 12	23,363	46	
Grantee-MVC 13	24,050	53	
Grantee-MVC 14	24,355	78	
Grantee-MVC 15	37,721	180	
Grantee-MVC 16	40,597	32	
Grantee-MVC 17	42,338	47	
Grantee-MVC 18	81,078	23	
Grantee-MVC 19	90,683	59	
Large			
Grantee-MVC 20	138,047	66	112
Grantee-MVC 21	157,473	596	
Grantee-MVC 22	213,145	226	
Grantee-MVC 23	416,613	353	
Total	1,334,059	1,924	171

* Project and Savings total from Project Level data September 2014.

The samples within each small and large substratum were randomly selected from the population of projects within each stratum. Random selection allowed for the allocation of samples across the entire sample frame of the grantees within that stratum. Additional projects were then selected from the grantees receiving the initial sample allocation as alternates if the initial sample projects could not be verified due to lack of grantee response, lack of interested participant, or insufficient data.

Onsite Selection

As mentioned in the residential sector, the additional level of rigor of onsite verification visits were prescribed for a subset of the sample projects within seven grantees across both strata. All samples selected for onsites also received a desk review.

Final Commercial M&V (MVC) Samples

Table B-8 shows the final list of grantees, the sample sizes, and level of rigor employed for the commercial sector.

Table B-8: Final Commercial M&V Sample

GRANTEES WITHIN EACH COMMERCIAL SUBSTRATA	TOTAL	DESK ANALYSIS ONLY	ONSITE
Grantee-MVC 4	1	1	
Grantee-MVC 5	2	2	
Grantee-MVC 6	2	2	
Grantee-MVC 9	6	6	
Grantee-MVC 12	4	4	
Grantee-MVC 13	5	5	
Grantee-MVC 14	3	3	
Grantee-MVC 15	10	10	
Grantee-MVC 16	6	1	5
Grantee-MVC 17	5	1	4
Grantee-MVC 18	5	3	2
Grantee-MVC 19	10	7	3
Grantee-MVC 20	11	8	3
Grantee-MVC 21	50	23	27
Grantee-MVC 22	18	11	7
Grantee-MVC 23	33	33	
Total	171	120	51

Multifamily Stratification

The team was able to include analysis of multifamily projects for the final evaluation due to the availability of sufficient project data. Upon review of these data, the team realized that grantees treated multifamily projects as either retrofits to individual specific units within a multifamily building or as retrofits to the multifamily building itself (for example, upgrades to building common areas and/or retrofits to all units in the building). Given that these two approaches to retrofits would result in very different levels of energy savings, we established two strata boundaries defined by individual unit projects and whole-building projects. The Neyman allocation method was used to allocate the sample to each of the two strata. The results of this allocation method are outlined in Table B-9.

Table B-9: Multifamily M&V Sample Design by Substrata (Q3 2012 - Q3 2013)

GRANTEES WITHIN EACH MULTIFAMILY SUBSTRATA	REPORTED SOURCE ENERGY SAVED (MMBtu)*	REPORTED NUMBER OF PROJECTS*	SAMPLE SIZE (NUMBER OF PROJECTS)
Small			
Grantee-MVMF 1	52,823	1,588	14
Grantee-MVMF 2	64,320	2,756	
Large			
Grantee-MVMF 3	78,999	145	38
Grantee-MVMF 4	24,511	40	
Grantee-MVMF 5	14,608	20	
Grantee-MVMF 6	24,398	101	
Grantee-MVMF 7	39,770	164	
Total	299,429	4,814	52

* Project and Savings total from Project Level data September 2014.

The samples within each small and large stratum were randomly selected from the population of projects within each stratum. Random selection allowed for the allocation of samples across the entire sample frame of the grantees within that stratum. Additional projects were then selected from the grantees receiving the initial sample allocation as alternates if the initial sample projects could not be verified due to lack of grantee response, or insufficient data.

Onsite Selection

Onsite visits were not conducted for the multifamily sector projects.

Final Multifamily M&V Samples

Table B-10 shows the final list of grantees, the sample sizes, and level of rigor employed for the multifamily sector.

Table B-10: Final Multifamily M&V (MVMF) Sample

GRANTEES WITHIN EACH MULTIFAMILY SUBSTRATA	TOTAL	DESK ANALYSIS
Small		
Grantee-MVMF 1	5	5
Grantee-MVMF 2	9	9
Large		
Grantee-MVMF 3	13	13
Grantee-MVMF 4	3	3
Grantee-MVMF 5	4	4
Grantee-MVMF 6	2	2
Grantee-MVMF 7	16	16
Total	52	52

B.3. MEASUREMENT AND VERIFICATION METHODS

The M&V activities conducted for the final impact evaluation included engineering review and verification activities to determine the energy savings for a sample of projects. To determine the overall estimated BBNP energy savings, the team used an ex-post analysis (actual savings based on post-retrofit conditions) in order to estimate the energy savings for each project selected in the sample. Gross verified energy savings were determined through information gathered from a combination of file reviews and onsite inspections. Gross verified savings were compared to reported savings to determine a realization rate for each sector.

Steps included in the verification approach, each of which is described in more detail in the following sections, were:

- Obtain Grantee Project Records
- Design Onsite Survey and Data Collection Forms
- Conduct Onsite Verifications
- Conduct Project File Reviews
- Establish Baseline Scenarios
- Verify Gross Energy Savings.

B.3.1. OBTAINING GRANTEE PROJECT RECORDS

The initial step of the evaluation activities involved obtaining DOE program records detailing the reported savings and number of projects for each of the grantees. This involved the following key sources of information:

- Project Level Database
- Program Level Database from Quarterly Summary Reports
- Measure Implementation Database
- Grantee Quarterly Reports

We encountered challenges in determining the quality and accuracy of the data. Due to these challenges, the team often used a triangulation approach to determine sources of inconsistency, areas of concern, and overall quality of the data. We worked with representatives from DOE and National Renewable Energy Laboratory (NREL) to correct errors, understand underlying issues, and interact with the grantees to correct issues.

We selected the Project Level Database for use in determining the M&V sample and conducting the impact analysis for energy savings for two main reasons:

1. The project data could be sorted into sectors to allow the team to determine savings and project totals for each sector. The Program Level data did not have this option.
2. Interviews with some grantees indicated that the project level data was "more correct" compared to the Program Level data.

Finally, the economic analysis utilized the Program Level Database, as this included specific metrics used in the analysis, such as program expenditures, leveraged costs, and project costs. This information was needed to conduct the economic analysis. The use of two different data sources for the analysis work in this report created some discrepancies in the reporting of the results. These are noted where applicable.

B.3.2. DESIGNING THE DATA COLLECTION INSTRUMENTS

Information gathered during the DOE data collection efforts informed the development of the surveys and data collection forms used for onsite verification activities. Due to governmental policy regarding population surveys, the team needed to undertake a number of steps to obtain approval to conduct onsite verifications.

First, each surveyor needed to complete training from the Lawrence Berkeley National Laboratory (LBNL) Environmental Health, Safety, and Security Division on Human Subjects Research. This training ensured that staff understood the policies and procedures related to the surveying of populations.

Next, the team designed the onsite survey for both the residential and commercial sectors, as well as an introduction letter to be sent to all potential participants in the sample. The surveys and introduction letter were then sent to the LBNL Human Subjects Committee for approval.[45] The surveys and approved letter are included in Appendix J and Appendix K, respectively.

[45] Federal regulations require that research involving human subjects or human derived data or tissues be reviewed by an Institutional Review Board (IRB). At Lawrence Berkeley National Laboratory, the IRB is the Human Subjects Committee (HSC). See: *http://www.lbl.gov/ehs/health_services/harc/hsc.shtml*

Paper data collection forms were developed and used in the field during the onsite activities during the final evaluation. All information gathered during the onsite inspections were entered into an internal *Microsoft Access* tracking database that was designed to track results for all impact evaluation activities.

B.3.3. CONDUCTING ONSITE VERIFICATIONS

Onsite inspections were conducted on a subset of sample projects in order to verify the accuracy of information reported through project documentation files, to gather additional project details, and to allow the team to note any discrepancies in reported versus actual project documentation. Typically, onsite inspection activities included:

- Collecting baseline (as available) and retrofit equipment information
- Obtaining the operating parameters as applicable
- Conducting a visual inspection
- Gathering equipment nameplate information
- Conducting brief onsite surveys with relevant parties to understand the facility or home operation, equipment operating specifics, and other input parameters needed to calculate energy savings. Additionally, a battery of net-to-gross questions was administered through the onsite survey.

B.3.4. CONDUCTING PROJECT FILE REVIEWS

Upon receipt of any documentation and project files for the sampled projects, we performed a file review. The project-specific documents requested for the sampled projects included customer applications, savings declarations performed by third party contractors (where applicable), pre- and post-project audits, customer invoices, and other information as available and appropriate.

We then conducted a file review to answer the following questions:

- Were the data files of sample projects complete and adequate to calculate and report savings?
- Were the measures installed as described in the program tracking and reporting system?
- Were input assumptions available, such as building size, building type, operating hours, etc.?
- Were the savings accurately reported to DOE?

Finally, depending on the selected project, additional supporting information was requested from the grantee, third party consultants, and implementation contractors when needed.

B.3.5. ESTABLISHING THE BASELINE SCENARIOS

To provide an accurate and defensible evaluation of baseline characteristics, a triangulation approach was utilized. We gathered and reviewed data from a variety of sources and reconciled the results to ensure that an accurate representation of the baseline characteristics was obtained. The following sources were utilized depending on the information available from each grantee:

- **Application or Project Documents.** Some grantees, through the use of applications for audit reports, gathered pre-installation project information. When available and applicable, the team used actual pre-installation information to calculate the ex-post energy savings.
- **Onsite Surveys.** For a subset of the sample population, the team conducted onsite verification of installed measures. During the onsite activities, questions were asked and observations were made regarding baseline equipment condition, operating hours and parameters.
- **Local Codes and Standards Requirements.** When information was not available via project documentation, phone interviews, or onsite surveys, or when the installed measure was found to be a replacement on burnout scenario, we used local energy and building code requirements as the basis for determining the baseline condition.

Table B-11 outlines the baselines used for this analysis for the most common measures analyzed in the sample.

Table B-11: Baseline Measure Data Used for Analysis

MEASURE	BASELINE
Furnace	80 AFUE
Boiler	80 AFUE
Air Conditioner	13 SEER
Air Source Heat Pump	7.7 HSPF
Water Heater – Gas	0.575 EF
Water Heater – Electric	0.92 EF
Insulation – All locations	Pre-existing conditions or R-5 if unknown
Compact Fluorescent Lamp (CFL) Direct Install	Pre-existing lighting or 60W Incandescent if unknown
T8 Fluorescent Lamp	Pre-existing lighting or T12 Fluorescent Lamp, 34W, 1.15 BF if unknown
Air Sealing	Pre-existing condition or 3600 CFM50 if unknown
Duct Sealing	Pre-existing condition or 60% distribution efficiency if unknown

B.3.6. VERIFYING GROSS IMPACTS

In order to calculate gross verified savings for each sampled project, the team created grantee-specific analysis tools that used the information gathered during the file review and onsite inspections. The team was challenged to create a consistent analysis methodology while working with grantees located across the country in varied climate zones that offered a wide range of measures and may have been influenced by regional savings algorithms used by local utilities. We used a three-step process when developing the grantee specific analysis tools in order to maintain a consistent approach, while recognizing the influence of regional aspects on the calculation of savings.

- **Step 1:** Uniform Methods Project (UMP) has created a number of protocols for energy efficiency measures. Only a few of the measures offered by the grantees currently have protocols developed as part of the UMP. The team used these protocols for the following measures:
  - Residential Furnaces and Boilers
  - Residential and Small Commercial AC Systems
  - Residential Lighting
  - Commercial Lighting and Lighting Controls
- **Step 2:** If the measure did not have a UMP protocol, the team utilized the closest applicable technical resource manuals (TRM) for savings algorithms or deemed values for input into the tool.
- **Step 3:** Where no local/regional TRM algorithms existed for measures implemented in a specific grantee territory, the team used TRMs from other locations for savings algorithms.

All algorithms included formulae and procedures for taking local weather conditions into account. Additionally, we did not make additional adjustments beyond what was presented in the algorithms provided by the UMP or regional TRMs. Lastly, stipulated values were used for variables that could not be verified or measured through the telephone surveys or onsite. Table B-12 lists all of the sources used during the development of the engineering algorithms for the calculation of gross verified savings.

Table B-12: Reference Documents Used M&V Analysis

REFERENCE DOCUMENT	EFFECTIVE/ REPORT DATE	VERSION
Database for Energy Efficient Resources (DEER)	October 14, 2009	
Efficiency Vermont TRM	July 18, 2008	2008-53
Massachusetts TRM	January 1, 2011	
Michigan Efficiency Measures Database 12/21/11	December 21, 2011	
Mid-Atlantic TRM	July 1, 2011	2.0
New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs	December 16, 2009	
NREL Uniform Methods Project	March 27, 2013	Draft Protocols
Pennsylvania PUC TRM	June 1, 2012	

REFERENCE DOCUMENT	EFFECTIVE/ REPORT DATE	VERSION
State of Illinois Energy Efficiency TRM	June 1, 2012	
State of Ohio Energy Efficiency TRM	August 6, 2010	
Tennessee Valley Authority Measurement Manual	July 14, 2010	
Texas Deemed Savings Installation and Efficiency Standards	April 1, 2010	
United Illuminating and Connecticut Light and Power Program Savings Documentation	September 21, 2010	
Wisconsin Business Programs: Deemed Savings Manual	March 22, 2010	1.0

Continued…

We applied data collected from our sampled desk reviews, phone surveys (in the case of the preliminary evaluation), and site visits to these various analysis tools. In the event we observed a discrepancy between site visit documentation and project documentation reviewed during the desk review, we deferred to the site visit data for our analysis.

There were a variety of fuel types that we encountered during the review of project savings. The M&V efforts addressed all fuel types including electric, natural gas, fuel oil, propane, and others. However, based on results from the preliminary evaluation, the team found that reporting of less common fuel types such as fuel oil and propane was very inconsistent and led to erroneous analysis findings for these fuel types. As a result, analysis was only performed on reported energy savings expressed in millions of BTUs (MMBtu), electricity kilowatt-hours (kWh) and natural gas therms. Energy savings analyzed based on project documentation and/or onsite visits by the evaluation team are ultimately expressed in MMBtu for consistency and for comparison with DOE reporting protocols. The conversion factors are located in Appendix K.

B.4. BILLING REGRESSION METHODS

A billing regression analysis approach was utilized for those instances when sufficient customer billing data and participant tracking data (for example, information on when measures were installed) were available. The billing regression model utilizes data on monthly electricity or natural gas consumption before and after program participation. To accomplish this, we reviewed all grantee data to determine which grantees had provided sufficient billing data to support a model. Based on this review, only 19 grantees had adequate billing data for the modeling task.

All model results are discussed in more detail in the Billing regression analysis Results section.

B.4.1. MODEL SPECIFICATIONS

Final Model Specification

For our general model, we developed a fixed effects billing regression model specification.[46] One of the principal advantages of using the billing regression model is that it theoretically allows for the consideration of confounding factors, such as customer size, geographic location, and changes in the features of the building between the pre- and post-participation months. Though some measure and household details were included in the grantee quarterly submissions, the data were often inconsistent and introduced added uncertainty. The final model specification selected is a simplified model that relies on fewer variables to control for external factors that might affect energy consumption; however, this specification produces savings estimates quite similar to those found in the more complex specifications. In addition to weather and measure variables, the billing model specification relied on dummy variables for month (to control for possible seasonal influences beyond weather) and customer-specific dummy variables to control for all other influences that may be affecting energy consumption at the customer level.

As discussed elsewhere in this report, the billing regression analysis uses a baseline of pre-project existing conditions at the site. This approach may differ from the M&V analysis where building code is used as the baseline if actual baseline conditions cannot be verified during onsite inspections or from supporting project documentation. As a consequence of this difference in methodology, the savings estimates generated by the two approaches are not fully comparable.

The fixed effects model specification for residential participants with electricity billing data is as follows:

$$kWh_{i,t} = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \varepsilon$$

- Where:

$kWh_{i,t}$	=	Normalized kWh usage in month t for customer i
$Post_{i,t}$	=	Binary variable indicating post-participation month for customer i
$Weather_t$	=	Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD])
$Month_t$	=	Set of binary variables indicating whether or not billing month t is January, February, March, April, etc.
α_i	=	Customer-specific constant

46 The fixed effects model is a model specification that incorporates non-random, time-invariant explanatory variables in the traditional multi-variate regression framework. These constant terms help control for possible influences relating to individual cohorts and time periods that are not controlled for explicitly in the available data. By controlling for these influences using these additional constant terms, the fixed effects model provides a more robust estimation of changes in energy use over time.

Similarly, an analogous model was developed for those program participants with natural gas consumption data:

$$Therms_{i,t} = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \varepsilon$$

- Where:

$Therms_{i,t}$	=	Normalized natural gas usage in month t for customer i
$Post_{i,t}$	=	Binary variable indicating post-participation month for customer i
$Weather_t$	=	Weather data for month t (HDD)
$Month_t$	=	Set of binary variables indicating whether or not billing month t is January, February, March, etc.
α_i	=	Customer-specific constant

Before the data were used in the model, both the electricity and gas data were subjected to a data cleaning process that screened out participants with insufficient pre-retrofit or post-retrofit data, and unusually small or large fuel consumption data. These data screens helped to eliminate outlier values that would have otherwise biased the model results. Our team tried a variety of data screens, all resulting in similar model savings estimates. Accordingly, we believe that our final data screens do not bias the results even though a significant amount of observations were omitted. Additional detail on these screens is provided in the section B.4.2 below.

Alternate Model Specifications

The team also ran a series of alternate model specifications to confirm that the results did not change substantially. Details on the specifications tried and the corresponding output can be found in Appendix G.

B.4.2. DATA CLEANING

Once all data were received from the grantees, our team developed data screens to clean the billing data for analysis. It was important to remove any potentially erroneous billing data from the final modeling dataset to avoid biasing the estimation results.

- The screens used to produce the final electricity dataset for modeling removed the following:
- Observations with monthly electricity consumption less than or equal to 100 kWh
- Observations with monthly electricity consumption greater than 10,000 kWh
- Observations with a billing period less than 28 days
- Observations with a billing period greater than 35 days
- Households with a pre-retrofit billing period less than 12 months

- Households with a post-retrofit billing period less than 12 months
- Households with average pre-retrofit monthly electricity consumption the less than or equal to 200 kWh
- Households with average pre-retrofit monthly electricity consumption greater than 5,000 kWh
- Households whose average monthly electricity consumption in the post-retrofit billing period was more than double the average consumption in the pre-retrofit billing period
- Households with no installed electricity savings listed in the program tracking data

Similarly, the screening process for the gas dataset removed the following:

- Observations with monthly electricity consumption less than or equal to 5 therms
- Observations with monthly electricity consumption greater than 300 therms
- Observations with a billing period less than 28 days
- Observations with a billing period greater than 35 days
- Households with average pre-retrofit billing period less than 12 months
- Households with a post-retrofit billing period less than 12 months
- Households with average pre-retrofit monthly natural gas consumption less than or equal to 20 therms
- Households with average pre-retrofit monthly natural gas consumption greater than 250 therms
- Households whose average monthly natural gas consumption in the post-retrofit billing period was more than double the average consumption in the pre-retrofit billing period
- Households with no installed natural gas savings listed in the program tracking data

A summary of these data screens is shown in Table B-13. Though a variety of data screens were tried on the models as a sensitivity test, none altered the results or statistical significance of the results greatly, so we opted to use the data screens listed above, even though they screened out 70-80% of the cases. Details on some of the alternate data screens we tried and their impact on the regression output can be found in Appendix E.

Table B-13: Summary of Electricity and Natural Gas Billing Regression Data Screens

DATA SCREEN	ALL DATA	DATA SCREENED OUT	DATA REMAINING	SCREENED DATA (PERCENT OF TOTAL)
Observations (Electricity)	642,991	470,769	172,222	27%
Observations (Gas)	437,149	310,097	127,052	29%
Households (Electricity)	22,231	17,780	4,451	20%
Households (Gas)	13,460	10,398	3,062	23%

B.5. REVIEW OF INDEPENDENT EVALUATIONS

As part of the data collection efforts, the team researched grantee-level program impact evaluations conducted by third party evaluators with the goal to assess if these third party evaluations could be incorporated into our analysis. We identified 20 evaluations; however, the majority of these evaluations were not impact evaluations, but rather process evaluations, marketing evaluations, informational brochures, or memos concerning the program. The team identified six third party impact evaluations that were benchmarked and reviewed for potential inclusion in the evaluation of the BBNP. Ultimately, we only identified one third party evaluation for inclusion in our analysis.

The findings of the benchmarking efforts are illustrated below. Table B-14 shows participation levels for each grantee by sector type.

Table B-14: Benchmarking Results: Participation and Sample Size

GRANTEE	PARTICIPATION				SAMPLE SIZE			
	Single-family	Multifamily	Low-Income	Commercial	Single-family	Multifamily	Low-Income	Commercial
West Coast grantee	72	100	8	280	14	33	3	24
Midwest grantee		21				21		
Northeast grantee	192				72			
Northeast grantee	5,118				100			
Southwest grantee	219	246		424	219	246		201
Southeast grantee	3,569	120		21	488	120		21

On a savings-per-project metric, the Southwest grantee's commercial program performed very well, at 1,080.9 MMBtu/year per project. This program only included electricity-saving end uses, and included commercial lighting and commercial HVAC measures. The Midwest grantee also did very well, at 856.2 MMBtu/year per project. The Midwest grantee only worked with gas-saving end-uses and included replacing heating units, installing air sealing measures, altering hot water distribution systems, and adding insulation to the roof cavity. These projects only included multifamily buildings, which accounts for the high savings value. The West Coast grantee had a low energy savings per project value, which can be explained by the fact that their commercial programs only included small commercial buildings, and the program only included electricity-saving end-uses, all of which would be residential-sized, not industrial-sized units. All remaining grantees measured gas and electricity savings, with the Northeast grantee's direct install incorporating fuel oil, wood, propane, coal, kerosene, and pellets as part of the program. Table B-15 shows total gross savings and savings per project by grantee.

Table B-15: Benchmarking Results: Gross Savings and Savings per Project

GRANTEE	GROSS SAVINGS (MMBtu)				SAVINGS PER PROJECT (MMBtu)			
	Single-family	Multifamily	Low-Income	Commercial	Single-family	Multifamily	Low-Income	Commercial
West Coast grantee	1,037	428	13.4	492.6	14.4	4.3	1.7	1.8
Midwest grantee		17,980				856.2		
Northeast grantee	10,445				54.4			
Northeast grantee	47,156				9.2			
Southwest grantee	2,351			458,318.80	10.7			1080.9
Southeast grantee	28,841	8,420		10,140.60	8.1	70.2		482.9

Each evaluator had preferred methods of measuring program energy savings. The West Coast grantee was evaluated by use of desk reviews only. The evaluators for the Southwest and Northeast grantees utilized billing regression analysis and desk reviews, while the evaluators for the Southeast grantee utilized a combination of billing regression analysis, desk reviews, and energy modeling to estimate savings. Table B-16 shows the methods used to determine energy savings by grantee.

Table B-16: Benchmarking Results: Methods Used to Determine Energy Savings

GRANTEE	METHODS USED		
	Billing Regression Analysis	Desk Reviews	Energy Modeling
West Coast grantee		x	
Midwest grantee			x
Northeast grantee	x	x	
Northeast grantee		x	

Southwest grantee	x	x	
Southeast grantee	x	x	x

Only two evaluations reported realization rates. The evaluator for the Northeast grantee reported a 78% realization rate. The Southeast grantee's evaluator reported 65.9% realization rate for single-family, and chose to apply a 100% realization rate to both commercial and multifamily due to the lack of required documentation to conduct the analyses.

B.6. NET-TO-GROSS METHODOLOGY

We conducted surveys to provide inputs to the NTG calculations with two groups: participating end users and participating and nonparticipating contractors. The final NTG estimate for the residential sector is based on both end user- and contractor-derived NTG estimates; participating end user free-ridership informs the lower bound NTG estimates (that is, NTG with free-ridership), and contractor-derived estimates of free-ridership and spillover inform the upper bound NTG estimates (that is, NTG with free-ridership and spillover) (Table B-17). The final NTG estimates for the commercial and multifamily sector are derived solely from participating end user free-ridership. The final residential NTG value is the mid-point between the end user- and contractor-derived NTG estimates. While there are some indications of spillover from the commercial grantees, the sample size of surveyed contractors is too small to develop a reliable estimate.

Table B-17: Net-to-Gross Ratio Calculation Methods

SECTOR	LOWER BOUND NTG ESTIMATES DERIVED FROM PARTICIPATING END USERS (FREE-RIDERSHIP ONLY)	UPPER BOUND NTG ESTIMATES DERIVED FROM PARTICIPATING AND NONPARTICIPATING CONTRACTORS (FREE-RIDERSHIP AND SPILLOVER)	FINAL NET-TO-GROSS RATIO
Residential	0.78	1.10	0.94
Commercial	0.85	Not estimated	0.85
Multifamily	0.99	Not estimated	0.99

B.6.1. LOWER BOUND NET-TO-GROSS RATIO ESTIMATES DERIVED FROM PARTICIPATING END USERS

Overview

Sampled commercial end users were those that completed an onsite verification survey as part of the M&V activities for the final evaluation; the onsite verification survey included the NTG questions. We sampled multifamily end users from a desk review and conducted the NTG survey over the phone. Sampled residential end users were those that completed an online survey that included process and NTG questions. Our end user survey questions sought information relating both to program influence (free-ridership) and spillover; however, we are able to provide numeric estimates of free-ridership only.

(Our study methodology did not include estimation of energy savings associated with respondents' reported spillover activity, nor with verifying the spillover.) Instead we gathered spillover estimates from participating and nonparticipating contractors (see following sub-section). We compiled the free-ridership results for each project from two components, what the participant would likely have done in the absence of the program and the influence the participant states that the program had on the upgrade actions taken. For commercial and multifamily sectors (which were based on the M&V sample), we rolled up the per-project results to the stratum level within each sector. We multiplied the stratum-average free-ridership score by the stratum verified savings and summed the resulting stratum-net-savings to obtain a sector net savings. We calculated sector NTG as the ratio of the sector-net-savings divided by the sector-verified-savings. Residential lower bound NTG was not based on M&V sampling, and thus did not have case weights tied to verified savings. Residential lower bound NTG was weighted in a similar fashion, but using a grantee-level weight (instead of stratum verified savings); grantee-stratum weights were developed by multiplying the ratio of a grantee's total project count to total BBNP project count by the ratio of respondents in the grantee's stratum to total survey respondents.

Additional Methodological Details

We used the survey method (equivalently, the self-report method) for the same reasons that have made it the most common method supporting NTG analyses: there are few other methods available and, as is typical, these methods are not appropriate for the program design or the available evaluation resources.[47] According to Haeri and Khawaja (2002), "self-report remains the most common method for determining free-ridership," in spite of the fact that many researchers engaged in estimating NTG have significant concerns with the methodology.[48]

Free-ridership (FR) was first calculated at the record level: each record received a free-ridership score ranging from 0-1 (where 0 means no free-ridership, and 1 means 100% free-ridership; thus, .6 means 60% free-ridership). The 0-1 FR range means someone could be a total free-rider (a value of 1), a partial free-rider (0.01-0.99) or not a free-rider (0). FR values consist of two components, *change and influence*, each of equal weight (and thus scored a value ranging from 0-.5).

The *change* component indicates what the participant would have likely done if the program had not incented them to do the upgrades, and assigns a FR change score (ranging from 0-0.5), depending on what the respondent indicates they would have done in absence of the program. The following list exhibits the options that respondents were able to choose from (regarding FR change), and the corresponding FR change value is listed in parentheses following each option:

1. Would they have done the upgrades anyway and paid the full cost themselves? (.5)
2. Would they have done some or different efficient upgrades, that would ultimately result in less savings than they achieved through the program? (.25)

47 These methods are experimental design and quasi-experimental design.

48 Haeriand and Khawaja, 2012 cite a TecMarket Works, 2006 which states, "the issues of identifying free-riders are complicated and estimating reliable program-specific free-ridership is problematic at best."

3. Would they not have done any upgrades at all in absence of the program? (0)

The *influence* component indicates how much influence that the program had on a respondent's decision to perform the upgrades through the program. Respondents were asked a series of questions regarding how much influence that various components of the program (that is, an energy audit, the program website, etc.) had on their decision to perform upgrades through the program. Respondents rated how influential each of these items had on their efficient actions, using a scale from 1-10 (where low scores indicate low program influence, an indicator of high free-ridership behavior, and high scores indicate high program influence, an indicator of low free-ridership behavior). Since the program is comprised of its components, the program is as influential as its highest-rated component. Thus, we took the highest influence rating for each respondent (as this indicates if any program influence is present) and assigned the following FR influence scores based on their highest influence rating, as outlined in the Table B-18.

Table B-18: Free-ridership Influence Scoring

HIGH SCORE	FR INFLUENCE VALUE
1	0.5
2	0.375
3	0.25
4	0.125
5	0.0

If a survey was missing, the data needed to compute its FR influence or FR change score, the team imputed the missing result with the sector average.[49] After computing *change* and *influence* components for each respondent, the two values were summed for each record to create a single FR total score ranging from 0 to 1. The scores of the individuals in each stratum were then averaged in order to create a stratum-level FR total score. Using the stratum FR total value, the team calculated stratum-net-savings by subtracting the stratum's FR value from 1 (to indicate the program effect, which is the inverse of FR) and multiplying the result by the stratum's total verified savings (in MMBtu). The sector's NTG value is the sum of all strata net savings (that is, the sector net savings) divided by the sum of all strata's total verified savings.

The reported FR-derived NTG values in this final report came from online survey (residential), onsite (commercial), and desk review (multifamily) samples. However, FR-based NTG data were collected from a variety of other sources as well, but these data were not included in the final reported FR-derived NTG

49 This approach to missing data reduces the sample variance in comparison with methods that would impute values that differ from the mean. We imputed three missing FR_influence values and 13 missing FR_change values for the residential sample (n=208), and imputed six FR_influence values and nine FR_change values for the commercial sample (n=73).

estimates due to small sample sizes or prior use in the preliminary report. Table B-19 lists all FR-derived NTG estimates, their sample sizes, and the associated population sizes.

Table B-19: Complete List of Free-ridership Net-to-Gross Data Sources

SECTOR	SOURCE	POPULATION (TOTAL PROJECT COUNT)	SAMPLE		NTG ESTIMATE
			Number of Respondents	Number of Grantees in Sample	
Residential	Preliminary M&V Evaluation - Onsite	74,369	207	17	0.80
	Final M&V evaluation- onsite		55	12	0.81
	Participant web survey		1100	15	0.78
Commercial	Preliminary M&V evaluation - onsite	3,547	72	9	0.90
	Final M&V evaluation- onsite		42	6	0.85
	Participant web survey		9	2	0.78
Multifamily	Final M&V evaluation - desk review	10,497	14	6	1.00
	Participant web survey		16	2	0.79

B.6.2. UPPER BOUND NET-TO-GROSS RATIO ESTIMATES DERIVED FROM PARTICIPATING AND NONPARTICIPATING CONTRACTORS

Overview

We estimated the number of energy efficiency upgrades associated with the 20 residential grantee programs included in the market assessment (see *Market Effects of the Better Buildings Neighborhood Program* (Final Evaluation Volume 5) for more details).[50] This provided an estimate of the net impacts of the residential BBNP grantees for participating contractors (that is, the estimate includes both free-ridership and spillover) and an estimate of nonparticipant spillover for nonparticipating contractors. We estimated a NTG ratio for the residential grantees by combining the total estimated net number of energy efficiency upgrades from participating and nonparticipating contractors and dividing by the total

[50] The market effects study included grantees with residential programs from three success groupings: high (six grantees), medium (13 grantees), and low (one grantee) as well as the top five commercial grantee programs (based on BTUs of savings). We initially selected grantees to be included in this study based on program data through Q4 2012 and on the success metric developed in the preliminary evaluation. However, we developed a revised success metric after the grantees were selected and surveys were completed. The revised success rankings for 11 of the 15 selected grantees were different from the preliminary success metric and only included one grantee categorized in the least successful stratum. Therefore, the findings may not reflect the results from the least successful grantees

number of BBNP-supported upgrades reported by participating contractors. We have not included the NTG ratio for the commercial grantees included in the market assessment because the estimate is based on a small sample and because the NTG ratio is strongly influenced by the contractors from a single commercial grantee program.

We estimated net BBNP upgrades by asking contractors to estimate the number of energy efficiency upgrades they would have completed in the absence of BBNP activities. In addition, we used contractors' ratings of the impacts of BBNP on their business and the energy efficiency upgrade market as a consistency check of program influence on net upgrades, combining a four question series into a scale. We estimated a NTG ratio of 1.21 for the residential grantees (Table B-20).

It is important to note that the NTG estimate applied only to the residential grantee programs included in the market assessment, all of which were chosen because of their success levels, and that the estimate did not apply to BBNP overall. Therefore, we applied an adjustment to the residential NTG value. For the purposes of our adjustment, we estimated a net spillover value of 0.21 by subtracting 1 from the NTG ratio of 1.21. Next, we applied an adjustment to the net spillover value proportionate to the percent of BBNP residential upgrades accounted for by residential grantees included in *Market Effects of the Better Buildings Neighborhood Program* (Final Evaluation Volume 5), to develop an adjusted NTG value of 1.10. It also is important to note that we could not directly estimate energy savings from any of the spillover upgrades because data on the type of equipment installed or replaced in these non-BBNP upgrades were not available. Further, the data were self-reported and were not corroborated by field studies.

Table B-20: Adjusted Residential Spillover Estimate Used in Upper Bound NTG Estimate

RESIDENTIAL NTG AND SPILLOVER FACTORS	VALUE
Residential BBNP upgrades, market assessment grantees	35,297
Total BBNP Residential upgrades	73,704
Percent of all BBNP residential upgrades accounted for by the residential grantees included in the market assessment	48%
NTG, residential grantees, market assessment	1.21
Net spillover, residential grantees, market assessment	0.21 (that is, NTG value minus one: 1.21 – 1.00 = 0.21)
Adjusted NTG value (adjusted by percent of BBNP residential upgrades accounted for by residential grantees included in the market assessment)	1.10 (that is, 1+ (48% * 0.21) = 1.1)

Additional Methodological Details

Below are further details of the steps we took to estimate the number of net BBNP upgrades; Table B-21 illustrates the steps with responses from several contractors.

- Respondents (participating and nonparticipating contractors) indicated whether the number of energy efficiency upgrades they would have completed in the absence of BBNP activities during the 2010-2013 period, with all other things remaining the same (that is, the economy, energy prices, and other energy efficiency programs), would have been higher, lower, or the same.

- If respondents thought the number of upgrades would have been higher in absence of the program, we asked them to estimate the percentage higher. If they thought the number of upgrades would have been lower, we asked them to estimate the percentage of the total number of upgrades that they would have completed during this period. From those estimates, we estimated the number of upgrades that the respondent would have conducted in absence of the program.[51] See column C in Table B-21.
- Subtracting this value from a respondent's estimate of total upgrades performed between 2010 and 2013 (column A) provides an initial estimate of the net impacts of BBNP for participating contractors (that is, the estimate includes both free-ridership and spillover) and an estimate of nonparticipant spillover for nonparticipating contractors (column D).

  For example, respondent 1 completed 160 upgrades between 2010 and 2013 (column A) and estimated that he/she would have completed 128 upgrades in the absence of the BBNP grantee (column C); we estimated a net impact of 32 upgrades for the respondent (column D & J). The same respondent completed five upgrades with BBNP, resulting in an estimated NTG ratio of 6.4 for the respondent (that is, 32 divided by five = 6.4; column K), meaning that the BBNP grantee program resulted in spillover upgrades for the respondent. Respondent 2 had an NTG value of less than one. The respondent estimated 1,080 upgrades in the absence of the BBNP grantee – or 2,520 net upgrades – but completed 3,000 upgrades with the grantee, resulting in an estimated NTG of 0.84 (that is, 2,520 divided by 3,000 = 0.84).
- Next, we used respondents' ratings of the impacts of BBNP on their business and the energy efficiency upgrade market as a consistency check of program influence on net upgrades. We combined the four question series (footnoted in Table B-21) into a scale and used an average score of seven or higher (that is, rating BBNP as having a positive impact on their business and the upgrade market) as the minimum required score to use a respondent's estimate of net impacts (column I).[52] Nonparticipating contractors, such as respondent 7, with a score below seven received NTG ratios of 0.0 (that is, zero nonparticipant spillover upgrades):
  - A rating of seven or higher = 100% net (that is, the program had a strong impact on their business, all BBNP projects are counted as net upgrades). For example, respondent 1.

51 Sixteen participating contractors and 123 non-participating contractors were unable to estimate the total number of upgrades that they had conducted from 2010 to 2013. Eleven of these respondents (eight participating contactors and three non-participating contractors) were able to estimate a percentage change in absence of the program. We estimated the total number of upgrades for these 11 respondents in order to estimate net upgrades. We found that the respondents who were able to estimate total upgrades had, on average, conducted 53 upgrades per FTE on average. To estimate the total upgrades for the 11 respondents, we multiplied the number of FTEs that they had reported by 53. The remaining 128 respondents were treated as zero values for the net upgrades analysis.

52 The four-question scale has a Cronbach's α of 0.90. Cronbach's α is a measure of inter-item correlation and scale reliability. A score of 0.9 or higher is generally considered an excellent indication of inter-item correlation and scale reliability (DeVellis, 1991).

- A rating of six = 80% net (that is, 80% of BBNP projects are counted as net upgrades).
- A rating of five = 60% net. For example, respondent 8.
- A rating of four = 40% net.
- A rating of three = 20% net.
- A rating of two or lower = 0% net (that is, strong disagreement that BBNP had a positive effect on their business; none of the BBNP projects are counted as net upgrades).

〉 We applied this rule similarly to participating contractors who said that there would have been no change in absence of the program. These respondents had initial net upgrade values of 0; however, if they gave positive ratings to BBNP, we proportionally assigned them percentages of BBNP program upgrades.

〉 For participating contractors identifying negative market effects (that is, they would have completed more projects without BBNP), we inversely applied a similar rule based on the respondents' agreement with the impact of BBNP on their business.[53] For example, respondent 5 below indicated that he/she would have conducted 480 upgrades in absence of the program and had conducted 400 in total, resulting in an initial net upgrade value of -80. This respondent then gave an average rating of three to the scale questions and, in particular, gave a rating greater than two to the statement "There is more business for your company than there would have been without the program," showing a slight positive impact of the program. We assigned this respondent 80% of the negative *net* upgrades, increasing the final net upgrade value to -64 (80% of -80 = -64).

〉 Last, for participating contractors, we examined the ratio of net BBNP upgrades to the number of upgrades completed with BBNP (that is, individual NTG ratios) to identify any outliers. Four participants had NTG ratios more than three standard deviations above or below the mean NTG ratio. Three outlier respondents estimated that, for every one BBNP upgrade, they had completed 60 or more additional upgrades as a result of the program. We replaced their estimates of net upgrades with their estimated number of BBNP upgrades.[54] For example, respondent 6 in had completed 650 total upgrades from 2010 to 2013, four of which were BBNP upgrades, and estimated that he/she would have completed only 98 upgrades in absence of the program, resulting in an initial NTG ratio of 138 (552 divided by four). We assigned a net upgrade value to this respondent equal to the number of BBNP upgrades that he/she completed, resulting in an NTG value of 1.0.

53 The in-depth interviews examined why some contractors reported negative program effects. They described dynamics such as BBNP unevenly promoting certain contractors over others, competing contractors utilizing subcontractors to get around BBNP rules, BBNP drawing contractors to come from other geographic areas, and nonparticipating contractors leveraging program opportunities.

54 These respondents had values over seven for the program influence scale, indicating strong BBNP influence.

Table B-21: Examples of Estimating Contractors' Net BBNP Upgrades

RESPONDENT	[A] NUMBER OF UPGRADES, 2010 TO 2013	[B] BBNP UPGRADES	[C] UPGRADES WITHOUT BBNP	[D] INITIAL NET BBNP UPGRADES (A – C)	[E] SCALE 1*	[F] SCALE 2*	[G] SCALE 3*	[H] SCALE 4*	[I] AVERAGE SCALE 1 TO 4	[J] FINAL NET BBNP UPGRADES (BASED ON E IF I < 7)	[K] NTG (J/ B)
1	160	5	128	32	10	10	10	10	10	32	6.4
2	3,600	3,000	1,080	2,520	10	8	7	5	7.5	2,520	0.84
3	400	210	40	360	5	5	5	5	5	126	0.6
4**	17	11	17	0	10	10	10	10	10	11	1
5**	400	90	480	-80	3	4	7	7	5.25	-64	-0.71
6**	650	4	98	552	10	10	10	10	10	4	1
7**	385	0	347	38	6	5	6	8	6.25	0	N/A

* Scale 1: There is more business for your company than there would have been without the program.

* Scale 2: There is more business in general in the marketplace than there would have been without the program.

* Scale 3: There will be more business for your company than there would have been without the program [in the next two years].

* Scale 4: There will be more business in general in the marketplace than there would have been without the program [in the next two years].

** Respondent 3: Final net BBNP upgrades = (0.6)*(column B), based on response of 5 to Scale 1 (column E)

** Respondent 4: Final net BBNP upgrades = (column B), based on no reported change in number of upgrades (column C) but positive responses of 10 to Scale 1 through 4 (column E through I)

** Respondent 5: Final net BBNP upgrades = (0.8)*(column D), based on negative initial net upgrades (column D) and a slightly positive response of 3 to Scale 1 (column E)

** Respondent 6: Final net BBNP upgrades = column B, based on initial NTG being greater than three standard deviations from the mean (552/4=138)

** Respondent 7: Final net BBNP upgrades = (column B), based on nonparticipation and response of 6 to Scale 1 (column E)

B.7. EXTRAPOLATION OF RESULTS TO OVERALL BBNP

In order to calculate the overall verified energy savings associated with BBNP, the team extrapolated the sample findings to the population through the use of case weights and realization rates. Extrapolation was done separately for the M&V sample frame and the billing regression analysis sample frame, and the resulting realization rates were then combined and extrapolated to the entire BBNP.

B.7.1. M&V EXTRAPOLATION

To ensure that each project was given the appropriate amount of weight in the final overall savings calculation, the team created case weights for each project based on the number of sample projects selected from each stratum. Following the California Evaluation Framework, a case weight (w_i) for each M&V sampled project was calculated based on the total number of projects in the stratum population (N_h) divided by the number of sample projects in the same stratum (n_h), where h denotes the stratum that contains $project_i$. A stratum is identified by sector and contribution to savings (large, medium, or small) as discussed above.

$$w_i = \frac{N_h}{n_h}$$

The realization rate was then calculated by dividing the sum of the case weight multiplied by the verified savings by the sum of the case weight multiplied by the reported savings, as outlined in the following formula:

$$b = \frac{\sum_{i=1}^{m} w_i y_i}{\sum_{i=1}^{m} w_i x_i}$$

- Where:

b	=	realization rate
m	=	number of sample projects across all stratums
w_i	=	case weight for stratum i
y_i	=	gross verified savings of each project in stratum i
x_i	=	reported savings of each project in stratum i

M&V realization rates were then calculated for each sector.

The M&V realization rates for both the preliminary and final evaluations were combined in order to have an M&V realization rate representative of the entire evaluation timeframe. A weighted average of the realization rates was calculated based on the total *ex ante* savings of all the grantees within each respective sampling frame.

This weighted average M&V sector level realization rate was calculated according to the following formula:

$$b_z = b_{m,z} * \left(\frac{Savings_{rep,m,z}}{Savings_{rep,t,z}}\right) + b_{b,z} * \left(\frac{Savings_{rep,b,z}}{Savings_{rep,t,z}}\right)$$

- Where:

b_z = weighted average realization rate by sector z

$b_{m,z}$ = Preliminary M&V calculated realization rate for sector z

$b_{b,z}$ = Final M&V calculated realization rate for sector z

z = sector

$Savings_{rep,m,z}$ = reported savings for all grantees within the preliminary M&V sample frame for sector z

Savingsrep,b,z = reported savings for all grantees within final M&V sample frame for sector z

Savingsrep,t,z = total reported savings for all grantees in sector z

A weighted realization rate for the multifamily sector could not be calculated as no realization rate was calculated for this sector during the preliminary evaluation.

B.7.2. BILLING REGRESSION ANALYSIS EXTRAPOLATION

The billing regression results also were used to develop realization rates for the residential and commercial sectors. These realization rates were created for each grantee that provided billing data and where robust billing regression models could be estimated. To develop a realization rate based on the billing regression results, a weighted average was calculated of the grantee-level realization rates that were estimated using the billing regression, with *ex ante* savings used as the weights.

B.7.3. OVERALL BBNP EXTRAPOLATION

In order to calculate the overall BBNP gross verified savings for each sector, the team calculated a BBNP level realization rate for each sector using the methodology from the California Evaluation Framework (TecMarket Works, 2004). According to the Framework, two statistically independent evaluation studies that provide statistically unbiased estimates of the savings of the program may be combined into a single estimate. If the two estimators, in this case the realization rates from the M&V analysis and the billing regression analysis, are both unbiased estimators of a given parameter, then any weighted average of the two estimators also is an unbiased estimator. The error bound of the result is the square root of the reciprocal of the sum of the weights.

The team recognized that potential issues might exist when combining the results from the billing and M&V analyses. First, the two analysis methods used different baselines for some of the measures. The billing regression analysis inherently uses a baseline of pre-project existing conditions as the baseline. This is due to the regression analysis comparing the energy use prior to the project implementation to the energy use after the project installation. However, the M&V analysis uses either a codes and standards baseline or the pre-project existing conditions baseline depending on the measure installed and the amount of information available for each measure. The second issue involves participant spillover savings, which are energy savings due to measures installed by a program participant, likely due to the influence of the program, but for which no program incentive was paid. The billing regression analysis would capture from the savings due to participant spillover, while the M&V activities did not.

To address these concerns, we overlapped the M&V and billing regression analysis sample frames in an effort to determine an adjustment factor that could account for these issues and allow the M&V and billing analyses to be merged.

Adjustment Factor

For the final evaluation, the team overlapped sampled grantees between the M&V and billing regression analysis sample frames. The intention of this overlap was to understand the differences on estimated savings when using M&V versus billing regression, normalize those differences, and merge the M&V and billing analyses to calculate an overall realization rate for the BBNP. After completion of the M&V and billing regression activities, an overlap of 75 projects existing in both sample frames was examined. This overlap presented an opportunity to corroborate the savings estimates of the two independent analysis methods and to address some of the inherent differences between the M&V and billing regression methodologies. Most notably:

- **Different baselines.** In the case of the billing regression, the baseline is the pre-existing conditions at the site, which may be less efficient than a building code baseline. In contrast, the savings estimates used for the M&V analysis first assumed the actual baseline identified during the verification exercise, and if this information is unavailable, building code was used. This is generally more efficient than the existing equipment baseline.
- **Spillover savings.** Spillover savings are energy savings due to measures installed by a program participant, likely due to the influence of the program, but for which no program incentive was paid. The billing regression analysis captures savings due to participant spillover, while the M&V activities do not.
- **Other factors.** The billing regression analysis captures the effect of outside factors that impact energy savings, such as changes in occupancy, changes in usage patterns, interactive effects, etc., but the M&V analysis generally does not account for these factors.

Adjustment Factor Methodology and Results

We used a regression model to estimate a correction factor that can be used to adjust for the aforementioned differences between the M&V and billing regression impact estimation results. This regression relied on monthly consumption data (either electricity or natural gas) before and after program participation, as well as weather information, and M&V verified savings estimates.

The model specification for participants with electricity billing data is as follows:

$$\Delta kWh_i = VerifSav_i + \Delta HDD_i + \Delta CDD_i + \varepsilon_i$$

- Where:

ΔkWh_i = Difference between pre-and-post retrofit normalized annual kWh usage for customer calculated through billing regression analysis

$VerifSav_i$ = Verified onsite savings determined through M&V activities for customer i

ΔHDD_i = Difference between normalized pre-and-post retrofit heating degree-days [HDD] for customer i

ΔCDD_i = Difference between normalized pre-and-post retrofit cooling degree-days [CDD] for customer i

ε_i = Random error term for customer i

Using the model results, the inverse of the estimated coefficient on VerifSav can be used as the adjustment factor to adjust the impact estimates obtained from the billing regression to match M&V savings.

The results of the adjustment regression model are shown in Table B-22 for single-family households. Ultimately, the model results were consistent with expectations, with the variable of interest (VerifSav) statistically significant and of the expected magnitude.

Table B-22: Single-family Electric Adjustment Factor Regression Model Results

N	R SQUARE	ADJ. R SQUARE	STD. ERROR OF THE ESTIMATE
28	0.691	0.653	1098.936

VARIABLE	COEFFICIENT (β)	STD. ERROR	T STAT	SIG.
(Constant)	611.189	255.437	2.393	2.5%
VERIF_SAV	1.426	0.203	7.027	0.0%
ΔHDD	0.305	0.311	0.982	33.6%
ΔCDD	0.13	0.853	0.152	88.0%

The coefficient on the VerifSav variable reflects how a change in the overall kWh consumption between the periods (ΔkWh_i) is affected by a change in the M&V savings. In other words, the point estimate of 1.426 in the residential electric model indicates that a change of 100 kWh found in the M&V savings analysis is equivalent to a change in consumption of 142.6 kWh between the pre and post periods. This is equivalent to the change in consumption captured by the billing regression model. For our analysis purposes, the adjustment factor for the billing regression results is the inverse of the coefficient on VerifSav, which yields an adjustment factor of 70.13 percent.

A similar model was conducted for the commercial sector that resulted in a coefficient estimate of 1.082 and an adjustment factor of 92.42 percent (see Table B-23). A multifamily model was not estimated as the overlap of points (12) proved to be insufficient for estimating the adjustment factor regression model. Instead, the single-family adjustment factor will be applied to the multifamily sector as the measures installed and site characteristics are much more consistent between these two sectors than between commercial and multifamily sites. Additionally, very few sites evaluated through the M&V activities had sufficient gas billing data available resulting in our inability to compute an equivalent, credible set of gas adjustment factors.

Table B-23: Commercial Electric Adjustment Factor Regression Model Results

N	R SQUARE	ADJ. R SQUARE	STD. ERROR OF THE ESTIMATE
35	0.978	0.976	15632.726

VARIABLE	COEFFICIENT (β)	STD. ERROR	T STAT	SIG.
(Constant)	7100.681	2849.41	2.492	1.8%
VERIF_SAV	1.082	0.029	36.82	0.0%
ΔHDD	-0.925	4.498	-0.206	83.8%
ΔCDD	-3.175	11.256	-0.282	78.0%

Table 3-6 summarizes the adjustment factors for each sector based on the regression models discussed above. These adjustment factors will be applied to the billing regression realization rates so that the findings are comparable with the M&V savings estimates, resulting in one final realization rate for each sector that will be applied to reported savings values.

Representativeness of the Adjustment Factor

During the review process for the final impact evaluation report, there were several questions relating to the representativeness of the adjustment factor, particularly since only a small sample of overlap sites was available for the estimation. The following charts provide additional information on the overlap sample and how it compares with the wider sample of grantees used in the billing regressions and M&V analysis.

Table B-24 provides detail on the distribution of grantees with electricity billing data that were used to estimate the adjustment factor. Of the 28 residential sites, 11 came from Chicago, while the majority of the commercial sites (21 of 35) came from Phoenix.

Table B-24: Distribution of the Adjustment Factor Sample

	GRANTEE	ADJUSTMENT FACTOR SAMPLE
Residential	ADECA, AL	1

	GRANTEE	ADJUSTMENT FACTOR SAMPLE
	Austin	3
	Boulder Co, CO	1
	Chicago	11
	Connecticut	1
	Philadelphia	1
	Phoenix	3
	Portland	1
	San Antonio	1
	Seattle	1
	Maryland	1
	University Park, MD	1
	WDC, WA	2
	Total	28
Commercial	Boulder Co, CO	5
	Phoenix	21
	Toledo-Lucas Co., OH	4
	Wisconsin	5
	Total	35

Although a few of the grantees are over represented in the adjustment factor sample, this does not necessarily cause a problem if these sites are still fairly representative of the overall grantee population. To investigate this, we examined the estimated savings for each grantee and identified where the adjustment sample values fell within this distribution.

The first value that we examined was the estimated savings from the billing regression for those grantees that were included in the billing analysis. Figure B-1 and Figure B-2 provide the distribution of average savings for these grantees for both the residential and commercial sites. Along with the individual grantee values, the average for the overlap group and the billing analysis group are highlighted. As seen in both graphs, the adjustment factor average lies relatively close to the mean savings value for both the residential and commercial samples.

Figure B-1: Residential Estimated Savings – Billing Analysis Sample

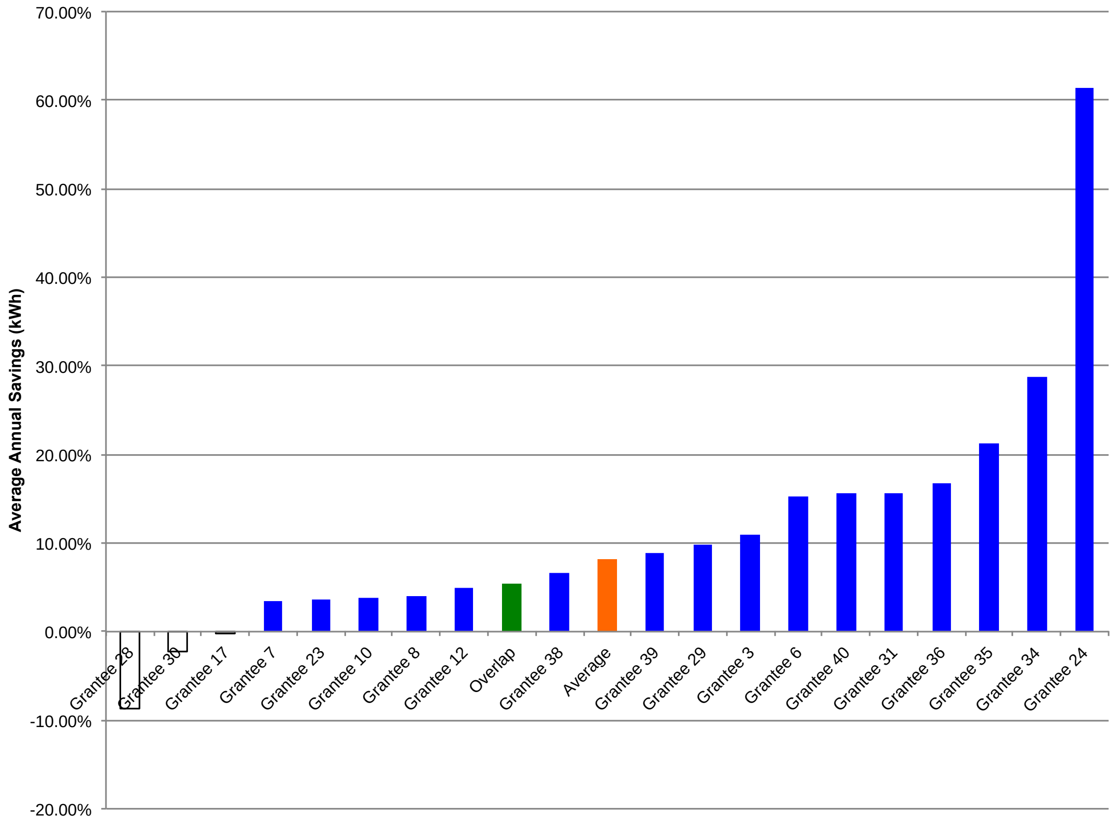
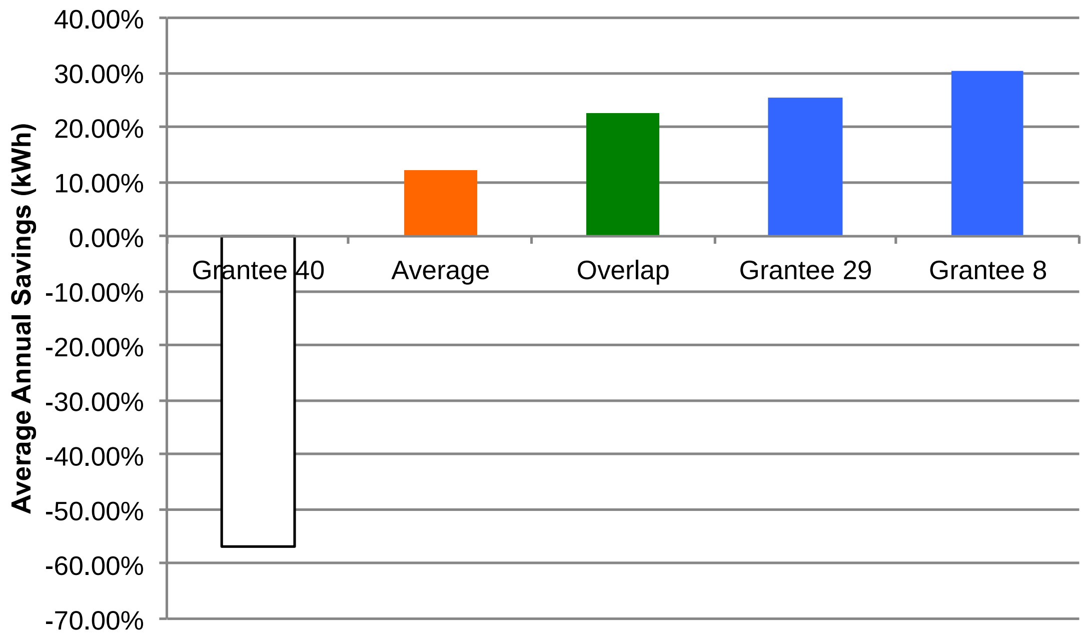


Figure B-2: Commercial Estimated Savings – Billing Analysis Sample



A similar exercise was done for the M&V savings, and this comparison is shown in Figure B-3 and Figure B-4. As before, the average M&V savings for each grantee is shown, along with the overall average and the average M&V savings for the adjustment sample. Again, the average for the adjustment sample is relatively close to the overall M&V sample average for both the residential and commercial sectors.

Figure B-3: Residential Estimated Savings M&V Analysis Sample

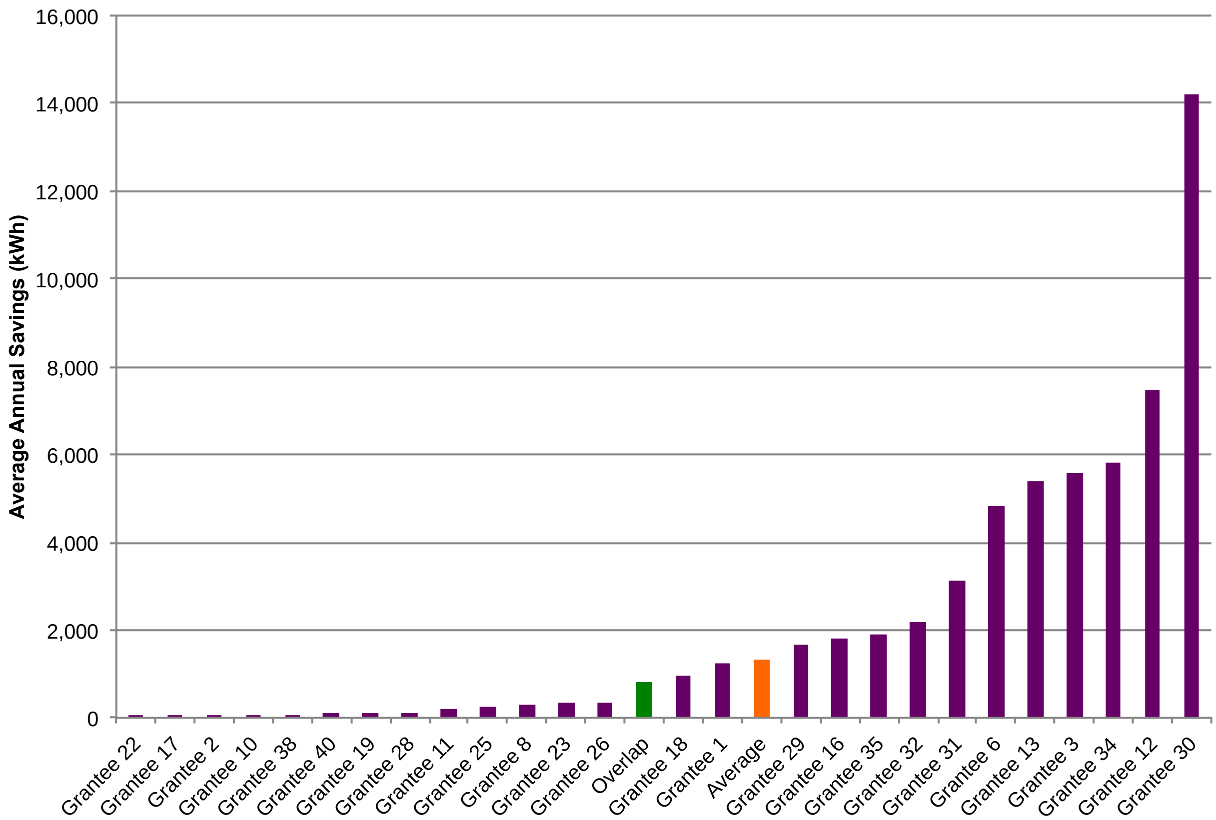
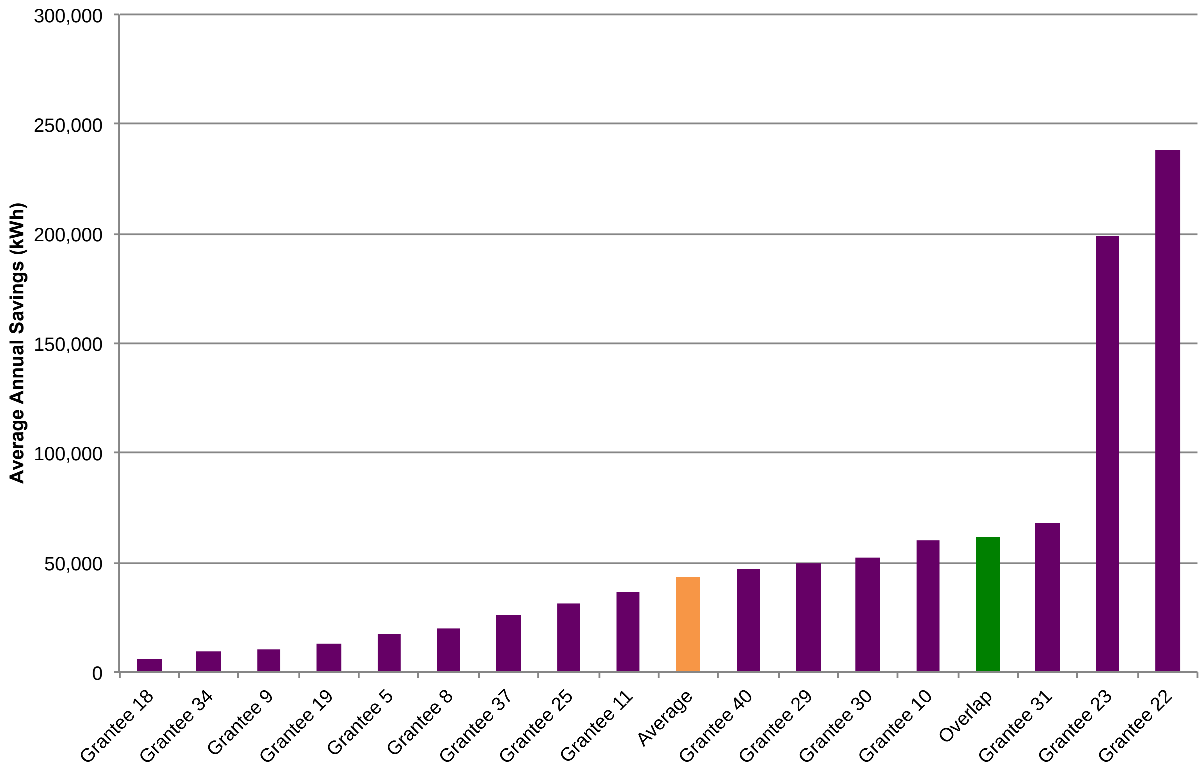


Figure B-4: Commercial Estimated Savings – M&V Analysis Sample



Taken together, these graphs indicate that the adjustment factor sample is not abnormally skewed from the group average for either the M&V or billing analysis components. We believe that this indicates that – even though the sample is small – it is still reasonably representative of the other grantees and, therefore, the adjustment factor should be used in the impact analysis.

Realization Rate

The overall sector realization rate was calculated by taking a weighted average of the realization rates calculated for the M&V extrapolation and the billing regression analysis extrapolation. These realization rates were weighted based on the total *ex ante* savings of all the grantees within each respective sampling frame.

This weighted average BBNP sector level realization rate was then calculated according to the following formula:

$$b_z = b_{m,z} * \left(\frac{Savings_{rep,m,z}}{Savings_{rep,t,z}}\right) + b_{b,z} * \left(\frac{Savings_{rep,b,z}}{Savings_{rep,t,z}}\right)$$

- Where:

b_z	=	weighted average realization rate by sector z
$b_{m,z}$	=	M&V calculated realization rate for sector z

$b_{b,z}$ = billing regression analysis calculated realization rate for sector z

z = residential or commercial

$Savings_{rep,m,z}$ = reported savings for all grantees within M&V sample frame for sector z

Savingsrep,b,z = reported savings for all grantees within Billing regression analysis sample frame for sector z

Savingsrep,t,z = total reported savings for all grantees in sector z

Once the weighted average realization rate was determined, this value was applied to the overall reported savings to determine a gross verified savings by sector.

$$Savings_{gross\ ver,z} = Savings_{rep,z} * b_z$$

- Where:

b_z = weighted average realization rate by sector z

z = residential or commercial

$Savings_{rep,z}$ = total reported savings for sector z

$Savings_{gross\ ver,z}$ = total gross verified savings for sector z

The total gross verified savings for BBNP was calculated as the sum of the sector gross verified savings.

Thus, the overall gross verified savings for BBNP is calculated as:

$$Savings_{gross\ ver,BBNP} = \sum_{z} Savings_{gross\ ver,z}$$

- Where:

$Savings_{gross\ ver,BBNP}$ = total gross verified savings of BBNP

$Savings_{gross\ ver,z}$ = total gross verified savings for sector z

Net verified savings for each sector were determined by applying the NTG ratio found in the influence/spillover analysis to the sector level gross verified savings from the verification sample only:

$$Savings_{net\ ver,z} = Savings_{gross\ ver,z} * NTG_z$$

- Where:

NTG_z = net-to-gross ratio for sector z = residential or commercial

$Savings_{gross\ ver,z}$ = total gross verified savings for sector z

$Savings_{net\ ver,z}$ = total net verified savings for sector z

Finally, net verified savings for BBNP were calculated as the sum of the sector net verified savings, and were calculated as:

$$Savings_{net\ ver,BBNP} = \sum_{z} Savings_{net\ ver,z}$$

- Where:

$Savings_{net\ ver,BBNP}$ = total net verified savings of BBNP

$Savings_{net\ ver,z}$ = total net verified savings for sector z.

B.8. ADDITIONAL OVERALL BBNP METRICS

The following section outlines how the additional metrics related to the preliminary impact evaluation findings were calculated and reported.

B.8.1. GREENHOUSE GAS EMISSION SAVINGS

Carbon dioxide (CO_2) and CO_2 equivalent reductions were calculated and reported for each year over the effective useful lifetime of the projects evaluated. Our approach was consistent with recommendations contained in the *Model Energy Efficiency Program Impact Evaluation Guide* for the emission factor approach (Schiller Consulting, 2007).This methodology employs the use of emission factors as follows:

$$avoided\ emissions = verified\ source\ energy\ savings * emissions\ factor$$

The emission factor is expressed as mass per unit of energy (pounds of CO_2 per MWh), and represents the characteristics of the emission sources displaced by reduced generation from conventional sources of electricity or reduced consumption of fossil fuels.

For the BBNP evaluation, CO_2e was calculated using EPA non-baseload emissions factors for greenhouse gas inventories.[55,56] The reference provides an avoided CO_2e value for a number of fuel types, as well as an average of electricity avoided CO_2e. These values were used to determine annual and lifetime avoided CO_2e.

B.8.2. LIFETIME ENERGY SAVINGS

The effective useful life (EUL) of retrofit equipment is an important consideration in the assessment of program effectiveness because the avoided energy, demand, and cost benefits continue to accrue over the lifetime of the measure. In order to calculate lifetime savings for the sample projects in the preliminary impact evaluation, individual project EULs were assigned based on the retrofit measure

55 Carbon Dioxide Equivalence (CO_2e) is a quantity that describes, for a given greenhouse gas (carbon dioxide, methane, hydro fluorocarbons, etc), the amount of CO_2 that would have the same global warming potential, when measured over a specified timescale.

56 EPA Year 2010 eGRID 9th edition Version 1.0 February 2014.

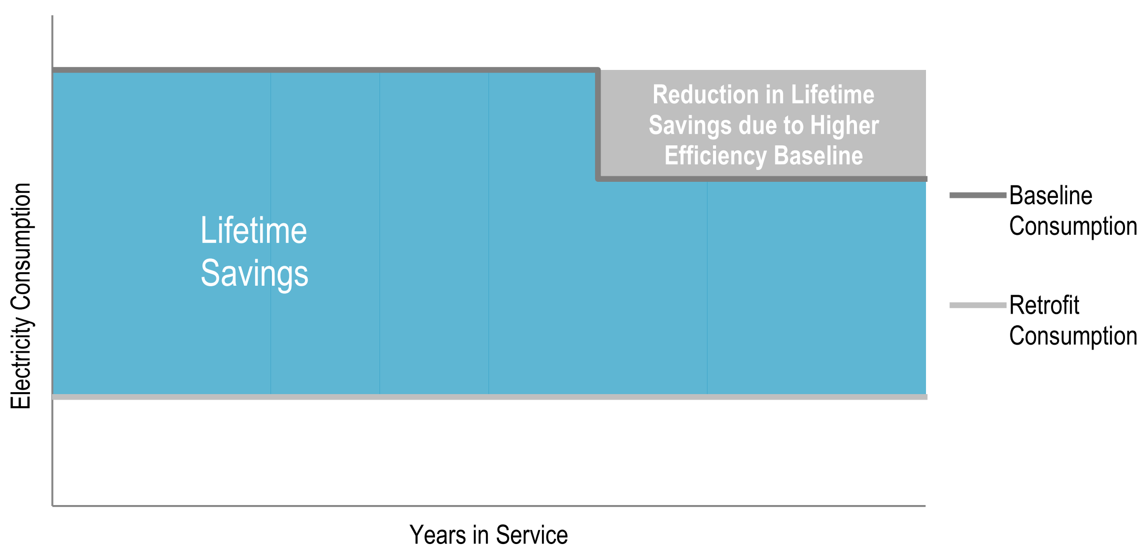
types implemented in the project, using values sourced from deemed savings databases, such as DEER, RTF, and regional TRMs. The lifetime energy savings were then calculated as:[57]

$$Lifetime\ Energy\ Savings = EUL * Annual\ Energy\ Savings$$

DOE did not report lifetime energy savings that would allow us to develop a realization rate. Therefore, we calculated lifetime savings for the entire sector populations by calculating a lifetime savings factor. This factor was calculated by dividing the sample lifetime savings by sample annual savings. This factor was then multiplied by the total verified annual savings to determine a verified lifetime savings.

Current and upcoming changes to energy efficiency regulations will affect the availability of specific lighting technologies in the future marketplace. Specifically, they will begin to phase out the use of certain incandescent general service lamps and T12 general service fluorescent technology. We did address this change in energy efficiency regulations, and, in the engineering analysis, these affected measures did not receive the full credit for achieving the first year annual energy savings over the lifetime of the measure. In these cases, the team reduced the future savings by increasing the assumed efficiency of the baseline technology at a certain point in the measure life, as illustrated in Figure B-5.

Figure B-5: Calculation of Lifetime Energy Savings with Future Baseline Adjustment



The length of time a measure received credit for the full first year annual energy savings values depended on the timing of the market baseline shift (not the timing of the regulation implementation). The methodology is commonly used by utilities and the team used the specific methodology outlined in the Illinois TRM (SAG, 2012).

57 The Database for Energy Efficient Resources (DEER). Database maintained by the California Public Utilities Commission and the California Energy Commission. *http://www.energy.ca.gov/deer/.* Accessed 7/9/2012.

B.9. ECONOMIC IMPACT ANALYSIS METHODS

A separate portion of the impact evaluation is to estimate BBNP's economic impacts.

B.9.1. ANALYSIS METHODS

The goal of an economic impact analysis of an energy efficiency program is twofold. The analysis should inform interested stakeholders and the public, as well as provide useful, action-oriented information to policymakers and program managers. To that end, the economic impact analysis should: 1) rely on program-specific data whenever possible; 2) be based on a reliable and transparent modeling framework; 3) fully document the modeling approach, the assumptions and limitations of that approach; and 4) report the full range of economic impact results and produce economic impact metrics that policy makers can use to improve program performance or affect program outcomes.

In contrast to the energy impact analysis, we utilized the Program Level information contained in the BBNP Quarterly Summary Reports to analyze the economic impact of the program offerings. These reports were used rather than the Project Level data as they contained the information needed for this analysis including program outlays, energy bill savings, and measure spending. As the two primary data sources slightly differ, discrepancies between the energy impact analysis and the economic analysis may exist.

Overview

Measuring the economic impacts estimated for BBNP is a complex process, as spending by grantees and program participants unfold over time for over 40 separate grantee offerings. From this perspective, the most appropriate analytical framework for estimating the economic impacts is to classify them into short-term and long-term impacts:

- **Short-term** impacts are associated with changes in business activity as a direct result of changes in spending (or final demand) by program administrators, program participants, and institutions that provide funding for energy efficiency programs.
- **Long-term** impacts are associated with the potential changes in relative prices, factor costs, and the optimal use of resources among program participants, as well as industries and households linked by competitive, supply-chain, or other factors.

This analysis measures the short-term economic impacts approximated for BBNP. These impacts are driven by changes (both positive and negative) in final demand, and are measured within a static input-output modeling framework that relies on data for an economy at a point in time and assumes that program spending does not affect the evolution of the economy. (This last event is what economists call a change in the "production possibilities frontier" of the economy.) Energy efficiency programs may have longer lasting effects, and this is clearly the case for continued post-installation energy savings. However, long-term, dynamic effects are not measured in this analysis, as it is unlikely that BBNP is causing significant structural changes in the economy given the relatively small magnitude of energy savings achieved relative to the overall size of the national economy.

Input-Output Modeling Framework

The economic modeling framework that best measures these short-term economic impacts is called input-output modeling. Input-output models involve mathematical representations of the economy that describe how different parts (or sectors) are linked to one another. There are several important points about input-output models that should be noted:

- **Input-output models provide a reasonably comprehensive picture of the economic activities within an economy and can be constructed for almost any study area.**
- **Input-output models use a simple, rectangular accounting framework called double-entry accounting.** This results in a model structure that is well ordered, symmetric, and where, by definition, inputs must be equal to outputs.
- **Input-output models are static models in that they measure the flow of inputs and outputs in an economy at a point in time.** With this information and the balanced accounting structure of an input-output model, an analyst can: 1) describe an economy at one time period; 2) introduce a change to the economy; and then 3) evaluate the economy after it has accommodated that change. This type of analysis is called *partial equilibrium* analysis.
- **In order to provide a common unit of measure, all transaction flows in an input-output model are stated in dollars.**

The IMPLAN Model

This analysis relies on an economic impact model of the U.S. economy constructed using the IMPLAN (for IMpact Analysis for PLANning) modeling software.[58] IMPLAN has several features that make it particularly well suited for this analysis:

- **IMPLAN is widely used and well respected.** IMPLAN models are constructed with data assembled for national income accounting purposes, thereby providing a tool that has a robust link to widely accepted data development efforts. The United States Department of Agriculture (USDA) recognized the IMPLAN modeling framework as "one of the most credible regional impact models used for regional economic impact analysis" and, following a review by experts from seven USDA agencies, selected IMPLAN as its analysis framework for monitoring job creation associated with the ARRA.[59]
- **The IMPLAN model's detailed descriptive capabilities provide a full characterization of the U.S. economy**, in, this case, 2011. The IMPLAN model has a wide range of economic data for 440 different industry sectors, as well as for households and government institutions.

58 IMPLAN (for IMpact Analysis for PLANning) was originally developed by the Forest Service of the U.S. Department of Agriculture in cooperation with the Federal Emergency Management Agency and the Bureau of Land Management of the U.S. Department of the Interior in 1993, and is currently licensed and distributed by the IMPLAN Group LLC.

59 See excerpts from an April 9, 2009 letter to MIG, Inc., from John Kort, Acting Administrator of the USDA Economic Research Service, on behalf of Secretary Vilsack, at *www.implan.com*.

- **The logical input-output modeling framework and detailed economic data within the IMPLAN model provide the structure necessary to adjust economic relationships or to build custom production functions for spending and activities that are linked back to BBNP.** This detailed and flexible modeling system permits the most accurate mapping of BBNP program and participant spending, and energy savings, to industry and household sectors in the IMPLAN model.

Terminology and Impact Metrics

Input-output analysis employs specific terminology to identify the different types of economic impacts. BBNP affects the economy *directly*, through the purchases of goods and services. Under our program-centric approach, these direct impacts include jobs (person-years of employment)[60] and income for grantee staff that administer and manage energy efficiency programs, contractors who provide audit and retrofit services, and energy efficiency equipment manufacturers. Direct impacts also include changes in spending or output resulting from the energy savings for participating households and businesses.

These direct changes in economic activity will, in turn, *indirectly* generate purchases of intermediate goods and services from other, related sectors of the economy. Because these indirect purchases represent interactions among businesses, they are often referred to as “supply-chain” impacts.

In addition, the direct and indirect increases in employment and income enhance overall economy purchasing power, thereby *inducing* further consumption- and investment- driven stimulus. These induced effects are often referred to as “consumption-driven” impacts. In this report, the indirect and induced impacts are grouped together and reported as “secondary” impacts.

The IMPLAN model reports the following impact measures:

- **Output** is the value of production for a specified period of time. Output is the broadest measure of economic activity, and includes intermediate goods and services and the components of value added (personal income, other income, and indirect business taxes). As such, output and personal income should not be added together.
- **Personal income** is the sum of wages and business income.
    - **Wages** includes workers’ wages and salaries, as well as other benefits such as health and life insurance, retirement payments, and noncash compensation.
    - **Business income** also is called proprietary income (or small business income) and represents the payments received by small-business owners or self-employed workers. Business

[60] The term “person-year of employment” is often used when measuring jobs to emphasize the transitory nature of program-related employment. In the case of these BBNP programs, the initial employment will last as long as program funding is available to encourage the installation of energy efficient equipment. As discussed earlier in the report, longer term employment gains also occur due to energy bill savings enjoyed by customers over the life of the equipment. For reporting purposes, all IMPLAN job estimates in this report have been converted to full-time equivalents, which represent a very specific person-year of employment (that is, a worker employed at least 2,080 hours in a standard year).

income would include, for example, income received by private business owners including doctors, accountants, lawyers, and others.

- **Job** impacts include both full- and part-time employment. These job impacts are measured in person-years of employment, and reported as full-time equivalent (FTE).[61]

All of the economic impacts in this analysis are transitory and depend on program spending by BBNP grantees, as well as spending and energy savings for program participants. As discussed previously, economic impacts are estimated for program outcomes over the Q1 2010 through Q3 2013 time period. Because this twelve-quarter time period includes partial years in 2010 and 2013, the economic impact modeling was conducted on a quarterly basis. Economic impact modeling on a quarterly basis presents certain complications, and it is important to understand the modeling issues associated with such analyses and how they affect the reporting of modeling results.

There are two main issues with quarterly analyses. First, the economic relationships in the IMPLAN model are based on annual data (for example, average annual output or income per worker). Second, the secondary spending effects are assumed to take place over a year even though the timing of the direct spending effects is known. Simply put, it takes time for the supply-chain and consumption-driven spending effects to ripple through the economy, with most analyses assuming this duration to be one year.

In most cases, summing quarterly spending across years can address these issues. In this analysis, partial years of activity in 2010 and 2013 prevent this outcome. Instead, the direct effects are assumed (or, more precisely, known) to occur in each quarter, with the direct job effects multiplied by four (the number of quarters in a year) while the direct monetary effects are not adjusted. For example, $1 million in spending for a labor-only service, where the average annual wage is $100,000, will generate 10 jobs over the course of a year (that is, the equivalent of ten positions each lasting one year or ten person-years of employment). Instead, if this $1 million in spending occurred in one quarter, it would support 40 jobs in that quarter (that is, person-quarter-years of employment). It is clear from this example that the average earnings for this quarter-year of work are $25,000, consistent with an average annual wage of $100,000 for a single person working fulltime. Perhaps more importantly, the 40 “jobs” in the quarter are equivalent to 10 person-years of employment, which is consistent with the initial example of 10 direct jobs if this spending occurred over the course of an entire year.

Gross and Net Impacts

Citing the economic impacts that occur as a result of an efficiency program provides an upper bound estimate of impacts. This upper bound estimate is often referred to as a measure of the *gross* economic impacts. Gross economic impacts offer a perspective on the magnitude of overall impacts that can be

61 The IMPLAN modeling software measures jobs as the annual average of monthly jobs in each industry (this is the same definition used by Quarterly Census of Employment and Wages [QCEW], U.S. Bureau of Labor Statistics [BLS], and U.S. Bureau of Economic Analysis [BEA] nationally). Thus, one job is equivalent to one person being employed for the duration of one year, two people being employed for half a year each, three people being employed for a third of a year each, etc. Furthermore, IMPLAN jobs include full-time, part-time, and temporary positions. For reporting purposes, all IMPLAN job estimates in this report have been converted to full-time equivalents (2,080 hours in a standard year).

traced back to the program; however, they do not necessarily reflect or measure the creation of new jobs or income.

An analysis of the *net* economic impacts requires that only economic stimuli that are new or additive to the economy be counted. To address this, the impact analysis first defines a Base Case scenario that describes what would have happened in the absence of the program. This base case scenario is typically implemented by posting a counterfactual argument that only counts economic activity that "but for" the program would not have occurred. The distinction between gross and net impacts for BBNP is important because federal funding used to support grantee energy efficiency programs will divert spending from other federal government programs. An additional alternative counterfactual also is explored and outlined in more detail in the next section of the report.

For energy efficiency programs, the *gross economic impacts* reflect the economic impacts without adjustments for impacts that might have occurred from spending in the base case scenario. Gross impacts include:

- **Program outlays** as BBNP grantees incur administrative costs, and purchase labor and materials to carry out their energy efficiency programs. (There are three major categories of program outlays, and these are discussed in detail in the next section of the report.)
- **Measure spending** represents spending on efficiency upgrades. Measure spending is allocated to equipment and labor, mapped to North American Industry Classification System (NAICS) codes, and then mapped to sectors in the economic impact model.
- **Reductions in energy consumption** and the associated increase in household disposable income and lower operating costs for businesses.[62]
  - **For residential program participants, lower energy costs will increase household disposable income.** These estimated residential energy bill savings are fed into a modified household consumption function (household spending on goods and services *less* expenditures on energy) to estimate how this additional spending affects the economy.
  - **For businesses, energy savings lowers production costs, which, in the short run, leads to changes in output.** To estimate the economic impacts associated with these lower energy costs, the project team implemented a 1-for-1 dollar change (that is, a $1 decrease in energy costs was assumed to be equivalent to an increase in production by $1).[63]

62 Both a realization rate adjustment and a net-to-gross adjusted will be applied to the energy bill savings in the final evaluation report. For the preliminary evaluation, the gross and net energy impact analysis was not completed in time for either of these adjustments to be incorporated into the economic impact analysis. The net-to-gross adjustment also will be applied to measure spending in the economic analysis conducted for the final evaluation report.

63 An economic impact analysis of a proposed cap-and-trade emissions reduction strategy conducted by ECONorthwest corroborates this method. This analysis found that the elasticity of production relative to energy costs was very close to -1.0 for many sectors of the economy. More details are available at: *http://www.ecy.wa.gov/climatechange/docs/20100707_wci_econanalysis.pdf*

- **Reductions in utility revenues** as households and businesses consume less electricity. To be balanced in our analysis, these revenue decreases are included in the analysis. To be consistent with reductions in energy consumption, these revenue decreases are included in post-installation quarters between Q1 2010 and Q3 2013. They are not, however, included in annual energy savings impacts beyond this twelve-quarter period.

The net economic impacts estimated for BBNP include adjustments to reflect the economic activity that occurs in the base case scenario. That is, net impacts are those impacts over and above what would have occurred in the base case scenario. The *net economic impacts* estimated for BBNP are based on:

- **Gross program impacts** (discussed above).
- **Less foregone federal spending on nondefense programs** as a result of the federal funding that is allocated to BBNP grantees.

B.9.2. MODEL INPUT DATA

The economic analysis relies on data for BBNP spending and activities between Q1 2010 and Q3 2013, as gathered from DOE Quarterly Summary Reports and, where necessary, detailed quarterly spreadsheets completed by program grantees. There are limitations to these data as they relate to the economic impact analysis. That is, these data were gathered to monitor program performance and potential market transformation effects. In some instances, detailed spending data necessary for economic impact modeling were not explicitly reported. Moreover, these data were gathered from 41 BBNP grantees, each implementing their own energy efficiency program(s). Thus, there was a degree of inconsistency in reporting across grantees.

BBNP tracks grantee spending for three major outlay categories: Marketing and Outreach (M&O), Labor and Materials (L&M), and Other. BBNP also tracks certain data for three major activity categories: audits (assessments), energy upgrades (retrofits), and loans. These outlay and activity categories are discussed in more detail below, as they relate to the economic impact analysis. They have been reorganized somewhat to facilitate the economic impact modeling process.

Outlays

BBNP outlays (or program expenditures) are reported, by grantee and quarter, for three major outlay categories in the Quarterly Summary Reports. These outlays are summarized in Table B-25. Between Q1 2010 and Q3 2013, total program outlays by BBNP grantees amounted to approximately $445.2 million (87.6% of total funds granted).

Table B-25: BBNP Outlays by Major Outlay Category

QUARTER / YEAR	MARKETING & OUTREACH (M&O)	LABOR & MATERIALS (L&M)	OTHER	TOTAL OUTLAYS
Q1 2010	$2,112,592	$2,132,578	$12,056,392	$16,301,563
Q1 2011	$4,326,945	$1,543,171	$12,202,950	$18,073,066

QUARTER / YEAR	MARKETING & OUTREACH (M&O)	LABOR & MATERIALS (L&M)	OTHER	TOTAL OUTLAYS
Q2 2011	$6,425,745	$10,899,299	$26,142,372	$43,467,417
Q3 2011	$6,738,810	$6,860,799	$26,789,014	$40,388,623
Q4 2011	$6,741,127	$5,964,228	$32,057,431	$44,762,785
Q1 2012	$12,942,750	$5,756,861	$23,798,764	$42,498,375
Q2 2012	$6,355,288	$9,803,836	$25,257,991	$41,417,115
Q3 2012	$5,445,143	$14,064,872	$22,416,247	$41,926,261
Q4 2012	$5,394,885	$14,996,178	$25,353,475	$45,744,538
Q1 2013	$3,713,080	$12,411,082	$17,055,328	$33,179,490
Q2 2013	$5,747,231	$15,384,053	$20,366,429	$41,497,713
Q3 2013	$5,271,870	$16,870,443	$13,823,158	$35,965,471
Total All Quarters	$71,215,466	$116,687,400	$257,319,550	$445,222,416

Continued…

Source: BBNP Quarterly Summary Reports.

The data and modeling assumptions for each major outlay category are as follows.

- **Marketing and Outreach (M&O)** outlays totaled $71.2 million between Q1 2010 and Q3 2013. This represents 16% of total outlays over the twelve quarters. M&O outlays consist of "grant outlays for communications activities designed to identify, reach and motivate potential program participants to take actions to either learn more (for example, audit or other informational activity) energy efficiency or initiate an energy efficiency retrofit at the PROGRAM level."[64] Total M&O outlays are reported by grantee in the Quarterly Summary Reports. Detailed M&O activities (for example, business organization outreach, online and traditional advertising, neighborhood meetings, websites, and webinars) also are reported, by grantee, in the Quarterly Summary Reports. However, there is no correspondence or conformity between detailed activities and outlays. That is, detailed M&O spending is not reported. As such, this analysis applies a dollar-value-weighting factor (or roughly an average cost per M&O activity) to the reported number of activities taking place each quarter to allocate total M&O spending in that quarter.

64 Quarterly Programmatic tab in the detailed quarterly spreadsheets.

〉 **Labor and Materials (L&M)** outlays totaled $116.7 million (or 26.2% of total outlays) over the Q1 2010 through Q3 2013 period. According to BBNP reporting instructions, L&M outlays are "Outlays incurred as part of an audit or retrofit directly associated with the installation of more energy efficient equipment, appliances, or building components (for example, insulation, windows, etc.) at the PROGRAM level."[65] Accordingly, L&M outlays are not explicitly included as inputs into the economic impact model. Rather, they are included as part of audit and efficiency upgrade (retrofits) activities as follows:

- **Audit** activity is tracked by number of residential and commercial audits completed, by grantee and quarter, in the Quarterly Summary Reports. Between Q1 2010 and Q3 2013, BBNP grantees accomplished 225,065 residential audits and 7,635 commercial audits. Spending on audits, however, is not explicitly reported and, as discussed previously, audit spending is assumed to be a component of L&M outlays. Using data compiled from the detailed quarterly spreadsheets submitted by BBNP grantees, audit spending was estimated by calculating an average audit cost for residential ($264 per audit) and commercial ($772 per audit) audits between Q1 2010 and Q3 2013 and applying those average costs to the number of residential and commercial audits in each quarter. Audit spending was then modeled by developing a custom production function for Building Inspection Services (NAICS 541350) using audit costs and audit hours from the detailed quarterly spreadsheets to estimate the number of audit jobs (person-years) per million in audit spending.
- **Energy Upgrades** (or retrofits) represent participants' spending on energy efficiency upgrades. Although a small, unknown amount of the costs of the energy upgrades is captured under L&M outlays, most of the costs of energy upgrades are borne by the participant in the form of out-of-pocket expenses or borrowed funds, or supported through other federal and nonfederal incentives and funding. As such, the economic impacts resulting from energy upgrades are, in fact, based on measure spending. Similarly, measure spending also captures the economic impacts associated with the loans initiated by BBNP grantees. (Measure spending is discussed in more detail in the next section.)

〉 **Other** outlays totaled $257.3 million (or 57.8% of total outlays) between Q1 2010 and Q3 2013. Other outlays consist of "Other program grant outlays at the PROGRAM level not classified as materials, labor, marketing, or outreach…(they) represent actual grant funds spent on program delivery and any associated incentives or loans issued during the quarter."[66] Other outlays are reported in total, by grantee, in the Quarterly Summary Reports. Those reports, however, do not include additional information to better understand the nature of these other program delivery costs or to distinguish between program delivery costs and program incentives. This analysis, therefore, relies on energy efficiency program cost data from the U.S. Energy Information

65 Ibid.

66 Quarterly Programmatic tab in the detailed quarterly spreadsheets.

Administration (EIA).[67] Nationally, in 2012, the EIA reports that 56.0% of total energy efficiency program costs went towards incentives, with the remaining 45% of total program costs allocated to direct (39.4% of total program costs) and indirect (5.5%) costs.[68] Incentive spending supports participants' spending on efficiency upgrades, but represents a transfer rather than a change in final demand. Accordingly, incentive spending was not explicitly included in the economic impact model. Other delivery costs were modeled through a custom production function for energy efficiency program activities, after removing potentially duplicate activities such as marketing and outreach, and auditing.

Measure Spending

Measure spending, as measured by invoiced costs (equivalently, total project cost), represent a significant positive stimulus effect that is not explicitly captured by BBNP outlay categories, or program audit and loan activities. Table B-26 summarizes BBNP efficiency project activities for residential and commercial sectors, as reported in the Quarterly Summary Reports or calculated from those data. The totals in this table were sourced from the Quarterly Summary Reports, which had the information needed to conduct the economic analysis. These totals may differ slightly from those used in the energy impact analysis as that analysis utilized the project level data. As discussed previously, there were discrepancies between these two data sources.

Table B-26: Summary of BBNP Efficiency Upgrades, by Sector

QUARTER / YEAR	RESIDENTIAL EFFICIENCY UPGRADES			COMMERCIAL EFFICIENCY UPGRADES			ALL UPGRADES
	Number of Upgrades	Average Invoiced Cost[a]	Total Invoiced Costs	Number of Upgrades	Average Invoiced Cost[a]	Total Invoiced Costs	Total Invoiced Costs
Q1 2010	4,195	$8,575	$35,974,205	45	$10,181	$458,137	$36,432,342
Q1 2011	4,247	$7,339	$31,170,664	107	$7,748	$829,040	$31,999,704
Q2 2011	4,060	$6,266	$25,439,628	134	$17,796	$2,384,708	$27,824,336
Q3 2011	4,579	$7,352	$33,665,891	219	$72,120	$15,794,263	$49,460,154
Q4 2011	5,177	$6,989	$36,179,533	370	$54,545	$20,181,716	$56,361,249
Q1 2012	6,108	$7,173	$43,810,715	355	$48,073	$17,066,043	$60,876,758

67 U.S. Energy Information Administration's (EIA's) *Annual Electric Power Industry Report*, 2012, Survey Form EIA-861, File 3A. According to the EIA, direct costs are "The cost for implementing energy efficiency programs (in thousand dollars) incurred by the utility." Incentive costs or payment represent a "Payment by the utility to the customer for energy efficiency incentives. Examples of incentives are zero or low-interest loans, rebates, and direct installation of low cost measures, such as water heater wraps or duct work." Lastly, indirect costs are "A utility cost that may not be meaningfully identified with any particular DSM program category. Indirect costs could be describe to one of several accounting cost categories (that is, Administrative, Marketing, Monitoring & Evaluation, Utility-Earned Incentives, Other)."

68 Although program incentives do not explicitly enter the economic impact model as a positive stimulus, they are included with program outlays in the counterfactual spending scenario.

QUARTER / YEAR	RESIDENTIAL EFFICIENCY UPGRADES			COMMERCIAL EFFICIENCY UPGRADES			ALL UPGRADES
	Number of Upgrades	Average Invoiced Cost[a]	Total Invoiced Costs	Number of Upgrades	Average Invoiced Cost[a]	Total Invoiced Costs	Total Invoiced Costs
Q2 2012	8,862	$6,275	$55,612,927	357	$37,752	$13,477,569	$69,090,496
Q3 2012	10,319	$6,493	$67,005,632	409	$62,928	$25,737,512	$92,743,144
Q4 2012	14,195	$6,313	$89,615,839	465	$58,197	$27,061,673	$116,677,512
Q1 2013	13,834	$6,487	$89,735,939	517	$85,267	$44,082,962	$133,818,901
Q2 2013	14,042	$6,432	$90,312,228	393	$63,652	$25,015,118	$115,327,346
Q3 2013	15,167	$5,950	$90,243,430	353	$83,037	$29,311,944	$119,555,374
Total All Quarters	104,785	$6,573	$688,766,631	3,724	$59,452	$221,400,685	$910,167,316

Source: BBNP Quarterly Summary Reports.

Note: The Quarterly Summary Reports refer to efficiency upgrades as "retrofits" and include the number and average invoiced cost for residential and commercial retrofits, by grantee, for each quarter. This information was used to calculate the weighted average invoice cost and, then, total invoice costs for each quarter.

According to calculations made using data from the Quarterly Summary Reports, it is estimated that BBNP supported approximately $688.8 million in residential and $221.4 million in commercial efficiency upgrades between Q1 2010 and Q3 2013.

A wide range of energy efficiency measures were installed as part of these efficiency upgrades, and the mix of measures changes over time. Although it is possible to calculate total spending on efficiency upgrades, by quarter and sector, the Quarterly Summary Reports do not provide a break out of spending across energy efficiency measures. To determine measure spending for each sector, this analysis used the detailed quarterly spreadsheets submitted by BBNP grantees to: 1) extract measure counts and total invoice amounts for each project; 2) estimate average measure costs using total invoice amounts for projects that consisted of a single measure; 3) apply the average measure cost to measure counts to calculate total measure spending for each quarter; 4) normalize total measure spending for each quarter on a "per million dollar" basis; and 5) apply the normalized measure spending functions to the total spending reported, by sector. Measure spending for each quarter was allocated to equipment and labor, and to the relevant industry sector using NAICS codes and IMPLAN industry codes.

Energy Savings

The Quarterly Summary Reports include the annual energy savings (both physical units and dollar value) associated with efficiency upgrades in each quarter.[69] Table B-27 reports the annual energy savings, by fuel type, and the estimated annual energy bill savings estimated for BBNP between Q1 2010 and Q3 2013. It is important to clarify that the annual energy savings and annual costs savings included in the Quarterly Summary Reports and shown in Table B-27 represent the benefits of the efficiency upgrade over the course of an entire year, and include the realization rates and NTG ratio determined as part of the BBNP final evaluation activities. The spending and production benefits to residential and commercial participants, respectively, in each quarter will be one-fourth of these reported annual amounts.

Table B-27: Reported Annual Energy Savings, by Fuel Type, and Estimated Annual Bill Savings

QUARTER / YEAR	ELECTRICITY (KWH)	NATURAL GAS (THERMS)	HEATING OIL (GALLONS)	LPG (GALLONS)	KEROSENE (GALLONS)	ESTIMATED ANNUAL BILL SAVINGS ($)
Q1 2010	1,965,348	347,884	430,472	966	0	$2,343,058
Q1 2011	4,010,656	536,584	126,545	1,589	0	$1,582,069
Q2 2011	4,763,523	415,534	153,531	3,462	338	$1,653,704
Q3 2011	9,409,680	538,530	197,876	8,928	194	$2,538,377
Q4 2011	12,058,105	747,971	40,537	52,809	66	$2,577,379
Q1 2012	17,438,294	937,618	47,379	12,218	152	$3,347,695
Q2 2012	13,940,213	835,641	106,818	10,488	295	$3,049,324
Q3 2012	16,631,263	950,782	123,958	23,465	503	$3,603,985
Q4 2012	22,148,032	1,504,441	276,690	20,399	774	$5,478,601
Q1 2013	24,363,939	1,658,274	275,201	15,889	460	$5,894,113
Q2 2013	16,607,331	1,338,261	201,952	24,242	211	$4,340,284
Q3 2013	28,057,508	1,241,777	92,943	10,662	482	$5,135,876
Total All Quarters	171,393,894	11,053,295	2,073,901	185,115	3,475	$41,544,464

Continued…

Source: BBNP Quarterly Summary Reports.

69 This analysis uses reported annual energy savings in the Quarterly Summary Reports. This information is self-reported by grantees in the detailed quarterly spreadsheets, and, according to the Quarterly Programmatic tab, grantees are asked to, "*Please enter the total annual bill savings based on the total measures installed during the most recent quarter. *If direct installation was conducted in your program, please include here the estimated savings from those efforts. In the Methodology tab, you can specify what types of measures were undertaken in your direct installation efforts.*" Most grantees did not provide additional information for direct installations.

Although the Quarterly Summary Reports include annual energy and bill savings by grantee and quarter, they do not break out the annual costs savings for residential and commercial sectors. Therefore, this analysis uses project-level data reported in grantees' detailed quarterly spreadsheets to allocate total annual energy bill savings to residential (72.0% of total bill savings) and commercial (28.0%) sectors.

Residential energy bill savings will increase the purchasing power of households on non-energy goods and services. Energy bill savings for commercial participants will lower their costs of production and, in the short run, lead to an increase in output. To estimate the changes in output, the distribution of energy bill savings was estimated across business sectors using the "Principle Building Type" variable in the grantees' detailed quarterly spreadsheets.[70]

The efficiency gains shown in Table B-26 could result in a loss of revenue to utilities and other fuel providers (producers of heating oil and propane), and this loss of revenue is included in the gross economic impacts.[71] If utilities and other fuel providers had similar economic impact multipliers as other sectors in the economy, then the energy bill savings in other sectors would roughly cancel out the loss of revenue in the utility sector. To be consistent with reductions in energy consumption, these revenue decreases are included in post-installation quarters between Q1 2010 and Q3 2013. They are not, however, included in annual energy savings impacts beyond this twelve-quarter period.

B.10. LEVERAGING (JAMES WOLF METHODOLOGY AND APPLICATION)

In order to gain a more consistent view of leveraging activities across grantees, DOE asked the research team to investigate grantees' use of leveraged funds using the methodology James Wolf reported in "*A Proposed Methodology to Determine the Leveraging Impacts of Technology Deployment Programs"* (Wolf, 2008). This methodology yields a conservative lower-bound estimate of quantity of funds leveraged.

Wolf specifies a definition for identifying leveraged funds that attempts to account for additionality in the calculation of leverage. The definition of leveraging DOE articulated in its Funding Opportunity Announcement (FOA) for BBNP, which includes "building owner contributions, partner contributions, in-kind contributions, project revenues, other federal funds (including other DOE funds), and state funds," is more consistent with popular usage and the methods of previous evaluators (DOE, 2009). The Wolf methodology is more stringent than was typical of the studies he reviewed and results in fewer funding sources or monies qualifying as leveraging.

Wolf's method begins with an investigation of the uses to which the non-program monies are applied. The method builds on a foundation of logic modeling and distinguishes between program activities, outputs, and outcomes. The method has two criteria associated with the monies' usage: 1) that the monies fund activities, not outputs or outcomes; and 2) that the monies fund what Wolf calls "direct"

70 The detailed quarterly spreadsheets provide grantees with a drop down menu for the Principle Building Type variable. Although infrequently populated, this approach likely generated a more consistent set of responses.

71 The economic impacts in future post-BBNP years do not include an adjustment for foregone utility revenues.

program activities – activities that are essential to the program's logic, and without which one or more outputs or outcomes would not be attained.

The first criteria (monies for activities) excludes from consideration of leverage funds the monies participants invest in their upgrades. While reducing participants' first costs through the provision of incentives is a program activity, measure installation (with the exception of any direct-install measures; that is, measures the program installs for free in all applicable participants' homes) is a program intermediate outcome, and the energy savings from the measure installations is a final program outcome.

The second criteria (monies for direct activities) excludes what the author calls "indirect" activities – activities that are complementary to the program's objectives but not essential to attaining outputs or outcomes. Research and development of emerging technologies is an example of an indirect activity for a program that provides incentives for high efficiency measures. As an example of a qualifying direct activity, a program might receive funds that enable it to serve an additional neighborhood or town. In this case, the program is using the funding source to conduct its direct activities in a territory it would not otherwise serve.

The Wolf methodology also defines three additionality criteria – timing, character of the contribution, and relative magnitude of funds. The first additionality criteria is timing. If the non-program funding source was already conducting qualifying activities (that is, direct program activities per the logic model) and subsequently the program accessed the non-program funding to conduct these activities, then these non-program funds cannot be considered as leveraged by the program. Indeed, in this case, the non-program funding source can be considered to have leveraged the program funds. The issue is one of possible causality: Would the outputs from the direct program activities funded by the non-program source have occurred in the absence of the program? If the non-program source was active prior to the program, the causality answer is "no." As applied to BBNP, this criteria means that none of the program administrator funds that benefited BBNP participants can be considered as funds that BBNP leveraged, if those funds were available prior to the launch of the BBNP-funded program. Rather, by this criteria, the program administrator leveraged BBNP funding.

The second additionality criteria is what Wolf calls "the character of the contribution" made by the program and the external source of funds. This criteria directs evaluators to consider what both the program and the non-program funding source contributed to the activities the external funds supported, including non-financial support like staff time and expertise. As with the consideration of timing, this consideration fundamentally seeks to determine likely causality: would the activities the non-program funding supported have occurred in the absence of the program or was the program's contribution instrumental in allowing those activities to occur.

The third additionality criteria assesses the relative magnitude of funds. If the amount of non-program funds is disproportionately greater than the program funds for the activity, then it seems unlikely that the program elicited the non-program funding; the methodology calls on the evaluator to make a judgment call as to whether leveraging occurred.

The author discusses, but does not specify in the criteria, the treatment of inter-governmental transfers. We exclude inter-governmental transfers of funds from its estimation on the following basis:

Leveraging has become an important issue for government programs as the current political climate (irrespective of partisan politics) favors public-private partnerships, by which taxpayers receive "more for their money" than they do with projects funded entirely by taxes. Taxpayers receive no more for their money when two governmental funding streams are combined to fund a set of activities – the funds are still all derived from taxes. Indeed, if governmental Office B decides to co-fund the activities of governmental Office A, one might wonder what Office B has now left unfunded and thus undone. Taxpayers are likely to have differing opinions on the relative importance of the co-funded activity of Office A and the resulting unfunded/undone activity of Office B.

Wolf suggests applying the steps of his methodology in succession for each funding source used by the program. Thus, the evaluator would explore for each funding source the activity or activities funded, the activity status as direct or indirect, the timing of each source compared to program start, the character of the contribution, and the relative magnitude of each source compared to program funds.

We developed an in-depth interview guide (see Appendix L) to obtain the information required by the Wolf methodology and interviewed 15 grantees that reported leveraged funds collectively comprising 78% of all funds grantees reported to DOE as leveraged. We conducted the interviews, lasting about one-half hour in length, between September 2013 and January 2014. We analyzed the data according to Wolf's method to identify amount of leveraged funds.

APPENDIX C. BILLING REGRESSION FINDINGS SUPPLEMENT

The following supplementary material provides expanded detail to material provided in the main report body.

C.1. FINAL MODEL RESULTS

Table C-1 and Table C-2 provide the expanded results of the residential electricity model; Table C-3 and Table C-4 provide the expanded results of the residential gas model; Table C-5 through Table C-8 provide analogous results for the commercial electricity and gas models.

Table C-1: Descriptive Statistics – Residential Electricity Model

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	938.61
Average Post-Retrofit Billing Months	17.01
Average Pre-Retrofit Billing Months	24.49
Adjusted R-Squared Statistic	0.251
Average Monthly Savings	8.13%

Table C-2: Detailed Residential Electricity Model Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
(β_1) Post	-76.2730	1.8493	-41.2445	0.00%	(-79.898, -72.648)
(β_2) HDD	0.3288	0.0068	48.5984	0.00%	(0.316, 0.342)
(β_3) CDD	1.7811	0.0130	137.2140	0.00%	(1.756, 1.807)
(β_4) January	58.2920	4.8647	11.9827	0.00%	(48.757, 67.827)
(β_5) February	-28.8830	4.7329	-6.1026	0.00%	(-38.159, -19.607)
(β_6) March	-65.8100	4.5505	-14.4619	0.00%	(-74.729, -56.891)
(β_7) April	-119.3200	4.7674	-25.0275	0.00%	(-128.664, -109.976)
(β_8) May	-130.5300	5.2786	-24.7291	0.00%	(-140.876, -120.184)
(β_9) June	-112.6100	6.7272	-16.7390	0.00%	(-125.795, -99.425)
(β_{10}) July	-90.8750	8.2524	-11.0119	0.00%	(-107.05, -74.7)
(β_{11}) August	-97.8950	8.5936	-11.3916	0.00%	(-114.738, -81.052)

Continued…

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
(β_{12}) September	-132.0000	7.8255	-16.8686	0.00%	(-147.338, -116.662)
(β_{13}) October	-130.0100	6.1036	-21.3013	0.00%	(-141.973, -118.047)
(β_{14}) November	-99.4510	4.9763	-19.9850	0.00%	(-109.205, -89.697)

Table C-3: Descriptive Statistics – Residential Natural Gas Model

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	66.74
Average Post-Retrofit Billing Months	17.70
Average Pre-Retrofit Billing Months	30.22
Adjusted R-Squared Statistic	0.740
Average Monthly Savings	12.44%

Table C-4: Detailed Residential Natural Gas Model Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
(β_1) Post	-8.2989	0.1678	-49.4444	0.00%	(-8.628, -7.97)
(β_2) HDD	0.1088	0.0006	177.8291	0.00%	(0.108, 0.11)
(β_3) January	9.3653	0.4242	22.0786	0.00%	(8.534, 10.197)
(β_4) February	3.9816	0.4149	9.5957	0.00%	(3.168, 4.795)
(β_5) March	-3.7755	0.3898	-9.6852	0.00%	(-4.539, -3.011)
(β_6) April	-20.3374	0.4082	-49.8206	0.00%	(-21.138, -19.537)
(β_7) May	-28.3123	0.4452	-63.5943	0.00%	(-29.185, -27.44)
(β_8) June	-27.1407	0.5284	-51.3667	0.00%	(-28.176, -26.105)
(β_9) July	-22.3499	0.5884	-37.9820	0.00%	(-23.503, -21.197)
(β_{10}) August	-21.9704	0.5908	-37.1859	0.00%	(-23.128, -20.812)
(β_{11}) September	-24.1872	0.5780	-41.8438	0.00%	(-25.32, -23.054)
(β_{12}) October	-26.0158	0.5055	-51.4608	0.00%	(-27.007, -25.025)
(β_{13}) November	-15.4198	0.4363	-35.3435	0.00%	(-16.275, -14.565)

Table C-5: Descriptive Statistics – Commercial Electricity Model

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	2,266.20
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.251
Average Monthly Savings	12.11%

Table C-6: Detailed Commercial Electricity Model Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
(β_1) Post	-274.3584	16.0095	-17.1372	0.00%	(-305.737, -242.98)
(β_2) HDD	0.8947	0.0635	14.0968	0.00%	(0.77, 1.019)
(β_3) CDD	1.0859	0.0748	14.5202	0.00%	(0.939, 1.232)
(β_4) January	-141.9472	41.6572	-3.4075	0.07%	(-223.595, -60.299)
(β_5) February	-107.8974	40.1998	-2.6840	0.73%	(-186.689, -29.106)
(β_6) March	25.6796	38.1837	0.6725	50.13%	(-49.16, 100.52)
(β_7) April	122.9841	39.7826	3.0914	0.20%	(45.01, 200.958)
(β_8) May	326.6888	44.1199	7.4046	0.00%	(240.214, 413.164)
(β_9) June	666.1090	57.0206	11.6819	0.00%	(554.349, 777.869)
(β_{10}) July	1017.5692	72.5608	14.0237	0.00%	(875.35, 1159.788)
(β_{11}) August	918.8735	75.0332	12.2462	0.00%	(771.808, 1065.938)
(β_{12}) September	673.8246	71.6745	9.4012	0.00%	(533.343, 814.307)
(β_{13}) October	268.2838	57.4955	4.6662	0.00%	(155.593, 380.975)
(β_{14}) November	-29.3217	44.3908	-0.6605	50.89%	(-116.328, 57.684)

Table C-7: Descriptive Statistics – Commercial Natural Gas Model

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	89.30
Average Post-Retrofit Billing Months	19.81
Average Pre-Retrofit Billing Months	28.75
Adjusted R-Squared Statistic	0.575
Average Monthly Savings	10.25%

Table C-8: Detailed Commercial Natural Gas Model Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
(β_1) Post	-9.1571	4.8316	-1.8953	5.90%	(-18.627, 0.313)
(β_2) HDD	0.1526	0.0212	7.1846	0.00%	(0.111, 0.194)
(β_3) January	13.1715	12.5219	1.0519	29.37%	(-11.371, 37.714)
(β_4) February	0.8950	12.2271	0.0732	94.17%	(-23.07, 24.86)
(β_5) March	16.8889	11.3075	1.4936	13.63%	(-5.274, 39.052)
(β_6) April	-4.2179	12.6962	-0.3322	74.00%	(-29.103, 20.667)
(β_7) May	-8.9543	14.2802	-0.6270	53.11%	(-36.943, 19.035)
(β_8) June	-3.2558	18.4170	-0.1768	85.98%	(-39.353, 32.842)
(β_9) July	5.6943	21.1850	0.2688	78.83%	(-35.828, 47.217)
(β_{10}) August	9.1260	21.2839	0.4288	66.84%	(-32.591, 50.842)
(β_{11}) September	2.1800	20.3833	0.1070	91.49%	(-37.771, 42.131)
(β_{12}) October	-10.8552	15.8960	-0.6829	49.52%	(-42.011, 20.301)
(β_{13}) November	9.6147	12.7531	0.7539	45.15%	(-15.381, 34.611)

Table C-9 shows the energy savings estimates for each of the 19 grantees in the billing regression analysis sample and expresses them as a share of consumption for residential buildings, and Table C-10 shows the energy savings estimates for the three grantees in the billing regression analysis sample with commercial buildings.

In total, nine of the grantees examined in the residential billing regression analysis met or exceeded the DOE goal of 15 percent savings with the largest average per-project electricity impact being achieved by Grantee 13, and the efficiency improvements made by Grantee 6 resulted in the largest per-project average gas savings. An additional two grantees (Grantee 1 and Grantee 5) achieved at least 15 percent energy savings, on average, on commercial projects.

Table C-9: Residential Electricity and Natural Gas Fuel Savings by Grantee

GRANTEE NAME	ELECTRICITY		NATURAL GAS	
	Average Monthly Savings (kWh)	Average Monthly Savings (Percent of consumption)	Average Monthly Savings (therms)	Average Monthly Savings (Percent of consumption)
Grantee 1	27.632	3.93%	4.372	6.54%
Grantee 2	169.288	15.21%	5.400	13.25%
Grantee 3	22.673	3.70%	14.354	17.07%
Grantee 4	34.997	3.80%	9.660	10.19%
Grantee 5	162.575	9.84%	NA	NA
Grantee 6	-15.420	-2.25%	20.514	49.40%
Grantee 7	-107.553	-8.70%	6.258	9.07%
Grantee 8	228.485	15.70%	NA	NA
Grantee 9	287.590	28.70%	22.566	31.04%
Grantee 10	266.953	21.23%	11.109	18.57%
Grantee 11	-1.817	-0.22%	NA	NA
Grantee 12	105.202	15.63%	16.544	25.06%
Grantee 13	1308.359	61.45%	NA	NA
Grantee 14	61.740	8.82%	NA	NA
Grantee 15	33.693	3.49%	7.967	8.67%
Grantee 16	54.394	4.89%	NA	NA
Grantee 17	50.143	6.65%	3.370	4.27%
Grantee 18	261.862	16.66%	NA	NA
Grantee 19	133.535	10.95%	NA	NA

Table C-10: Commercial Electricity and Natural Gas Fuel Savings by Grantee

GRANTEE	ELECTRICITY		NATURAL GAS	
	Average Monthly Savings (kWh)	Average Monthly Savings (Percent of consumption)	Average Monthly Savings (therms)	Average Monthly Savings (Percent of consumption)

Grantee 1	212.341	30.23%	9.157	13.70%
Grantee 5	415.920	25.17%	NA	NA
Grantee 12	-382.336	-56.81%	NA	NA

C.2. MODELS BY RESIDENTIAL SUBSECTOR: SINGLE-FAMILY, MULTIFAMILY UNITS, AND MULTIFAMILY BUILDINGS

The following model output uses the final residential electricity model specifications and filters presented in this report, and presents the models by subsector: single-family, multifamily units, and multifamily buildings.

Table C-11: Residential Electricity Savings by Building Type

BUILDING TYPE	OBSERVATIONS	HOUSEHOLDS	AVERAGE MONTHLY SAVINGS (KWH)	AVERAGE MONTHLY SAVINGS PERCENT OF CONSUMPTION)
Single-family	128,853	3,471	87.85	8.71%
Multifamily Units	31,089	740	18.20	2.80%
Multifamily Buildings	257	9	353.44	70.90%
All Residential	160,199	4,220	76.27	8.13%

Table C-12: Descriptive Statistics – Single-family Electricity Model

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	1,009.20
Average Post-Retrofit Billing Months	17.40
Average Pre-Retrofit Billing Months	23.69
Adjusted R-Squared Statistic	0.270
Average Monthly Savings	8.71%

Table C-13: Single-family Electricity Model Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-87.8550	2.2072	-39.8038	0.0000	(-92.18, -83.53)
HDD_NORM	0.2833	0.0080	35.2238	0.0000	(0.27, 0.3)
CDD_NORM	1.8317	0.0147	124.2415	0.0000	(1.8, 1.86)
JAN	80.6210	5.7846	13.9371	0.0000	(69.28, 91.96)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
FEB	-16.5790	5.6511	-2.9339	0.0033	(-27.66, -5.5)
MAR	-66.1550	5.4401	-12.1608	0.0000	(-76.82, -55.49)
APR	-146.7000	5.6913	-25.7760	0.0000	(-157.85, -135.55)
MAY	-166.0000	6.3399	-26.1837	0.0000	(-178.43, -153.57)
JUN	-143.8200	8.0095	-17.9559	0.0000	(-159.52, -128.12)
JUL	-112.9200	9.7000	-11.6416	0.0000	(-131.93, -93.91)
AUG	-129.4700	10.1370	-12.7714	0.0000	(-149.34, -109.6)
SEP	-168.0700	9.1846	-18.2995	0.0000	(-186.07, -150.07)
OCT	-166.1100	7.1945	-23.0885	0.0000	(-180.21, -152.01)
NOV	-127.3500	5.8712	-21.6904	0.0000	(-138.86, -115.84)

Continued…

Table C-14: Descriptive Statistics – Multifamily Units Electricity Model

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	649.71
Average Post-Retrofit Billing Months	15.41
Average Pre-Retrofit Billing Months	27.86
Adjusted R-Squared Statistic	0.133
Average Monthly Savings	2.80%

Table C-15: Multifamily Units Electricity Model Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-18.2025	2.5030	-7.2724	0.0000	(-23.11, -13.3)
HDD_NORM	0.2368	0.0126	18.8513	0.0000	(0.21, 0.26)
CDD_NORM	0.9059	0.0361	25.1261	0.0000	(0.84, 0.98)
JAN	21.4446	6.7826	3.1617	0.0016	(8.15, 34.74)
FEB	-19.3860	6.4606	-3.0007	0.0027	(-32.05, -6.72)
MAR	-45.7306	6.0623	-7.5435	0.0000	(-57.61, -33.85)
APR	-64.9973	6.6175	-9.8221	0.0000	(-77.97, -52.03)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MAY	-76.1327	7.3084	-10.4172	0.0000	(-90.46, -61.81)
JUN	-69.7302	9.4563	-7.3739	0.0000	(-88.26, -51.2)
JUL	-17.0893	12.1502	-1.4065	0.1596	(-40.9, 6.73)
AUG	11.9581	12.4827	0.9580	0.3381	(-12.51, 36.42)
SEP	-28.7362	11.5708	-2.4835	0.0130	(-51.41, -6.06)
OCT	-68.5295	9.0692	-7.5563	0.0000	(-86.31, -50.75)
NOV	-33.3147	7.2544	-4.5923	0.0000	(-47.53, -19.1)

Continued…

Table C-16: Descriptive Statistics – Multifamily Building Electricity Model

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	498.54
Average Post-Retrofit Billing Months	14.33
Average Pre-Retrofit Billing Months	15.68
Adjusted R-Squared Statistic	0.566
Average Monthly Savings	70.90%

Table C-17: Multifamily Buildings Electricity Model Regression Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-353.4449	24.2021	-14.6039	0.0000	(-400.88, -306.0)
HDD_NORM	0.3769	0.1045	3.6077	0.0004	(0.17, 0.58)
CDD_NORM	1.5312	0.2251	6.8034	0.0000	(1.09, 1.97)
JAN	-93.8621	63.5408	-1.4772	0.1410	(-218.4, 30.68)
FEB	-116.7939	68.5179	-1.7046	0.0896	(-251.09, 17.5)
MAR	-28.6064	59.7822	-0.4785	0.6327	(-145.78, 88.57)
APR	-18.5503	57.0777	-0.3250	0.7455	(-130.42, 93.32)
MAY	66.2329	68.2800	0.9700	0.3330	(-67.6, 200.06)
JUN	20.0950	85.1980	0.2359	0.8137	(-146.89, 187.08)
JUL	34.0133	105.5691	0.3222	0.7476	(-172.9, 240.93)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
AUG	112.5672	111.1936	1.0124	0.3124	(-105.37, 330.51)
SEP	130.4577	102.0571	1.2783	0.2024	(-69.57, 330.49)
OCT	95.4700	77.9174	1.2253	0.2217	(-57.25, 248.19)
NOV	65.3759	66.8553	0.9779	0.3291	(-65.66, 196.41)

C.2.1. NATURAL GAS MODELS

The following model output uses the final residential natural gas model specifications and filters presented in this report, and presents the models by subsector: single-family, multifamily units, and multifamily buildings.

Table C-18: Residential Natural Gas Savings by Building Type

BUILDING TYPE	OBSERVATIONS	HOUSEHOLDS	AVERAGE MONTHLY SAVINGS (THERMS)	AVERAGE MONTHLY SAVINGS (PERCENT OF CONSUMPTION)
Single-family	96,511	2,315	10.16	15.14%
Multifamily Units	30,001	728	3.25	4.97%
Multifamily Buildings	201	9	32.21	38.49%
All Residential	126,713	3,052	8.30	12.44%

Table C-19: Descriptive Statistics – Single-family Natural Gas Model

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	67.11
Average Post-Retrofit Billing Months	18.42
Average Pre-Retrofit Billing Months	30.94
Adjusted R-Squared Statistic	0.719
Average Monthly Savings	15.14%

Table C-20: Single-family Natural Gas Model Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-10.1568	0.2029	-50.0680	0.0000	(-10.55, -9.76)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
HDD_NORM	0.1080	0.0007	150.4790	0.0000	(0.11, 0.11)
JAN	10.2866	0.5041	20.4075	0.0000	(9.3, 11.27)
FEB	3.9302	0.4968	7.9103	0.0000	(2.96, 4.9)
MAR	-3.0883	0.4659	-6.6280	0.0000	(-4, -2.18)
APR	-20.4277	0.4860	-42.0364	0.0000	(-21.38, -19.48)
MAY	-29.1724	0.5299	-55.0562	0.0000	(-30.21, -28.13)
JUN	-29.0815	0.6185	-47.0225	0.0000	(-30.29, -27.87)
JUL	-25.3076	0.6828	-37.0640	0.0000	(-26.65, -23.97)
AUG	-25.3533	0.6824	-37.1528	0.0000	(-26.69, -24.02)
SEP	-26.8762	0.6687	-40.1890	0.0000	(-28.19, -25.57)
OCT	-26.3559	0.5890	-44.7444	0.0000	(-27.51, -25.2)
NOV	-15.5407	0.5148	-30.1853	0.0000	(-16.55, -14.53)

Continued…

Table C-21: Descriptive Statistics – Multifamily Units Natural Gas Model

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	65.43
Average Post-Retrofit Billing Months	15.42
Average Pre-Retrofit Billing Months	28.00
Adjusted R-Squared Statistic	0.825
Average Monthly Savings	4.97%

Table C-22: Multifamily Units Natural Gas Model Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-3.2549	0.2692	-12.0901	0.0000	(-3.78, -2.73)
HDD_NORM	0.1260	0.0012	104.1483	0.0000	(0.12, 0.13)
JAN	3.7425	0.7180	5.2123	0.0000	(2.34, 5.15)
FEB	2.5690	0.6835	3.7586	0.0002	(1.23, 3.91)
MAR	-6.0750	0.6422	-9.4599	0.0000	(-7.33, -4.82)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
APR	-15.9653	0.6991	-22.8357	0.0000	(-17.34, -14.6)
MAY	-19.7073	0.7753	-25.4177	0.0000	(-21.23, -18.19)
JUN	-11.0889	1.0069	-11.0128	0.0000	(-13.06, -9.12)
JUL	-1.1520	1.1672	-0.9870	0.3237	(-3.44, 1.14)
AUG	0.7419	1.1926	0.6221	0.5339	(-1.6, 3.08)
SEP	-3.7327	1.1596	-3.2190	0.0013	(-6.01, -1.46)
OCT	-15.9936	0.9713	-16.4664	0.0000	(-17.9, -14.09)
NOV	-11.1654	0.7649	-14.5972	0.0000	(-12.66, -9.67)

Continued…

Table C-23: Descriptive Statistics – Multifamily Building Natural Gas Model

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	83.68
Average Post-Retrofit Billing Months	13.50
Average Pre-Retrofit Billing Months	13.64
Adjusted R-Squared Statistic	0.586
Average Monthly Savings	38.49%

Table C-24: Multifamily Buildings Natural Gas Model Results

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-32.2104	6.6922	-4.8131	0.0000	(-45.33, -19.09)
HDD_NORM	0.1121	0.0307	3.6476	0.0003	(0.05, 0.17)
JAN	-32.6465	20.4790	-1.5941	0.1127	(-72.79, 7.49)
FEB	-43.7893	24.8961	-1.7589	0.0803	(-92.59, 5.01)
MAR	-48.1889	23.6910	-2.0341	0.0434	(-94.62, -1.75)
APR	-1.3597	16.2076	-0.0839	0.9332	(-33.13, 30.41)
MAY	-19.6811	17.7434	-1.1092	0.2688	(-54.46, 15.1)
JUN	-55.6275	22.7766	-2.4423	0.0156	(-100.27, -10.99)
JUL	-56.5605	26.1587	-2.1622	0.0319	(-107.83, -5.29)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
AUG	-60.2329	27.1328	-2.2199	0.0277	(-113.41, -7.05)
SEP	-61.6099	26.3970	-2.3340	0.0207	(-113.35, -9.87)
OCT	-59.7813	20.9747	-2.8502	0.0049	(-100.89, -18.67)
NOV	-21.0950	17.8227	-1.1836	0.2381	(-56.03, 13.84)

C.3. CONFIDENCE AND PRECISION

Confidence and precision statistics were calculated for the sampling error of the M&V and billing regression analysis studies and are presented in the following tables. After determining final realization rates for each study, error bounds were calculated in accordance with the California Evaluation Framework and as described in Section 3. Confidence was selected at the 90% level. Relative precision values were calculated by dividing the error bound of the verified source MMBtu savings by the verified source MMBtu savings. Additionally, where possible, the error ratios also were calculated.

For the residential analysis, statistics were computed for both the M&V and billing analyses and ultimately combined to reflect a combined realization rate. The M&V analysis did realize a slightly lower precision value. Error bounds were combined using the equation below:

$$Error\ Bound_{RES\_total} = \sqrt{Error\ Bound^2_{RES\_M\&V} + Error\ Bound^2_{RES_{billing}}}$$

Relative precision was then calculated by dividing the combined error bound by the total verified gross savings. Results are presented in Table 4-6.

APPENDIX D. ALTERNATE BILLING REGRESSION MODEL SPECIFICATIONS

We ran a series of alternate model specifications to confirm that the results would not change substantially. Each of the specifications was run using electricity bills with both heating degree-days (HDD) and cooling degree-days (CDD) included as controls for weather, and then the same specification was run using natural gas bills with only HDD to control for weather. Additional detail on these alternate model specifications and the corresponding savings estimates are provided below. All of the model output is based on data after the final screens (Appendix B.4.2) were applied.[72]

D.1. LOGGED CONSUMPTION

The alternative specification was the same as the final models except for the fact that the monthly fuel consumption was logged. By transforming the data using the natural log, much of the variability in individual bills is eliminated, allowing the model to focus on the overall change in fuel consumption from pre- to the post-retrofit period. Logging the data in a regression model causes it to estimate the percent change in consumption, rather than the unit change, which can be a better fit for this type of data.

$$Ln(kWh_{i,t}) = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \varepsilon$$

$$Ln(Therms_{i,t}) = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \varepsilon$$

Where:

$Ln =$ Natural log operator

$kWh_{i,t} =$ Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t} =$ Normalized natural gas usage (therms) in month t for customer i

$Post_{i,t} =$ Binary variable indicating post-participation month for customer i

$Weather_t =$ Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD] in kWh model, but only HDD in therm model)

$Month_t =$ Set of binary variables indicating whether or not billing month t is January, February, March, etc.

$\alpha_i =$ Customer-specific constant

$\varepsilon =$ Regression residual

72 In order to increase the sample size, the output for the last three model specifications are based on more conservative screens. The Normalized Annual model screens out households with a pre-period less than 12 months, a post-period less than 12 months, households with no installed savings of the specified fuel type (electric or gas, respectively), and any households whose average consumption in the post-retrofit period was more than double their average consumption in the pre-period. The first Weighted Annual model screens out households who have less than one observation in each month during each period (for example, households must have at least one pre-period bill each month (January – December) as well as at least one post-period bill from each month) and have an average pre-period monthly consumption less than 10,000 kWh (for electric) or less than 300 therms (for gas). The second Weighted Annual model relaxes these screens by requiring that households have at least six months with observations in corresponding months (for example, households have at least one pre-period bill from each month January – June and at least one post-period bill from each month January – June).

Table D-1: Descriptive Statistics – Residential Logged Electric Model (shown in Table E-2)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	938.61
Average Post-Retrofit Billing Months	17.01
Average Pre-Retrofit Billing Months	24.49
Adjusted R-Squared Statistic	0.262
Average Monthly Savings	6.21%

Table D-2: Logged Electricity Model Regression Results - Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-0.0642	0.0016	-40.3496	0.0000	(-0.067, -0.061)
HDD_NORM	0.0003	0.0000	44.1449	0.0000	(0, 0)
CDD_NORM	0.0015	0.0000	138.7351	0.0000	(0.002, 0.002)
JAN	0.0629	0.0042	15.0453	0.0000	(0.055, 0.071)
FEB	-0.0213	0.0041	-5.2424	0.0000	(-0.029, -0.013)
MAR	-0.0666	0.0039	-17.0320	0.0000	(-0.074, -0.059)
APR	-0.1393	0.0041	-33.9692	0.0000	(-0.147, -0.131)
MAY	-0.1606	0.0045	-35.3785	0.0000	(-0.169, -0.152)
JUN	-0.1489	0.0058	-25.7429	0.0000	(-0.16, -0.138)
JUL	-0.1183	0.0071	-16.6660	0.0000	(-0.132, -0.104)
AUG	-0.1255	0.0074	-16.9826	0.0000	(-0.14, -0.111)
SEP	-0.1455	0.0067	-21.6204	0.0000	(-0.159, -0.132)
OCT	-0.1504	0.0052	-28.6495	0.0000	(-0.161, -0.14)
NOV	-0.1080	0.0043	-25.2267	0.0000	(-0.116, -0.1)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-3: Descriptive Statistics – Commercial Logged Electric Model (shown in Table E-4)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	2,266.20
Average Post-Retrofit Billing Months	19.72

Continued…

MODEL SUMMARY	
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.220
Average Monthly Savings	14.57%

Table D-4: Logged Electricity Model Regression Results – Commercial

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-0.1575	0.0072	-21.8446	0.0000	(-0.172, -0.143)
HDD_NORM	0.0003	0.0000	12.2373	0.0000	(0, 0)
CDD_NORM	0.0005	0.0000	14.5706	0.0000	(0, 0.001)
JAN	-0.0607	0.0188	-3.2358	0.0012	(-0.097, -0.024)
FEB	-0.0654	0.0181	-3.6115	0.0003	(-0.101, -0.03)
MAR	0.0043	0.0172	0.2506	0.8021	(-0.029, 0.038)
APR	0.0242	0.0179	1.3509	0.1768	(-0.011, 0.059)
MAY	0.0968	0.0199	4.8729	0.0000	(0.058, 0.136)
JUN	0.2410	0.0257	9.3862	0.0000	(0.191, 0.291)
JUL	0.3317	0.0327	10.1521	0.0000	(0.268, 0.396)
AUG	0.3124	0.0338	9.2444	0.0000	(0.246, 0.379)
SEP	0.2366	0.0323	7.3292	0.0000	(0.173, 0.3)
OCT	0.0847	0.0259	3.2707	0.0011	(0.034, 0.135)
NOV	-0.0432	0.0200	-2.1593	0.0308	(-0.082, -0.004)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-5: Descriptive Statistics –Residential Logged Natural Gas Model (shown in Table E-6)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	66.74
Average Post-Retrofit Billing Months	17.70
Average Pre-Retrofit Billing Months	30.22
Adjusted R-Squared Statistic	0.823
Average Monthly Savings	11.90%

Table D-6: Logged Natural Gas Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-0.1267	0.0022	-56.5062	0.0000	(-0.131, -0.122)
HDD_NORM	0.0016	0.0000	192.0979	0.0000	(0.002, 0.002)
JAN	-0.0025	0.0057	-0.4364	0.6626	(-0.014, 0.009)
FEB	-0.0455	0.0055	-8.2058	0.0000	(-0.056, -0.035)
MAR	-0.0525	0.0052	-10.0885	0.0000	(-0.063, -0.042)
APR	-0.1784	0.0055	-32.7274	0.0000	(-0.189, -0.168)
MAY	-0.3783	0.0059	-63.6209	0.0000	(-0.39, -0.367)
JUN	-0.6490	0.0071	-91.9652	0.0000	(-0.663, -0.635)
JUL	-0.8140	0.0079	-103.5730	0.0000	(-0.829, -0.799)
AUG	-0.8627	0.0079	-109.3323	0.0000	(-0.878, -0.847)
SEP	-0.8419	0.0077	-109.0504	0.0000	(-0.857, -0.827)
OCT	-0.5314	0.0068	-78.7067	0.0000	(-0.545, -0.518)
NOV	-0.1159	0.0058	-19.8871	0.0000	(-0.127, -0.104)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-7: Descriptive Statistics – Commercial Logged Natural Gas Model (shown in Table E-8)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	89.30
Average Post-Retrofit Billing Months	19.81
Average Pre-Retrofit Billing Months	28.75
Adjusted R-Squared Statistic	0.657
Average Monthly Savings	3.28%

Table D-8: Logged Natural Gas Model Regression Results – Commercial

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-0.0334	0.0651	-0.5130	0.6083	(-0.161, 0.094)
HDD_NORM	0.0024	0.0003	8.4846	0.0000	(0.002, 0.003)

Continued…

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
JAN	-0.0497	0.1687	-0.2949	0.7682	(-0.38, 0.281)
FEB	-0.1294	0.1647	-0.7855	0.4327	(-0.452, 0.193)
MAR	-0.0098	0.1523	-0.0645	0.9486	(-0.308, 0.289)
APR	-0.0911	0.1710	-0.5325	0.5948	(-0.426, 0.244)
MAY	-0.2074	0.1923	-1.0783	0.2817	(-0.584, 0.17)
JUN	-0.1609	0.2480	-0.6485	0.5172	(-0.647, 0.325)
JUL	-0.2302	0.2853	-0.8069	0.4203	(-0.789, 0.329)
AUG	-0.2164	0.2867	-0.7550	0.4508	(-0.778, 0.345)
SEP	-0.3110	0.2745	-1.1330	0.2581	(-0.849, 0.227)
OCT	-0.2584	0.2141	-1.2069	0.2284	(-0.678, 0.161)
NOV	0.1671	0.1718	0.9726	0.3315	(-0.17, 0.504)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.2. INTERACTED WEATHER

The interacted weather model included a term to reflect any weather-specific effects that were isolated to the post-period. Due to the presence of the interaction variable, the savings estimates produced from these models required information about the typical weather conditions, as well as average fuel consumption, unlike the final models.

$$kWh_{i,t} = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \beta_3(Weather_t \times Post_{i,t}) + \sum_{j=4}^{14} \beta_j(Month_t) + \varepsilon$$

$$Therms_{i,t} = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \beta_3(Weather_t \times Post_{i,t}) + \sum_{j=4}^{14} \beta_j(Month_t) + \varepsilon$$

Where:

$kWh_{i,t}$ = Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t}$ = Normalized natural gas usage (therms) in month t for customer i

$Post_{i,t}$ = Binary variable indicating post-participation month for customer i

$Weather_t$ = Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD] in kWh model, but only HDD in therm model)

$Weather_t \times Post_{i,t}$ = Interaction between weather data and post-participation month

$Month_t$ = Set of binary variables indicating whether or not billing month t is January, February, March, etc.

α_i = Customer-specific constant

ε = Regression residual

Table D-9: Descriptive Statistics – Residential Interacted Weather Electric Model (shown in Table E-10)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	938.61
Average Monthly HDD	396.40
Average Monthly CDD	134.54
Average Post-Retrofit Billing Months	17.01
Average Pre-Retrofit Billing Months	24.49
Adjusted R-Squared Statistic	0.265
Average Monthly Savings	7.98%

Table D-10: Interacted Weather Electric Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	61.0460	4.7631	12.8164	0.0000	(51.71, 70.38)
HDD_NORM	0.3906	0.0073	53.8324	0.0000	(0.38, 0.4)
CDD_NORM	2.0725	0.0146	141.6126	0.0000	(2.04, 2.1)
JAN	57.1890	4.8352	11.8276	0.0000	(47.71, 66.67)
FEB	-30.4860	4.7036	-6.4814	0.0000	(-39.71, -21.27)
MAR	-62.9640	4.5229	-13.9212	0.0000	(-71.83, -54.1)
APR	-114.7800	4.7410	-24.2101	0.0000	(-124.07, -105.49)
MAY	-127.2500	5.2468	-24.2529	0.0000	(-137.53, -116.97)
JUN	-111.0100	6.6850	-16.6058	0.0000	(-124.11, -97.91)
JUL	-86.1560	8.2013	-10.5052	0.0000	(-102.23, -70.08)
AUG	-102.5700	8.5410	-12.0091	0.0000	(-119.31, -85.83)
SEP	-133.0900	7.7770	-17.1133	0.0000	(-148.33, -117.85)
OCT	-128.8600	6.0654	-21.2451	0.0000	(-140.75, -116.97)
NOV	-97.3020	4.9459	-19.6733	0.0000	(-107, -87.61)
POST:HDD_NORM	-0.1321	0.0069	-19.0123	0.0000	(-0.15, -0.12)
POST:CDD_NORM	-0.6209	0.0149	-41.8135	0.0000	(-0.65, -0.59)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-11: Descriptive Statistics – Commercial Interacted Weather Electric Model (shown in Table E-12)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	2,266.20
Average Monthly HDD	330.28
Average Monthly CDD	224.61
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.254
Average Monthly Savings	12.16%

Table D-12: Interacted Weather Electric Model Regression Results – Commercial

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-202.9389	36.5912	-5.5461	0.0000	(-274.66, -131.22)
HDD_NORM	0.8706	0.0691	12.5943	0.0000	(0.74, 1.01)
CDD_NORM	1.1981	0.0771	15.5304	0.0000	(1.05, 1.35)
JAN	-141.6780	41.5823	-3.4072	0.0007	(-223.18, -60.18)
FEB	-104.7156	40.1349	-2.6091	0.0091	(-183.38, -26.05)
MAR	25.9141	38.1183	0.6798	0.4966	(-48.8, 100.63)
APR	118.1853	39.8068	2.9690	0.0030	(40.16, 196.21)
MAY	319.8828	44.1557	7.2444	0.0000	(233.34, 406.43)
JUN	663.9576	57.1471	11.6184	0.0000	(551.95, 775.97)
JUL	1021.4146	72.8128	14.0280	0.0000	(878.7, 1164.13)
AUG	914.6952	75.2216	12.1600	0.0000	(767.26, 1062.13)
SEP	662.8022	71.8464	9.2253	0.0000	(521.98, 803.62)
OCT	255.9581	57.6237	4.4419	0.0000	(143.02, 368.9)
NOV	-34.3719	44.4060	-0.7740	0.4389	(-121.41, 52.66)
POST:HDD_NORM	0.0210	0.0575	0.3656	0.7146	(-0.09, 0.13)
POST:CDD_NORM	-0.3541	0.0740	-4.7831	0.0000	(-0.5, -0.21)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-13: Descriptive Statistics – Residential Interacted Weather Natural Gas Model (shown in Table E-14)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	66.74
Average Monthly HDD	396.61
Average Post-Retrofit Billing Months	16.96
Average Pre-Retrofit Billing Months	24.45
Adjusted R-Squared Statistic	0.743
Average Monthly Savings	11.58%

Table D-14: Interacted Weather Natural Gas Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-0.3327	0.2524	-1.3180	0.1875	(-0.83, 0.16)
HDD_NORM	0.1167	0.0006	183.5217	0.0000	(0.12, 0.12)
JAN	9.7501	0.4213	23.1434	0.0000	(8.92, 10.58)
FEB	3.9078	0.4120	9.4847	0.0000	(3.1, 4.72)
MAR	-3.5977	0.3871	-9.2942	0.0000	(-4.36, -2.84)
APR	-19.5330	0.4058	-48.1369	0.0000	(-20.33, -18.74)
MAY	-27.5480	0.4424	-62.2652	0.0000	(-28.42, -26.68)
JUN	-26.3430	0.5250	-50.1781	0.0000	(-27.37, -25.31)
JUL	-21.5530	0.5846	-36.8686	0.0000	(-22.7, -20.41)
AUG	-21.1790	0.5870	-36.0825	0.0000	(-22.33, -20.03)
SEP	-23.4770	0.5742	-40.8865	0.0000	(-24.6, -22.35)
OCT	-25.0750	0.5025	-49.9025	0.0000	(-26.06, -24.09)
NOV	-14.7000	0.4335	-33.9069	0.0000	(-15.55, -13.85)
POST:HDD_NORM	-0.0186	0.0004	-42.0176	0.0000	(-0.02, -0.02)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-15: Descriptive Statistics – Commercial Interacted Weather Natural Gas Model (shown in Table E-16)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	89.30
Average Monthly HDD	330.28
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.578
Average Monthly Savings	15.72%

Table D-16: Interacted Weather Natural Gas Model Regression Results – Commercial

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-24.0361	8.3320	-2.8848	0.0042	(-40.37, -7.71)
HDD_NORM	0.1380	0.0221	6.2305	0.0000	(0.09, 0.18)
JAN	12.9820	12.4481	1.0429	0.2978	(-11.42, 37.38)
FEB	1.0313	12.1549	0.0848	0.9324	(-22.79, 24.85)
MAR	14.2931	11.3031	1.2645	0.2070	(-7.86, 36.45)
APR	-7.9039	12.7333	-0.6207	0.5352	(-32.86, 17.05)
MAY	-11.8897	14.2590	-0.8338	0.4050	(-39.84, 16.06)
JUN	-7.3065	18.4015	-0.3971	0.6916	(-43.37, 28.76)
JUL	2.3874	21.1138	0.1131	0.9100	(-39, 43.77)
AUG	5.1809	21.2348	0.2440	0.8074	(-36.44, 46.8)
SEP	-1.5585	20.3347	-0.0766	0.9390	(-41.41, 38.3)
OCT	-14.2347	15.8774	-0.8965	0.3707	(-45.35, 16.88)
NOV	6.8893	12.7388	0.5408	0.5890	(-18.08, 31.86)
POST:HDD_NORM	0.0303	0.0138	2.1854	0.0296	(0, 0.06)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.3. COMMERCIAL MODELS WITH ADDED CONTROL

The commercial models were run incorporating three separate indicators of economic growth, in order to control for changes in energy consumption caused by increased commercial operation and/or production. The three variables included were urban consumer price index, proprietor income, and personal income. Please note that none of these specifications were run using residential buildings, only commercial.

D.3.1. CONSUMER PRICE INDEX

The urban Consumer Price Index (CPI-U) is an indicator for the spending patterns of all urban consumers. The CPI is an economic indicator that measures inflation based on the consumers' experience. Thus, including CPI in the models for commercial buildings allows us to see the impact of the retrofits on their energy consumption, controlling for major changes in the economy caused by inflation. For this analysis, annual federal CPI values were obtained from the Bureau of Labor Statistics and assigned to each utility bill based on the day the meter was read.

$$kWh_{i,t} = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \beta_{14}(CPI_t) + \varepsilon$$

$$Therms_{i,t} = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \beta_{14}(CPI_t) + \varepsilon$$

Where:

$kWh_{i,t}$ = Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t}$ = Normalized natural gas usage (therms) in month t for customer i

$Post_{i,t}$ = Binary variable indicating post-participation month for customer i

$Weather_t$ = Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD] in kWh model, but only HDD in therm model)

$Month_t$ = Set of binary variables indicating whether or not billing month t is January, February, March, etc.

CPI_t = Urban Consumer Price Index in month t, relative to January 2006

α_i = Customer-specific constant

ε = Regression residual

Table D-17: Descriptive Statistics – Commercial Consumer Price Index Electric Model (shown in Table E-18)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	2,266.20
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.253
Average Monthly Savings	7.49%

Table D-18: Consumer Price Index Electric Model Regression Results – Commercial

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-169.8107	26.5774	-6.3893	0.0000	(-221.9, -117.72)
CPI_U	-9.7739	1.9844	-4.9254	0.0000	(-13.66, -5.88)
HDD_NORM	0.9019	0.0634	14.2206	0.0000	(0.78, 1.03)
CDD_NORM	1.0981	0.0748	14.6902	0.0000	(0.95, 1.24)
JAN	-135.9131	41.6342	-3.2645	0.0011	(-217.52, -54.31)
FEB	-100.1468	40.1910	-2.4918	0.0127	(-178.92, -21.37)
MAR	44.0888	38.3287	1.1503	0.2501	(-31.04, 119.21)
APR	145.3429	40.0018	3.6334	0.0003	(66.94, 223.75)
MAY	349.8258	44.3260	7.8921	0.0000	(262.95, 436.7)
JUN	689.1591	57.1563	12.0574	0.0000	(577.13, 801.19)
JUL	1037.1048	72.5977	14.2857	0.0000	(894.81, 1179.4)
AUG	942.3200	75.1102	12.5458	0.0000	(795.1, 1089.54)
SEP	695.1811	71.7350	9.6910	0.0000	(554.58, 835.78)
OCT	282.7455	57.5138	4.9161	0.0000	(170.02, 395.47)
NOV	-21.7934	44.3733	-0.4911	0.6233	(-108.77, 65.18)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-19: Descriptive Statistics – Commercial Consumer Price Index Natural Gas Model (shown in Table E-20)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	89.30
Average Post-Retrofit Billing Months	19.81
Average Pre-Retrofit Billing Months	28.75
Adjusted R-Squared Statistic	0.573
Average Monthly Savings	10.87%

Table D-20: Consumer Price Index Natural Gas Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-9.7074	8.1455	-1.1917	0.2343	(-25.67, 6.26)
CPI_U	0.0553	0.6584	0.0840	0.9331	(-1.24, 1.35)
HDD_NORM	0.1528	0.0214	7.1398	0.0000	(0.11, 0.19)
JAN	13.0980	12.5722	1.0418	0.2983	(-11.54, 37.74)
FEB	0.7767	12.3270	0.0630	0.9498	(-23.38, 24.94)
MAR	16.7832	11.3951	1.4728	0.1418	(-5.55, 39.12)
APR	-4.3300	12.7862	-0.3387	0.7351	(-29.39, 20.73)
MAY	-9.0582	14.3561	-0.6310	0.5285	(-37.2, 19.08)
JUN	-3.2839	18.4490	-0.1780	0.8588	(-39.44, 32.88)
JUL	5.7623	21.2338	0.2714	0.7863	(-35.86, 47.38)
AUG	9.2069	21.3392	0.4315	0.6664	(-32.62, 51.03)
SEP	2.2321	20.4248	0.1093	0.9130	(-37.8, 42.26)
OCT	-10.7950	15.9372	-0.6774	0.4987	(-42.03, 20.44)
NOV	9.6600	12.7846	0.7556	0.4505	(-15.4, 34.72)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.3.2. PERSONAL INCOME

Similar to CPI, personal income is a measure of economic activity. While the CPI reflects inflation experienced by urban consumers through their expenditure, personal income measures the main driver of consumption, income. It includes income from sources like salaries, wages, and bonuses from employment, investment dividends, rental payments from real estate, profit sharing from business, and others. Hence, including personal income in the commercial models allows us to control for any impacts of economic expansion or decline on the energy consumption of these buildings. For this analysis, values of annual personal income in the U.S. were obtained from the Bureau of Economic Analysis and assigned to each utility bill based on the day the meter was read.

$$kWh_{i,t} = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \beta_{14}(\mathrm{P}ersonal_t) + \varepsilon$$

$$Therms_{i,t} = \alpha_i + \beta_1(Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \beta_{14}(\mathrm{P}ersonal_t) + \varepsilon$$

$Where:$

$kWh_{i,t}$ = Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t}$ = Normalized natural gas usage (therms) in month t for customer i

$Post_{i,t}$ = Binary variable indicating post-participation month for customer i

$Weather_t$ = Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD] in kWh model, but only HDD in therm model)

$Month_t$ = Set of binary variables indicating whether or not billing month t is January, February, March, etc.

$\mathrm{P}ersonal_t$ = Personal income in month t, relative to January 2006

α_i = Customer-specific constant

ε = Regression residual

Table D-21: Descriptive Statistics – Nonresidential Personal Income Electric Model (shown in Table E-22)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	2,266.20
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.253
Average Monthly Savings	7.36%

Table D-22: Personal Income Electric Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-166.8600	27.4410	-6.0807	0.0000	(-220.64, -113.08)
PERSONAL_INC	-1056.9000	219.2200	-4.8212	0.0000	(-1486.57, -627.23)
HDD_NORM	0.8852	0.0634	13.9538	0.0000	(0.76, 1.01)
CDD_NORM	1.1062	0.0748	14.7824	0.0000	(0.96, 1.25)
JAN	-99.8000	42.5260	-2.3468	0.0190	(-183.15, -16.45)
FEB	-73.0610	40.8070	-1.7904	0.0734	(-153.04, 6.92)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL

Continued…

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MAR	56.2600	38.6710	1.4548	0.1457	(-19.54, 132.06)
APR	147.8100	40.0770	3.6882	0.0002	(69.26, 226.36)
MAY	345.8900	44.2580	7.8153	0.0000	(259.14, 432.64)
JUN	677.3500	57.0150	11.8802	0.0000	(565.6, 789.1)
JUL	1021.4000	72.4970	14.0889	0.0000	(879.31, 1163.49)
AUG	921.2700	74.9640	12.2895	0.0000	(774.34, 1068.2)
SEP	671.4500	71.6090	9.3766	0.0000	(531.1, 811.8)
OCT	263.6700	57.4490	4.5896	0.0000	(151.07, 376.27)
NOV	-30.0480	44.3490	-0.6775	0.4981	(-116.97, 56.88)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-23: Descriptive Statistics – Nonresidential Personal Income Natural Gas Model (shown in Table E-24)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	89.30
Average Post-Retrofit Billing Months	19.81
Average Pre-Retrofit Billing Months	28.75
Adjusted R-Squared Statistic	0.573
Average Monthly Savings	13.38%

Table D-24: Personal Income Natural Gas Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-11.9532	8.2228	-1.4537	0.1470	(-28.07, 4.16)
PERSONAL_INC	29.0561	69.0931	0.4205	0.6744	(-106.37, 164.48)
HDD_NORM	0.1537	0.0214	7.1723	0.0000	(0.11, 0.2)
JAN	11.7100	13.0110	0.9000	0.3688	(-13.79, 37.21)
FEB	-0.4782	12.6710	-0.0377	0.9699	(-25.31, 24.36)
MAR	15.9761	11.5285	1.3858	0.1668	(-6.62, 38.57)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
APR	-4.9718	12.8386	-0.3873	0.6988	(-30.14, 20.19)
MAY	-9.5554	14.3701	-0.6649	0.5066	(-37.72, 18.61)
JUN	-3.3851	18.4436	-0.1835	0.8545	(-39.53, 32.76)
JUL	6.0721	21.2316	0.2860	0.7751	(-35.54, 47.69)
AUG	9.7203	21.3585	0.4551	0.6494	(-32.14, 51.58)
SEP	2.7152	20.4495	0.1328	0.8945	(-37.37, 42.8)
OCT	-10.3146	15.9686	-0.6459	0.5188	(-41.61, 20.98)
NOV	9.9042	12.7883	0.7745	0.4392	(-15.16, 34.97)

Continued…

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.3.3. PROPRIETOR INCOME

Proprietor income is a measurement of income for business owners; it includes receipts from wages, interest, rent, and profits in excess of total production costs. Similar to personal income, proprietor income is seen as an indicator of economic growth. However, since it only looks at the income of business owners, it may be a better predictor of changes in production than personal income. For this analysis, values of annual personal income in the U.S. were obtained from the Bureau of Economic Analysis and assigned to each utility bill based on the day the meter was read.

$$kWh_{i,t} = a_i + b_1(Post_{i,t}) + b_2(Weather_t) + \sum_{j=3}^{13} b_j(Month_t) + b_{14}(\Pr oprietor_t) + e$$

$$Therms_{i,t} = a_i + b_1(Post_{i,t}) + b_2(Weather_t) + \sum_{j=3}^{13} b_j(Month_t) + b_{14}(\Pr oprietor_t) + e$$

Where:

$kWh_{i,t}$ = Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t}$ = Normalized natural gas usage (therms) in month t for customer i

$Post_{i,t}$ = Binary variable indicating post-participation month for customer i

$Weather_t$ = Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD] in kWh model, but only HDD in therm model)

$Month_t$ = Set of binary variables indicating whether or not billing month t is January, February, March, etc.

$\Pr oprietor_t$ = Proprietor income in month t, relative to January 2006

a_i = Customer-specific constant

e = Regression residual

Table D-25: Descriptive Statistics – Nonresidential Proprietor Income Electric Model (shown in Table E-26)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	2,266.20
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.253
Average Monthly Savings	6.90%

Table D-26: Proprietor Income Electric Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-156.4711	26.7801	-5.8428	0.0000	(-208.96, -103.98)
PROPRIETOR_INC	-681.9722	124.2760	-5.4876	0.0000	(-925.55, -438.39)
HDD_NORM	0.8947	0.0634	14.1150	0.0000	(0.77, 1.02)
CDD_NORM	1.0981	0.0747	14.6955	0.0000	(0.95, 1.24)
JAN	-95.5065	42.4578	-2.2494	0.0245	(-178.72, -12.29)
FEB	-69.6183	40.7517	-1.7084	0.0876	(-149.49, 10.26)
MAR	60.3659	38.6569	1.5616	0.1184	(-15.4, 136.13)
APR	154.5103	40.1467	3.8486	0.0001	(75.82, 233.2)
MAY	353.7633	44.3408	7.9783	0.0000	(266.86, 440.67)
JUN	687.6823	57.0858	12.0465	0.0000	(575.79, 799.57)
JUL	1034.3042	72.5354	14.2593	0.0000	(892.13, 1176.47)
AUG	934.3938	74.9939	12.4596	0.0000	(787.41, 1081.38)
SEP	682.5489	71.6037	9.5323	0.0000	(542.21, 822.89)
OCT	270.1250	57.4256	4.7039	0.0000	(157.57, 382.68)
NOV	-26.9958	44.3380	-0.6089	0.5426	(-113.9, 59.91)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-27: Descriptive Statistics – Nonresidential Proprietor Income Natural Gas Model (shown in Table E-28)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	89.30
Average Post-Retrofit Billing Months	19.81
Average Pre-Retrofit Billing Months	28.75
Adjusted R-Squared Statistic	0.573
Average Monthly Savings	12.42%

Table D-28: Proprietor Income Natural Gas Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-11.0893	8.1613	-1.3588	0.1752	(-27.09, 4.91)
PROPRIETOR_INC	11.7664	40.0217	0.2940	0.7690	(-66.68, 90.21)
HDD_NORM	0.1530	0.0213	7.1773	0.0000	(0.11, 0.19)
JAN	12.1709	12.9937	0.9367	0.3496	(-13.3, 37.64)
FEB	-0.0541	12.6632	-0.0043	0.9966	(-24.87, 24.77)
MAR	16.2101	11.5569	1.4026	0.1617	(-6.44, 38.86)
APR	-4.8747	12.9094	-0.3776	0.7060	(-30.18, 20.43)
MAY	-9.5628	14.4499	-0.6618	0.5086	(-37.88, 18.76)
JUN	-3.6146	18.4840	-0.1956	0.8451	(-39.84, 32.61)
JUL	5.6448	21.2163	0.2661	0.7904	(-35.94, 47.23)
AUG	9.2240	21.3174	0.4327	0.6655	(-32.56, 51.01)
SEP	2.2551	20.4144	0.1105	0.9121	(-37.76, 42.27)
OCT	-10.6532	15.9339	-0.6686	0.5042	(-41.88, 20.58)
NOV	9.7350	12.7782	0.7618	0.4467	(-15.31, 34.78)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.4. MEASURE-SPECIFIC MODELS

The next three models explained the changes in fuel consumption using the specific measures installed rather than using only the general indicator for post-participation.

D.4.1. NUMBER OF DIFFERENT TYPES OF MEASURES INSTALLED

The simplest of these is the measure count model, which used the sum of the binary installed measure flags from the tracking data as an indication of the number of different types of measures installed. The measure count was interacted with the indicator for the post-period so that the model would estimate the impact of each additional measure on fuel consumption in the post-period.

$$kWh_{i,t} = \alpha_i + \beta_1(MeasCount_i \times Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \varepsilon$$

$$Therms_{i,t} = \alpha_i + \beta_1(MeasCount_i \times Post_{i,t}) + \beta_2(Weather_t) + \sum_{j=3}^{13} \beta_j(Month_t) + \varepsilon$$

Where:

$kWh_{i,t}$ = Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t}$ = Normalized natural gas usage (therms) in month t for customer i

$MeasCount_i$ = Number of different types of measures installed for customer i, from tracking data

$Post_{i,t}$ = Binary variable indicating post-participation month for customer i

$Weather_t$ = Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD] in kWh model, but only HDD in therm model)

$Month_t$ = Set of binary variables indicating whether or not billing month t is January, February, March, etc.

α_i = Customer-specific constant

ε = Regression residual

Table D-29: Descriptive Statistics – Residential Measure Count Electric Model (shown in Table E-30)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	938.61
Average Number of Measure Types Installed	3.61
Average Post-Retrofit Billing Months	17.01
Average Pre-Retrofit Billing Months	24.49
Adjusted R-Squared Statistic	0.261
Average Monthly Savings per Measure Type Installed	1.61%
Average Monthly Savings	5.82%

Table D-30: Measure Count Electric Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MEAS_COUNT	-15.1280	0.4499	-33.6260	0.0000	(-16.01, -14.246)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
HDD_NORM	0.3265	0.0068	48.0926	0.0000	(0.313, 0.34)
CDD_NORM	1.7853	0.0130	137.2041	0.0000	(1.76, 1.811)
JAN	58.8450	4.8747	12.0715	0.0000	(49.291, 68.399)
FEB	-25.7680	4.7455	-5.4300	0.0000	(-35.069, -16.467)
MAR	-63.3230	4.5588	-13.8903	0.0000	(-72.258, -54.388)
APR	-118.5600	4.7760	-24.8241	0.0000	(-127.921, -109.199)
MAY	-130.4100	5.2889	-24.6573	0.0000	(-140.776, -120.044)
JUN	-113.9900	6.7440	-16.9024	0.0000	(-127.208, -100.772)
JUL	-93.4020	8.2730	-11.2900	0.0000	(-109.617, -77.187)
AUG	-101.2600	8.6158	-11.7528	0.0000	(-118.147, -84.373)
SEP	-135.3100	7.8453	-17.2473	0.0000	(-150.687, -119.933)
OCT	-131.7800	6.1182	-21.5390	0.0000	(-143.772, -119.788)
NOV	-100.1400	4.9856	-20.0858	0.0000	(-109.912, -90.368)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-31: Descriptive Statistics – Nonresidential Measure Count Electric Model (shown in Table E-32)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	2,266.20
Average Number of Measure Types Installed	1.23
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.249
Average Monthly Savings per Measure Type Installed	7.25%
Average Monthly Savings	8.95%

Table D-32: Measure Count Electric Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MEAS_COUNT	-164.3497	10.1101	-16.2559	0.0000	(-184.166, -144.534)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
HDD_NORM	0.9292	0.0634	14.6565	0.0000	(0.805, 1.053)
CDD_NORM	1.0457	0.0747	14.0026	0.0000	(0.899, 1.192)
JAN	-151.7037	41.6885	-3.6390	0.0003	(-233.413, -69.994)
FEB	-114.7536	40.2416	-2.8516	0.0044	(-193.627, -35.88)
MAR	22.2342	38.2282	0.5816	0.5608	(-52.693, 97.161)
APR	126.0935	39.8291	3.1659	0.0016	(48.028, 204.158)
MAY	335.8474	44.1602	7.6052	0.0000	(249.294, 422.401)
JUN	686.8816	57.0240	12.0455	0.0000	(575.114, 798.649)
JUL	1047.7013	72.5421	14.4427	0.0000	(905.519, 1189.884)
AUG	950.8669	75.0071	12.6770	0.0000	(803.853, 1097.881)
SEP	705.4004	71.6322	9.8475	0.0000	(565.001, 845.8)
OCT	294.1645	57.4659	5.1189	0.0000	(181.531, 406.798)
NOV	-15.9467	44.4169	-0.3590	0.7196	(-103.004, 71.11)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-33: Descriptive Statistics – Residential Measure Count Natural Gas Model (shown in Table E-34)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	66.74
Average Number of Measure Types Installed	3.55
Average Post-Retrofit Billing Months	17.70
Average Pre-Retrofit Billing Months	30.22
Adjusted R-Squared Statistic	0.740
Average Monthly Savings per Measure Type Installed	3.35%
Average Monthly Savings	11.90%

Table D-34: Measure Count Natural Gas Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MEAS_COUNT	-2.2351	0.0425	-52.6327	0.0000	(-2.318, -2.152)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
HDD_NORM	0.1087	0.0006	177.8003	0.0000	(0.108, 0.11)
JAN	9.4039	0.4236	22.1979	0.0000	(8.574, 10.234)
FEB	4.0928	0.4144	9.8760	0.0000	(3.281, 4.905)
MAR	-3.6840	0.3893	-9.4631	0.0000	(-4.447, -2.921)
APR	-20.3270	0.4077	-49.8602	0.0000	(-21.126, -19.528)
MAY	-28.3180	0.4446	-63.6903	0.0000	(-29.189, -27.447)
JUN	-27.2410	0.5277	-51.6202	0.0000	(-28.275, -26.207)
JUL	-22.5200	0.5877	-38.3163	0.0000	(-23.672, -21.368)
AUG	-22.1620	0.5901	-37.5538	0.0000	(-23.319, -21.005)
SEP	-24.3720	0.5774	-42.2128	0.0000	(-25.504, -23.24)
OCT	-26.0880	0.5049	-51.6686	0.0000	(-27.078, -25.098)
NOV	-15.4520	0.4357	-35.4631	0.0000	(-16.306, -14.598)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-35: Descriptive Statistics – Nonresidential Measure Count Natural Gas Model (shown in Table E-36)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	89.30
Average Number of Measure Types Installed	1.72
Average Post-Retrofit Billing Months	19.81
Average Pre-Retrofit Billing Months	28.75
Adjusted R-Squared Statistic	0.575
Average Monthly Savings per Measure Type Installed	4.79%
Average Monthly Savings	8.25%

Table D-36: Measure Count Natural Gas Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MEAS_COUNT	-4.2801	2.3550	-1.8174	0.0701	(-8.896, 0.336)
HDD_NORM	0.1526	0.0213	7.1798	0.0000	(0.111, 0.194)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
JAN	13.5182	12.5271	1.0791	0.2814	(-11.035, 38.071)
FEB	1.2419	12.2333	0.1015	0.9192	(-22.735, 25.219)
MAR	17.7229	11.3299	1.5643	0.1188	(-4.484, 39.929)
APR	-3.5304	12.7374	-0.2772	0.7818	(-28.496, 21.435)
MAY	-8.4033	14.3102	-0.5872	0.5575	(-36.451, 19.645)
JUN	-2.6714	18.4454	-0.1448	0.8849	(-38.824, 33.482)
JUL	5.9235	21.2107	0.2793	0.7802	(-35.65, 47.496)
AUG	9.5273	21.3169	0.4469	0.6552	(-32.254, 51.308)
SEP	2.5816	20.4155	0.1265	0.8995	(-37.433, 42.596)
OCT	-10.3175	15.9282	-0.6477	0.5176	(-41.537, 20.902)
NOV	10.4041	12.7831	0.8139	0.4163	(-14.651, 35.459)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.4.2. CATEGORIES OF MEASURES INSTALLED

The measure categories model used the binary installed measure flags from the program tracking data to generate flags for the installation of one or more measures from each of the following categories: appliances, building envelope (for example, insulation, air sealing), HVAC, lighting, renewables (for example, photovoltaic cells, solar hot water heaters), water heaters (non-solar), and other. Each of the measure categories was interacted with the indicator for the post-period so that the model would estimate the impact of installing one or more measures from each measure category on fuel consumption in the post-period. Measure categories were only included in the models if the associated measures were believed to be of that fuel type. So all measure categories were included in the electric model, while only building envelope, HVAC, water heaters, and other were included in the natural gas mode.

$$kWh_{i,t} = \alpha_i + \sum_{k=1}^{7} \beta_k (MeasCateg_{i,k} \times Post_{i,t}) + \beta_8 (Weather_t) + \sum_{j=9}^{19} \beta_j (Month_t) + \varepsilon$$

$$Therms_{i,t} = \alpha_i + \sum_{k=1}^{4} \beta_k (MeasCateg_{i,k} \times Post_{i,t}) + \beta_5 (Weather_t) + \sum_{j=6}^{16} \beta_j (Month_t) + \varepsilon$$

Where:

$kWh_{i,t}$ = Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t}$ = Normalized natural gas usage (therms) in month t for customer i

$MeasCateg_i$ = Set of binary variabes indicating whether or not customer i installed at least one measure in that measure category; from tracking data.

$Post_{i,t}$ = Binary variable indicating post-participation month for customer i

$Weather_t$ = Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD] in kWh model, but only HDD in therm model)

$Month_t$ = Set of binary variables indicating whether or not billing month t is January, February, March, etc.

α_i = Customer-specific constant

ε = Regression residual

Table D-37: Descriptive Statistics – Residential Measure Category Electric Model (shown in Table E-39)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	938.61
Average Post-Retrofit Billing Months	17.01
Average Pre-Retrofit Billing Months	24.49
Adjusted R-Squared Statistic	0.261
Average Monthly Savings	7.74%

Table D-38: Measure-Level Electric Model Savings Summary – Residential

SAVINGS SUMMARY		
Measure Installed	Percent Buildings with Measure Installed	Average Monthly Savings
Appliances	6.0%	4.0%
Building Envelope	78.3%	7.5%
HVAC	52.7%	8.7%
Lighting	38.8%	-6.5%
Renewables	0.6%	49.6%
Water Heaters	32.6%	-5.7%
Other Measures	15.6%	7.2%

Table D-39: Measure Categories Electric Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MEAS_APP	-37.6490	7.5789	-4.9676	0.0000	(-52.5, -22.79)
MEAS_ENVL	-70.6830	2.8139	-25.1192	0.0000	(-76.2, -65.17)
MEAS_HVAC	-81.3750	3.2715	-24.8739	0.0000	(-87.79, -74.96)
MEAS_LIGHT	61.3440	5.0726	12.0932	0.0000	(51.4, 71.29)
MEAS_RENEW	-465.4300	22.4230	-20.7568	0.0000	(-509.38, -421.48)
MEAS_WH	53.5100	5.2243	10.2425	0.0000	(43.27, 63.75)
MEAS_OTHER	-67.4760	5.5072	-12.2523	0.0000	(-78.27, -56.68)
HDD_NORM	0.3237	0.0068	47.9210	0.0000	(0.31, 0.34)
CDD_NORM	1.8033	0.0130	139.1113	0.0000	(1.78, 1.83)
JAN	59.8190	4.8510	12.3313	0.0000	(50.31, 69.33)
FEB	-27.6110	4.7228	-5.8463	0.0000	(-36.87, -18.35)
MAR	-64.7340	4.5374	-14.2668	0.0000	(-73.63, -55.84)
APR	-120.8000	4.7534	-25.4134	0.0000	(-130.12, -111.48)
MAY	-134.0100	5.2643	-25.4564	0.0000	(-144.33, -123.69)
JUN	-119.1100	6.7119	-17.7461	0.0000	(-132.27, -105.95)
JUL	-102.3500	8.2375	-12.4249	0.0000	(-118.5, -86.2)
AUG	-111.6300	8.5806	-13.0096	0.0000	(-128.45, -94.81)
SEP	-143.6800	7.8124	-18.3913	0.0000	(-158.99, -128.37)
OCT	-135.7800	6.0891	-22.2989	0.0000	(-147.71, -123.85)
NOV	-101.8600	4.9622	-20.5272	0.0000	(-111.59, -92.13)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-40: Descriptive Statistics – Nonresidential Measure Category Electric Model (shown in Table E-42)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	2,266.20
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.252

Average Monthly Savings	11.60%

Table D-41: Measure-Level Electric Model Savings Summary – Nonresidential

MEASURE SAVINGS		
Measure Installed	Percent Buildings with Measure Installed	Average Monthly Savings
Appliances	0.7%	16.0%
Building Envelope	1.5%	8.9%
HVAC	2.4%	-6.9%
Lighting	72.7%	13.3%
Renewables	0.2%	-2.0%
Water Heaters	0%	NA
Other Measures	29.5%	6.3%

Table D-42: Measure Categories Electric Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MEAS_APP	-361.5012	176.5587	-2.0475	0.0406	(-707.56, -15.45)
MEAS_ENVL	-201.2017	152.6345	-1.3182	0.1875	(-500.37, 97.96)
MEAS_HVAC	156.4689	106.8887	1.4638	0.1433	(-53.03, 365.97)
MEAS_LIGHT	-301.0120	18.6575	-16.1336	0.0000	(-337.58, -264.44)
MEAS_RENEW	45.7979	375.9785	0.1218	0.9031	(-691.12, 782.72)
MEAS_OTHER	-143.5864	30.5314	-4.7029	0.0000	(-203.43, -83.74)
HDD_NORM	0.9044	0.0634	14.2579	0.0000	(0.78, 1.03)
CDD_NORM	1.0793	0.0747	14.4417	0.0000	(0.93, 1.23)
JAN	-144.1505	41.6370	-3.4621	0.0005	(-225.76, -62.54)
FEB	-110.0550	40.1790	-2.7391	0.0062	(-188.81, -31.3)
MAR	24.8794	38.1677	0.6518	0.5145	(-49.93, 99.69)
APR	124.2959	39.7680	3.1255	0.0018	(46.35, 202.24)
MAY	330.4442	44.1008	7.4929	0.0000	(244.01, 416.88)
JUN	672.9465	57.0039	11.8053	0.0000	(561.22, 784.67)
JUL	1026.2781	72.5248	14.1507	0.0000	(884.13, 1168.43)
AUG	926.9290	75.0067	12.3579	0.0000	(779.92, 1073.94)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
SEP	680.9064	71.6389	9.5047	0.0000	(540.49, 821.32)
OCT	275.0528	57.4735	4.7857	0.0000	(162.4, 387.7)
NOV	-24.9056	44.3804	-0.5612	0.5747	(-111.89, 62.08)

Continued…

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-43: Descriptive Statistics – Residential Measure Category Natural Gas Model (shown in Table E-45)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	66.74
Average Post-Retrofit Billing Months	17.70
Average Pre-Retrofit Billing Months	30.22
Adjusted R-Squared Statistic	0.740
Average Monthly Savings	12.18%

Table D-44: Measure-Level Natural Gas Model Savings Summary – Residential

MEASURE SAVINGS		
Measure Installed	Percent Buildings with Measure Installed	Average Monthly Savings
Building Envelope	84.2%	11.2%
HVAC	34.0%	5.6%
Water Heaters	26.3%	5.1%
Other Measures	21.4%	-2.4%

Table D-45: Measure Categories Natural Gas Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MEAS_ENVL	-7.4915	0.2144	-34.9450	0.0000	(-7.91, -7.07)
MEAS_HVAC	-3.7239	0.3338	-11.1554	0.0000	(-4.38, -3.07)
MEAS_WH	-3.4317	0.4292	-7.9950	0.0000	(-4.27, -2.59)
MEAS_OTHER	1.6265	0.4596	3.5391	0.0004	(0.73, 2.53)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
HDD_NORM	0.1088	0.0006	177.8748	0.0000	(0.11, 0.11)
JAN	9.3793	0.4238	22.1299	0.0000	(8.55, 10.21)
FEB	4.0356	0.4146	9.7337	0.0000	(3.22, 4.85)
MAR	-3.7128	0.3895	-9.5325	0.0000	(-4.48, -2.95)
APR	-20.3210	0.4079	-49.8235	0.0000	(-21.12, -19.52)
MAY	-28.2990	0.4448	-63.6190	0.0000	(-29.17, -27.43)
JUN	-27.1460	0.5279	-51.4216	0.0000	(-28.18, -26.11)
JUL	-22.3940	0.5880	-38.0876	0.0000	(-23.55, -21.24)
AUG	-22.0340	0.5904	-37.3230	0.0000	(-23.19, -20.88)
SEP	-24.2500	0.5776	-41.9855	0.0000	(-25.38, -23.12)
OCT	-26.0190	0.5051	-51.5105	0.0000	(-27.01, -25.03)
NOV	-15.4180	0.4359	-35.3697	0.0000	(-16.27, -14.56)

Continued…

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-46: Descriptive Statistics – Nonresidential Measure Category Natural Gas Model (shown in Table E-48)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	89.30
Average Post-Retrofit Billing Months	19.81
Average Pre-Retrofit Billing Months	28.75
Adjusted R-Squared Statistic	0.575
Average Monthly Savings	12.79%

Table D-47: Measure-Level Natural Gas Model Savings Summary – Nonresidential

MEASURE SAVINGS		
Measure Installed	Percent Buildings with Measure Installed	Average Monthly Savings
Building Envelope	35.3%	25.2%
HVAC	69.9%	8.5%
Water Heaters	0%	NA

Other Measures	42.1%	-4.8%

Table D-48: Measure Categories Natural Gas Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
MEAS_ENVL	-22.4674	10.4814	-2.1435	0.0328	(-43.01, -1.92)
MEAS_HVAC	-7.5852	6.6747	-1.1364	0.2567	(-20.67, 5.5)
MEAS_OTHER	4.3197	9.5785	0.4510	0.6523	(-14.45, 23.09)
HDD_NORM	0.1504	0.0212	7.0917	0.0000	(0.11, 0.19)
JAN	13.2963	12.4856	1.0649	0.2877	(-11.18, 37.77)
FEB	1.4046	12.1934	0.1152	0.9084	(-22.49, 25.3)
MAR	16.8030	11.2966	1.4874	0.1379	(-5.34, 38.94)
APR	-4.2922	12.6862	-0.3383	0.7353	(-29.16, 20.57)
MAY	-9.3629	14.2635	-0.6564	0.5120	(-37.32, 18.59)
JUN	-4.5726	18.4096	-0.2484	0.8040	(-40.66, 31.51)
JUL	3.3404	21.1443	0.1580	0.8746	(-38.1, 44.78)
AUG	7.0780	21.2512	0.3331	0.7393	(-34.57, 48.73)
SEP	0.2509	20.3519	0.0123	0.9902	(-39.64, 40.14)
OCT	-11.9663	15.8855	-0.7533	0.4518	(-43.1, 19.17)
NOV	8.4781	12.7586	0.6645	0.5069	(-16.53, 33.48)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.4.3. RETROFIT COMPREHENSIVENESS

Similarly, the core and non-core points model expressed the change in consumption using a value representing the comprehensiveness of the building retrofit. The core and non-core points were assigned based on the binary installed measure flags in the program tracking data, according to a point system similar to that used in the BBNP process evaluation.

For example, each project could receive a maximum of one core point for heating and one core point for cooling. So a project that installed a heat pump would receive two core points (one for heating and one for cooling), while a project that installed two heating measures (for example, new furnace and a high efficiency wood stove) would only receive one core point (for heating).

Appliances and lighting controls are examples of measures that earned non-core points, because their impact on overall energy consumption is not expected to be as significant as core measures like insulation or photovoltaic cells. The maximum number of points across all grantees was 6 core and 6 non-core; the average project in the billing data has 2.2 core and 0.8 non-core points.

Both of these variables interacted with the indicator for the post-period, so that the model would estimate the impact of each additional core and non-core point on fuel consumption in the post-period.

$$kWh_{i,t} = \alpha_i + \beta_1(Core_i \times Post_{i,t}) + \beta_2(NonCore_i \times Post_{i,t}) + \beta_3(Weather_t) + \sum_{j=4}^{14} \beta_j(Month_t) + \varepsilon$$

$$Therms_{i,t} = \alpha_i + \beta_1(Core_i \times Post_{i,t}) + \beta_2(NonCore_i \times Post_{i,t}) + \beta_3(Weather_t) + \sum_{j=4}^{14} \beta_j(Month_t) + \varepsilon$$

Where:

$kWh_{i,t}$ = Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t}$ = Normalized natural gas usage (therms) in month t for customer i

$Core_i$ = Number of core points earned by customer i, based on mix of measures installed

$NonCore_i$ = Number of non-core points earned by customer i, based on mix of measures installed

$Post_{i,t}$ = Binary variable indicating post-participation month for customer i

$Weather_t$ = Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD] in kWh model, but only HDD in therm model)

$Month_t$ = Set of binary variables indicating whether or not billing month t is January, February, March, etc.

α_i = Customer-specific constant

ε = Regression residual

Table D-49: Descriptive Statistics – Residential Comprehensiveness Electric Model (shown in Table E-51)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	938.61
Average Post-Retrofit Billing Months	17.01
Average Pre-Retrofit Billing Months	24.49
Adjusted R-Squared Statistic	0.256
Average Monthly Savings	6.86%

Table D-50: Point-Level Electric Model Savings Summary – Residential

SAVINGS BREAKDOWN		
Type	Average Number of Points per Building	Percent Savings Per Point
Core Points	2.56	3.02%
Non-Core Points	0.74	-1.17%

Table D-51: Comprehensiveness Electric Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
CORE	-28.3900	0.8605	-32.9924	0.0000	(-30.08, -26.7)
NONCORE	11.0170	2.1667	5.0847	0.0000	(6.77, 15.26)
HDD_NORM	0.3238	0.0068	47.7652	0.0000	(0.31, 0.34)
CDD_NORM	1.7894	0.0130	137.6885	0.0000	(1.76, 1.81)
JAN	59.4940	4.8682	12.2209	0.0000	(49.95, 69.04)
FEB	-25.1720	4.7386	-5.3121	0.0000	(-34.46, -15.88)
MAR	-63.5260	4.5528	-13.9532	0.0000	(-72.45, -54.6)
APR	-119.3200	4.7699	-25.0152	0.0000	(-128.67, -109.97)
MAY	-131.5700	5.2822	-24.9082	0.0000	(-141.92, -121.22)
JUN	-115.8400	6.7350	-17.1997	0.0000	(-129.04, -102.64)
JUL	-95.6940	8.2623	-11.5820	0.0000	(-111.89, -79.5)
AUG	-103.6100	8.6045	-12.0414	0.0000	(-120.47, -86.75)
SEP	-137.1200	7.8348	-17.5014	0.0000	(-152.48, -121.76)
OCT	-133.1200	6.1100	-21.7872	0.0000	(-145.1, -121.14)
NOV	-100.2700	4.9791	-20.1382	0.0000	(-110.03, -90.51)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-52: Descriptive Statistics – Nonresidential Comprehensiveness Electric Model (shown in Table E-54)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	2,266.20
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.250
Average Monthly Savings	10.95%

Table D-53: Point-Level Electric Model Savings Summary – Nonresidential

SAVINGS BREAKDOWN		
Type	Average Number of Points per Building	Percent Savings Per Point
Core Points	0.77	11.79%
Non-Core Points	0.31	6.01%

Table D-54: Comprehensiveness Electric Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
CORE	-267.1966	17.5127	-15.2573	0.0000	(-301.52, -232.87)
NON-CORE	-136.2837	29.6763	-4.5923	0.0000	(-194.45, -78.12)
HDD_NORM	0.9090	0.0635	14.3197	0.0000	(0.78, 1.03)
CDD_NORM	1.0734	0.0748	14.3529	0.0000	(0.93, 1.22)
JAN	-145.4998	41.6832	-3.4906	0.0005	(-227.2, -63.8)
FEB	-110.3092	40.2253	-2.7423	0.0061	(-189.15, -31.47)
MAR	24.3486	38.2092	0.6372	0.5240	(-50.54, 99.24)
APR	124.1705	39.8090	3.1192	0.0018	(46.14, 202.2)
MAY	331.0183	44.1437	7.4986	0.0000	(244.5, 417.54)
JUN	673.7737	57.0446	11.8113	0.0000	(561.97, 785.58)
JUL	1028.7137	72.5814	14.1732	0.0000	(886.45, 1170.97)
AUG	930.6266	75.0541	12.3994	0.0000	(783.52, 1077.73)
SEP	685.2187	71.6896	9.5581	0.0000	(544.71, 825.73)
OCT	277.5252	57.5111	4.8256	0.0000	(164.8, 390.25)
NOV	-23.7437	44.4151	-0.5346	0.5929	(-110.8, 63.31)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-55: Descriptive Statistics – Residential Comprehensiveness Natural Gas Model (shown in Table E-57)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	66.74
Average Post-Retrofit Billing Months	16.96

Continued…

MODEL SUMMARY	
Average Pre-Retrofit Billing Months	24.45
Adjusted R-Squared Statistic	0.740
Average Monthly Savings	11.86%

Table D-56: Point-Level Natural Gas Model Savings Summary – Residential

SAVINGS BREAKDOWN		
Type	Average Number of Points per Building	Percent Savings Per Point
Core Points	2.36	4.00%
Non-Core Points	0.89	2.72%

Table D-57: Comprehensiveness Natural Gas Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
CORE	-2.6697	0.0874	-30.5514	0.0000	(-2.84, -2.5)
NON-CORE	-1.8183	0.1746	-10.4153	0.0000	(-2.16, -1.48)
HDD_NORM	0.1089	0.0006	178.0143	0.0000	(0.11, 0.11)
JAN	9.3845	0.4239	22.1395	0.0000	(8.55, 10.22)
FEB	4.0492	0.4147	9.7653	0.0000	(3.24, 4.86)
MAR	-3.7154	0.3895	-9.5384	0.0000	(-4.48, -2.95)
APR	-20.3070	0.4079	-49.7830	0.0000	(-21.11, -19.51)
MAY	-28.2750	0.4449	-63.5593	0.0000	(-29.15, -27.4)
JUN	-27.1440	0.5280	-51.4120	0.0000	(-28.18, -26.11)
JUL	-22.3910	0.5880	-38.0793	0.0000	(-23.54, -21.24)
AUG	-22.0160	0.5904	-37.2900	0.0000	(-23.17, -20.86)
SEP	-24.2220	0.5776	-41.9341	0.0000	(-25.35, -23.09)
OCT	-26.0120	0.5052	-51.4926	0.0000	(-27, -25.02)
NOV	-15.4150	0.4360	-35.3587	0.0000	(-16.27, -14.56)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-58: Descriptive Statistics – Nonresidential Comprehensiveness Natural Gas Model (shown in Table E-60)

MODEL SUMMARY	
Average Monthly Normalized Usage (therm)	89.30
Average Post-Retrofit Billing Months	19.72
Average Pre-Retrofit Billing Months	35.62
Adjusted R-Squared Statistic	0.574
Average Monthly Savings	9.29%

Table D-59: Point-Level Natural Gas Model Savings Summary – Nonresidential

SAVINGS BREAKDOWN		
Type	Average Number of Points per Building	Percent Savings Per Point
Core Points	1.05	6.48%
Non-Core Points	0.60	4.12%

Table D-60: Comprehensiveness Natural Gas Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
CORE	-5.7837	4.4200	-1.3085	0.1916	(-14.45, 2.88)
NON-CORE	-3.6768	7.9120	-0.4647	0.6425	(-19.18, 11.83)
HDD_NORM	0.1525	0.0213	7.1742	0.0000	(0.11, 0.19)
JAN	13.4430	12.5321	1.0727	0.2842	(-11.12, 38.01)
FEB	1.2371	12.2382	0.1011	0.9195	(-22.75, 25.22)
MAR	17.5859	11.3312	1.5520	0.1217	(-4.62, 39.8)
APR	-3.5665	12.7332	-0.2801	0.7796	(-28.52, 21.39)
MAY	-8.4723	14.3109	-0.5920	0.5543	(-36.52, 19.58)
JUN	-2.8410	18.4548	-0.1539	0.8778	(-39.01, 33.33)
JUL	5.9013	21.2050	0.2783	0.7810	(-35.66, 47.46)
AUG	9.4810	21.3116	0.4449	0.6567	(-32.29, 51.25)
SEP	2.5415	20.4105	0.1245	0.9010	(-37.46, 42.55)
OCT	-10.3339	15.9242	-0.6489	0.5168	(-41.55, 20.88)
NOV	10.2526	12.7782	0.8023	0.4230	(-14.79, 35.3)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.5. MODEL WITH MATCHED CONTROLS

D.5.1. MATCHED COMPARISON GROUP MODELS

We explored an alternative analysis approach that allowed us to include a counterfactual by developing a matched comparison group; a true control group was not available due to program design. We developed a matched comparison group by exploiting the variation in program participation dates as described below. This analysis was only conducted for residential customers as matching across business types would be problematic.

Program participants are split into two groups, early participants and late participants, based on the date of participation in the program. We flagged households treated by the program between January 1, 2011 and December 30, 2011 as early participants, and households treated after December 30, 2011 as late participants. Early participants were classified as the treatment group and late participants were classified as the comparison group. We selected December 30, 2011 as the cutoff date for the treatment group to ensure that there was sufficient data in the post treatment period such that the comparison group contained a sufficient number of households with at least 12 non-treatment months of data in the post period. We then matched each treatment group household with the household in the comparison group with: 1) the minimum sum of squared differences in normalized monthly energy usage in the 12 months prior to January 1, 2011; and 2) a treatment date at least 365 days after the treatment group household's treatment date.[73]

After the matching process was complete, we estimated billing regression models using a dataset that includes only the treatment group and their matched comparison group households.

Using this analysis approach proved problematic. The matched comparison approach requires a wide range of billing data (ideally 3 years) for each household. A significant proportion of grantee programs did not have sufficient data and, therefore, were not represented in the treatment group.

D.5.2. ADJUSTED FINAL MODEL SPECIFICATION

The first model is based on the final model specifications, but the post-retrofit period variable was replaced with a variable that interacts the post-retrofit period with an indicator of a household being in the treatment group. This variable estimates the impact of the retrofit in treatment group households in the post-period. We also included a variable that interacts the post-retrofit period with an indicator of the household being in the comparison group. We included this variable to account for months after comparison group households had been retrofit. These months were for comparison group households that were matched to very early participants. All of the model output was based on data after the final screens (Section 3.4.2) were applied.

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73 We investigated matching based on other household variables, including, HDD, CDD and billing period length but there was not strong evidence that these provided a better match than using monthly energy consumption alone.

$$kWh_{i,t} = \alpha_i + \beta_1(Post * Treatment)_{i,t} + \beta_2(Post * Comparison)_{i,t} + \beta_3(Weather_t) + \sum_{4}^{14} \beta_j(Month_t) + \varepsilon_t$$

$$Therms_{i,t} = \alpha_i + \beta_1(Post * Treatment)_{i,t} + \beta_2(Post * Comparison)_{i,t} + \beta_3(Weather_t) + \sum_{4}^{14} \beta_j(Month_t) + \varepsilon_t$$

Where:

$kWh_{i,t}$ = Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t}$ = Normalized natural gas usage (Therms) in month t for customer i

$Post_{i,t}$ = Binary variable indicating post-retrofit month for customer i

$Treatment_i$ = Binary variable indicating a household in the treatment group

$Comparison_i$ = Binary variable indicating a household in the comparison group

$Month_t$ = Set of binary variables indicating whether or not billing month t is January, February, March, etc.

α_i = Customer-specific constant

ε_t = Regression residual

Table D-61: Descriptive Statistics – Residential Matched Comparison Electric Model (shown in Table E-62)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	997.97
Average Treatment Group Post-Retrofit Billing Months	19.35
Average Treatment Group Pre-Retrofit Billing Months	21.53
Adjusted R-Squared Statistic	0.741
Average Monthly Savings	5.89%

Table D-62: Matched Comparison Electric Model Regression Results - Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POSTTRXX	-58.7716	4.1512	-14.1580	0.0000	(-66.91,-50.64)
POSTCTRL	-30.7904	7.0896	-4.3430	0.0000	(-44.69,-16.89)
HDD_NORM	0.2746	0.0153	17.9030	0.0000	(0.24,0.3)
CDD_NORM	1.4838	0.0252	58.9760	0.0000	(1.43,1.53)
JAN	-71.0381	7.9373	-8.9500	0.0000	(-86.6,-55.48)
FEB	-120.1315	8.0179	-14.9830	0.0000	(-135.85,-104.42)
MAR	-207.3356	9.6544	-21.4760	0.0000	(-226.26,-188.41)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
					Continued…
APR	-227.5241	11.4014	-19.9560	0.0000	(-249.87,-205.18)
MAY	-174.2840	14.0443	-12.4100	0.0000	(-201.81,-146.76)
JUN	-80.3371	18.6481	-4.3080	0.0000	(-116.89,-43.79)
JUL	-69.5914	20.6685	-3.3670	0.0008	(-110.1,-29.08)
AUG	-116.2527	19.9461	-5.8280	0.0000	(-155.35,-77.16)
SEP	-178.9798	16.3301	-10.9600	0.0000	(-210.99,-146.97)
OCT	-177.0011	12.0195	-14.7260	0.0000	(-200.56,-153.44)
NOV	-95.8135	8.9593	-10.6940	0.0000	(-113.37,-78.25)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-63: Descriptive Statistics – Residential Matched Comparison Natural Gas Model (shown in Table E-64)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	63.19
Average Treatment Group Post-Retrofit Billing Months	21.75
Average Treatment Group Pre-Retrofit Billing Months	24.42
Adjusted R-Squared Statistic	0.79
Average Monthly Savings	13.63%

Table D-64: Matched Comparison Natural Gas Model Regression Results - Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POSTTRXX	-8.6133	0.3626	-23.7550	0.0000	(-9.32, -7.9)
POSTCTRL	-6.3671	0.8743	-7.2820	0.0000	(-8.08, -4.65)
HDD_NORM	0.1235	0.0013	92.2840	0.0000	(0.12, 0.13)
CDD_NORM	0.0144	0.0022	6.5130	0.0000	(0.01, 0.02)
JAN	3.7679	0.6950	5.4210	0.0000	(2.41, 5.13)
FEB	-2.0238	0.7073	-2.8610	0.0042	(-3.41, -0.64)
MAR	-15.1075	0.8594	-17.5800	0.0000	(-16.79, -13.42)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
					Continued…
APR	-26.2773	0.9955	-26.3950	0.0000	(-28.23, -24.33)
MAY	-25.4384	1.2029	-21.1470	0.0000	(-27.8, -23.08)
JUN	-21.8478	1.6127	-13.5480	0.0000	(-25.01, -18.69)
JUL	-21.2573	1.7746	-11.9790	0.0000	(-24.74, -17.78)
AUG	-21.4064	1.7280	-12.3880	0.0000	(-24.79, -18.02)
SEP	-23.0428	1.4029	-16.4250	0.0000	(-25.79, -20.29)
OCT	-20.5652	1.0249	-20.0660	0.0000	(-22.57, -18.56)
NOV	-8.6279	0.7721	-11.1740	0.0000	(-10.14, -7.11)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.5.3. MONTHLY CONSUMPTION MODEL SPECIFICATION

In addition to the final model specification, we investigated a monthly consumption billing regression model based on the Variation in Adoption (VIA) model developed by Harding and Hsiaw (2012). Using this model, we examined program impacts by month for the treatment group. The model includes a set of 24 binary variables that indicate the 24 months in the post-retrofit period. These variables capture exogenous monthly variation in consumption in the post-retrofit period such as weather. A set of 24 binary variables that indicate months after a treatment group household was retrofit through the program capture the impact of the program. Also included is a variable indicating months after retrofit for comparison group households. These months exist for comparison group households that are matched to very early participants.

$$ADC(kWh)_{i,t} = \alpha_i + \sum_{1}^{24} \beta_j (PostMonth_t) + \sum_{25}^{24} \beta_j (TreatmentPostMonth_t) + \beta_{49} (PostComparison)_{i,t} + \varepsilon_t$$

$$ADC(Therms)_{i,t} = \alpha_i + \sum_{1}^{24} \beta_j (PostMonth_t) + \sum_{25}^{24} \beta_j (TreatmentPostMonth_t) + \beta_{49} (Post * Comparison)_{i,t} + \varepsilon_t$$

Where:

$ADC(kWh)_{i,t}$ = Average daily consumption (kWh) in month t for customer i

$ADC(Therms)_{i,t}$ = Average daily consumption (Therms) in month t for customer i

$PostMonth_t$ = Binary variable indicating month (January 2011 to December 2012) after first household treated by program

$TreatmentPostMonth_i$ = Binary variable indicating post-retrofit month (January 2011 to December 2012) for treatment group customer i

$PostComparison_i$ = Binary variable indicating a post-retrofit period for comparison customer i

α_i = Customer-specific constant

ε_t = Regression residual

Table D-65: Descriptive Statistics – Residential Matched Comparison Monthly Consumption Electric Model (shown in Table E-66)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	997.97
Average Post-Retrofit Billing Months	19.35
Average Pre-Retrofit Billing Months	21.53
Adjusted R-Squared Statistic	0.695
Average Monthly Savings	4.81%

Table D-66: Matched Comparison Monthly Consumption Electric Model Regression Results - Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
JAN11	2.2802	0.3563	6.3990	0.0000	(1.58,2.98)
FEB11	-0.0140	0.3788	-0.0370	0.9706	(-0.76,0.73)
MAR11	-4.6589	0.3842	-12.1260	0.0000	(-5.41,-3.91)
APR11	-6.3286	0.3956	-15.9960	0.0000	(-7.1,-5.55)
MAY11	-2.8701	0.4090	-7.0170	0.0000	(-3.67,-2.07)
JUN11	3.9735	0.4217	9.4220	0.0000	(3.15,4.8)
JUL11	11.0460	0.4372	25.2670	0.0000	(10.19,11.9)
AUG11	8.7433	0.4971	17.5900	0.0000	(7.77,9.72)
SEP11	-0.5754	0.5093	-1.1300	0.2586	(-1.57,0.42)
OCT11	-4.2601	0.5240	-8.1300	0.0000	(-5.29,-3.23)
NOV11	-2.8927	0.5604	-5.1620	0.0000	(-3.99,-1.79)
DEC11	1.9833	0.5649	3.5110	0.0004	(0.88,3.09)
JAN12	-0.7877	0.5669	-1.3890	0.1647	(-1.9,0.32)
FEB12	-1.5498	0.5561	-2.7870	0.0053	(-2.64,-0.46)
MAR12	-6.4293	0.5694	-11.2920	0.0000	(-7.55,-5.31)
APR12	-6.9760	0.5599	-12.4590	0.0000	(-8.07,-5.88)
MAY12	-4.6771	0.5323	-8.7870	0.0000	(-5.72,-3.63)
JUN12	6.3882	0.4763	13.4110	0.0000	(5.45,7.32)
JUL12	12.4801	0.5390	23.1560	0.0000	(11.42,13.54)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
					Continued…
AUG12	4.8504	0.5574	8.7020	0.0000	(3.76,5.94)
SEP12	-2.9028	0.6429	-4.5150	0.0000	(-4.16,-1.64)
OCT12	-7.2708	0.6944	-10.4700	0.0000	(-8.63,-5.91)
NOV12	-5.1053	0.6482	-7.8760	0.0000	(-6.38,-3.83)
DEC12	-0.3817	0.6280	-0.6080	0.5433	(-1.61,0.85)
TJAN11	-9.8026	1.5693	-6.2470	0.0000	(-12.88,-6.73)
TFEB11	-8.3458	0.9792	-8.5230	0.0000	(-10.27,-6.43)
TMAR11	-6.2281	0.8467	-7.3560	0.0000	(-7.89,-4.57)
TAPR11	-1.0126	0.7691	-1.3170	0.1880	(-2.52,0.49)
TMAY11	1.1777	0.7252	1.6240	0.1044	(-0.24,2.6)
TJUN11	3.0561	0.7287	4.1940	0.0000	(1.63,4.48)
TJUL11	0.7150	0.7005	1.0210	0.3073	(-0.66,2.09)
TAUG11	-2.0686	0.6885	-3.0050	0.0027	(-3.42,-0.72)
TSEP11	-1.6633	0.6881	-2.4170	0.0156	(-3.01,-0.31)
TOCT11	-2.4563	0.6788	-3.6180	0.0003	(-3.79,-1.13)
TNOV11	-1.8318	0.6905	-2.6530	0.0080	(-3.19,-0.48)
TDEC11	-2.6672	0.6893	-3.8690	0.0001	(-4.02,-1.32)
TJAN12	-2.3681	0.6929	-3.4180	0.0006	(-3.73,-1.01)
TFEB12	-2.3503	0.7043	-3.3370	0.0008	(-3.73,-0.97)
TMAR12	-0.9838	0.7326	-1.3430	0.1793	(-2.42,0.45)
TAPR12	-1.2285	0.7236	-1.6980	0.0895	(-2.65,0.19)
TMAY12	-0.2650	0.7075	-0.3750	0.7080	(-1.65,1.12)
TJUN12	-1.0873	0.6710	-1.6200	0.1051	(-2.4,0.23)
TJUL12	-4.1221	0.7177	-5.7430	0.0000	(-5.53,-2.72)
TAUG12	-1.5253	0.7316	-2.0850	0.0371	(-2.96,-0.09)
TSEP12	-2.0753	0.8035	-2.5830	0.0098	(-3.65,-0.5)
TOCT12	0.1085	0.8559	0.1270	0.8992	(-1.57,1.79)
TNOV12	4.5028	0.8459	5.3230	0.0000	(2.84,6.16)
TDEC12	4.3331	0.8459	5.1230	0.0000	(2.68,5.99)
CTRLDUM	1.0222	0.4828	2.1170	0.0342	(0.08,1.97)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

Table D-67: Descriptive Statistics – Residential Matched Comparison Monthly Consumption Natural Gas Model (shown in Table E-68)

MODEL SUMMARY	
Average Monthly Normalized Usage (kWh)	63.52
Average Treatment Group Post-Retrofit Billing Months	21.75
Average Treatment Group Pre-Retrofit Billing Months	24.42
Adjusted R-Squared Statistic	0.502
Average Monthly Savings	13.77%

Table D-68: Matched Comparison Monthly Consumption Natural Gas Model Regression Results - Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
JAN11	2.7124	0.0454	59.7850	0.0000	(2.62,2.8)
FEB11	2.2907	0.0497	46.1230	0.0000	(2.19,2.39)
MAR11	0.5913	0.0510	11.5970	0.0000	(0.49,0.69)
APR11	-0.2925	0.0512	-5.7150	0.0000	(-0.39,-0.19)
MAY11	-0.9819	0.0522	-18.8230	0.0000	(-1.08,-0.88)
JUN11	-1.6554	0.0536	-30.8730	0.0000	(-1.76,-1.55)
JUL11	-1.8018	0.0567	-31.7560	0.0000	(-1.91,-1.69)
AUG11	-1.7908	0.0657	-27.2530	0.0000	(-1.92,-1.66)
SEP11	-1.5253	0.0680	-22.4230	0.0000	(-1.66,-1.39)
OCT11	-0.5505	0.0691	-7.9700	0.0000	(-0.69,-0.42)
NOV11	0.9882	0.0803	12.3000	0.0000	(0.83,1.15)
DEC11	2.4013	0.0823	29.1690	0.0000	(2.24,2.56)
JAN12	2.1944	0.0802	27.3680	0.0000	(2.04,2.35)
FEB12	2.0811	0.0820	25.3930	0.0000	(1.92,2.24)
MAR12	0.0553	0.0820	0.6740	0.5002	(-0.11,0.22)
APR12	-0.8519	0.0807	-10.5630	0.0000	(-1.01,-0.69)
MAY12	-1.3495	0.0818	-16.5010	0.0000	(-1.51,-1.19)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
JUN12	-1.6509	0.0837	-19.7300	0.0000	(-1.81,-1.49)
JUL12	-1.7515	0.0892	-19.6380	0.0000	(-1.93,-1.58)

Continued…

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
AUG12	-1.7161	0.0915	-18.7640	0.0000	(-1.9,-1.54)
SEP12	-1.4715	0.0954	-15.4300	0.0000	(-1.66,-1.28)
OCT12	-0.5102	0.1060	-4.8130	0.0000	(-0.72,-0.3)
NOV12	0.4381	0.1099	3.9860	0.0001	(0.22,0.65)
DEC12	1.5609	0.1130	13.8110	0.0000	(1.34,1.78)
TJAN11	-0.9819	0.1417	-6.9300	0.0000	(-1.26,-0.7)
TFEB11	-1.4830	0.1005	-14.7510	0.0000	(-1.68,-1.29)
TMAR11	-0.8437	0.1006	-8.3840	0.0000	(-1.04,-0.65)
TAPR11	-0.4421	0.0972	-4.5480	0.0000	(-0.63,-0.25)
TMAY11	0.0506	0.0966	0.5230	0.6006	(-0.14,0.24)
TJUN11	0.3943	0.0945	4.1740	0.0000	(0.21,0.58)
TJUL11	0.4297	0.0917	4.6840	0.0000	(0.25,0.61)
TAUG11	0.3060	0.0901	3.3960	0.0007	(0.13,0.48)
TSEP11	0.0881	0.0889	0.9900	0.3219	(-0.09,0.26)
TOCT11	-0.1070	0.0883	-1.2120	0.2255	(-0.28,0.07)
TNOV11	-0.4376	0.0949	-4.6100	0.0000	(-0.62,-0.25)
TDEC11	-0.8846	0.0960	-9.2170	0.0000	(-1.07,-0.7)
TJAN12	-0.7332	0.0955	-7.6730	0.0000	(-0.92,-0.55)
TFEB12	-0.6688	0.1000	-6.6910	0.0000	(-0.86,-0.47)
TMAR12	-0.5539	0.1002	-5.5310	0.0000	(-0.75,-0.36)
TAPR12	-0.3170	0.0993	-3.1930	0.0014	(-0.51,-0.12)
TMAY12	-0.2353	0.1009	-2.3310	0.0197	(-0.43,-0.04)
TJUN12	-0.1848	0.1032	-1.7900	0.0735	(-0.39,0.02)
TJUL12	-0.1552	0.1090	-1.4240	0.1544	(-0.37,0.06)
TAUG12	-0.1781	0.1113	-1.6000	0.1096	(-0.4,0.04)
TSEP12	-0.2139	0.1140	-1.8770	0.0606	(-0.44,0.01)
TOCT12	-0.1387	0.1228	-1.1290	0.2588	(-0.38,0.1)
TNOV12	0.0927	0.1261	0.7350	0.4623	(-0.15,0.34)

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
TDEC12	0.2069	0.1299	1.5930	0.1111	(-0.05,0.46)
CTRLDUM	-0.0162	0.0769	-0.2110	0.8327	(-0.17,0.13)

Source: Analysis by Evergreen Economics of data provided by Better Buildings

D.6. WEIGHTED ANNUAL CONSUMPTION

Next we developed a weighting scheme to remove the need for monthly indicator variables that control for seasonal changes in energy use for reasons other than temperature. This was done by aggregating the billing data for each household to determine the average normalized monthly fuel consumption, HDD, and CDD during each period for each calendar month. For each month with no observations in the pre period, the corresponding month in the post period was set to a missing value; this process was repeated for months with no observations in the post period. The resulting dataset contained up to 12 months of data in the pre and post periods for each household, with the same calendar months present in each period. First we ran the model including only those households with 12 months of data (full calendar year) in the pre and post periods, than ran the model requiring only 6 months of data in the pre and post periods, with the same calendar months in each period.

The total fuel consumption was determined for each period by summing each remaining month's fuel consumption, HDD, and CDD. Since the calendar months present in each period did not differ, any differences in monthly consumption due to seasonal effects not related to heating or cooling would be the same in each summed period, thus it was not necessary to include monthly dummies to control for these effects.

$$kWh_{i,t} = a_i + b_1(Post_{i,t}) + b_2(Weather_t) + e$$
$$Therms_{i,t} = a_i + b_1(Post_{i,t}) + b_2(Weather_t) + e$$

Where:

$kWh_{i,t}$ = Normalized electricity usage (kWh) in month t for customer i

$Therms_{i,t}$ = Normalized natural gas usage (therms) in month t for customer i

$Post_{i,t}$ = Binary variable indicating post-participation month for customer i

$Weather_t$ = Weather data for month t (heating degree-days [HDD] and cooling degree-days [CDD] in kWh model, but only HDD in therm model)

a_i = Customer-specific constant

e = Regression residual

Table D-69: Descriptive Statistics – Residential Annualized (Full Year) Electric Model (shown in Table E-70)

MODEL SUMMARY	
Average Annual Normalized Usage (kWh)	1,102.54
Average Post-Retrofit Billing Months	12.00
Average Pre-Retrofit Billing Months	12.00
Adjusted R-Squared Statistic	0.020
Average Monthly Savings	6.95%

Table D-70: Annualized (Full Year) Monthly Consumption Electric Model Regression Results - Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-76.6745	7.4890	-10.2383	0.0000	(-91.353, -61.996)
HDD_NORM_YR	0.0157	0.0147	1.0652	0.2257	(-0.013, 0.045)
CDD_NORM_YR	0.0874	0.0194	4.5064	0.0000	(0.049, 0.125)

Table D-71: Descriptive Statistics – Nonresidential Annualized (Full Year) Electric Model (shown in Table E-72)

MODEL SUMMARY	
Average Annual Normalized Usage (kWh)	3,666.61
Average Post-Retrofit Billing Months	12.00
Average Pre-Retrofit Billing Months	12.00
Adjusted R-Squared Statistic	0.090
Average Monthly Savings	12.97%

Table D-72: Annualized (Full Year) Monthly Consumption Electric Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-475.4643	107.7447	-4.4129	0.0000	(-686.644, -264.285)
HDD_NORM_YR	-0.1699	0.2563	-0.6629	0.3196	(-0.672, 0.332)
CDD_NORM_YR	-0.0828	0.5098	-0.1624	0.3932	(-1.082, 0.916)

Table D-73: Descriptive Statistics – Residential Annualized (Full Year) Natural Gas Model (shown in Table E-74)

MODEL SUMMARY	
Average Annual Normalized Usage (therms)	71.13
Average Post-Retrofit Billing Months	12.00
Average Pre-Retrofit Billing Months	12.00
Adjusted R-Squared Statistic	0.131
Average Monthly Savings	11.77%

Table D-74: Annualized (Full Year) Monthly Consumption Natural Gas Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-8.3714	0.4459	-18.7721	0.0000	(-9.245, -7.497)
HDD_NORM_YR	0.0165	0.0010	17.2553	0.0000	(0.015, 0.018)

Table D-75: Descriptive Statistics – Nonresidential Annualized (Full Year) Natural Gas Model (shown in Table E-76)

MODEL SUMMARY	
Average Annual Normalized Usage (therms)	145.08
Average Post-Retrofit Billing Months	12.00
Average Pre-Retrofit Billing Months	12.00
Adjusted R-Squared Statistic	0.042
Average Monthly Savings	-7.26%

Table D-76: Annualized (Full Year) Monthly Consumption Natural Gas Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	10.5366	5.3569	1.9669	0.0581	(0.037, 21.036)
HDD_NORM_YR	0.0386	0.0152	2.5423	0.0163	(0.009, 0.068)

Table D-77: Descriptive Statistics – Residential Annualized (Partial Year) Electric Model (shown in Table E-78)

MODEL SUMMARY	
Average Annual Normalized Usage (kWh)	1,241.39
Average Post-Retrofit Billing Months	9.87
Average Pre-Retrofit Billing Months	9.87
Adjusted R-Squared Statistic	0.007
Average Monthly Savings	7.26%

Table D-78: Annualized (Partial Year) Monthly Consumption Electric Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-90.0787	7.4567	-12.0802	0.0000	(-104.694, -75.464)
HDD_NORM_YR	-0.0030	0.0164	-0.1828	0.3918	(-0.035, 0.029)
CDD_NORM_YR	0.0753	0.0256	2.9409	0.0057	(0.025, 0.125)

Table D-79: Descriptive Statistics – Nonresidential Annualized (Partial Year) Electric Model (shown in Table E-80)

MODEL SUMMARY	
Average Annual Normalized Usage (kWh)	4,132.88
Average Post-Retrofit Billing Months	10.69
Average Pre-Retrofit Billing Months	10.69
Adjusted R-Squared Statistic	0.049
Average Monthly Savings	10.56%

Table D-80: Annualized (Partial Year) Monthly Consumption Electric Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-436.5857	84.6998	-5.1545	0.0000	(-602.597, -270.574)
HDD_NORM_YR	-0.0103	0.2385	-0.0432	0.3981	(-0.478, 0.457)

CDD_NORM_YR	0.0042	0.4282	0.0098	0.3984	(-0.835, 0.843)

Table D-81: Descriptive Statistics – Residential Annualized (Partial Year) Natural Gas Model (shown in Table E-82)

MODEL SUMMARY	
Average Annual Normalized Usage (therms)	78.26
Average Post-Retrofit Billing Months	10.13
Average Pre-Retrofit Billing Months	10.13
Adjusted R-Squared Statistic	0.040
Average Monthly Savings	9.06%

Table D-82: Annualized (Partial Year) Monthly Consumption Natural Gas Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	-7.0932	0.4964	-14.2881	0.0000	(-8.066, -6.12)
HDD_NORM_YR	0.0175	0.0010	17.4814	0.0000	(0.016, 0.019)

Table D-83: Descriptive Statistics – Nonresidential Annualized (Partial Year) Natural Gas Model (shown in Table E-84)

MODEL SUMMARY	
Average Annual Normalized Usage (therms)	173.03
Average Post-Retrofit Billing Months	9.86
Average Pre-Retrofit Billing Months	9.86
Adjusted R-Squared Statistic	0.096
Average Monthly Savings	-10.17%

Table D-84: Annualized (Partial Year) Monthly Consumption Natural Gas Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
POST	17.5988	3.8214	4.6054	0.0000	(10.109, 25.089)

HDD_NORM_YR	0.0505	0.0094	5.3531	0.0000	(0.032, 0.069)

D.7. NORMALIZED ANNUAL CONSUMPTION

The next model we used was normalized annual consumption model, which normalizes the consumption during each period before comparing the pre and post, instead of determining the heating and cooling slopes in the same model as the other components of consumption. The first step in this process was to run grantee-level models with pre-period data to determine the household baseline consumption (intercepts), heating slope, and cooling slope for each household. Then the post-period annual consumption was estimated using the known HDD and CDD in the post-period multiplied by their heating and cooling slopes, respectively, then adding the household's monthly baseline consumption multiplied by 12. Then the expected difference between the pre-period and the post-period was determined by subtracting the pre-period consumption from the expected post-period consumption.

The actual difference between the pre- and post-period represents the impact of participation. So we included the expected difference as Part=0 and the observed difference as Part=1. The final model used this data to determine the impact of participation in the program with the coefficient on the Part variable.

Normalized Annual Consumption:

$$Fuel_{i,t} = \mu_i + \beta_w(Weather_t) + \varepsilon$$

$$NAC_{i,t} = (12 \times \mu_i) + (\hat{\beta}_w \times Weather_t)$$

$$\Delta NAC_{i,t} = \alpha_i + \beta_P(Part_i) + \varepsilon$$

Table D-85: Descriptive Statistics – Residential Normalized Annual Electric Model (shown in Table E-86)

MODEL SUMMARY	
Average Annual Normalized Usage (kWh)	13,933.55
Average Post-Retrofit Billing Months	16.47
Average Pre-Retrofit Billing Months	22.75
Adjusted R-Squared Statistic	0.012
Average Monthly Savings	9.52%

Table D-86: Normalized Annual Consumption Electric Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
PART	-1327.0300	128.9600	-10.2902	0.0000	(-1579.792, -1074.268)

Table D-87: Descriptive Statistics – Nonresidential Normalized Annual Electric Model (shown in Table E-88)

MODEL SUMMARY	
Average Annual Normalized Usage (kWh)	47,842.98
Average Post-Retrofit Billing Months	19.31
Average Pre-Retrofit Billing Months	33.79
Adjusted R-Squared Statistic	0.153
Average Monthly Savings	23.78%

Table D-88: Normalized Annual Consumption Electric Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
PART	-11374.7100	915.1700	-12.4291	0.0000	(-13168.443, -9580.977)

Table D-89: Descriptive Statistics – Residential Normalized Annual Natural Gas Model (shown in Table E-90)

MODEL SUMMARY	
Average Annual Normalized Usage (therms)	938.94
Average Post-Retrofit Billing Months	17.34
Average Pre-Retrofit Billing Months	25.89
Adjusted R-Squared Statistic	0.000
Average Monthly Savings	0.14%

Table D-90: Normalized Annual Consumption Natural Gas Model Regression Results – Residential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
PART	-1.3265	474.5635	-0.0028	0.3984	(-931.471, 928.818)

Table D-91: Descriptive Statistics – Nonresidential Normalized Annual Natural Gas Model (shown in Table E-92)

MODEL SUMMARY	
Average Annual Normalized Usage (therms)	5,835.82
Average Post-Retrofit Billing Months	19.99
Average Pre-Retrofit Billing Months	27.49
Adjusted R-Squared Statistic	0.002
Average Monthly Savings	3.83%

Table D-92: Normalized Annual Consumption Natural Gas Model Regression Results – Nonresidential

VARIABLE	COEFFICIENT (β)	STANDARD ERROR	β/STANDARD ERROR	PROBABILITY [|Z|>Z]	95% CONFIDENCE INTERVAL
PART	-223.2700	193.8700	-1.1516	0.2051	(-603.255, 156.715)

APPENDIX E. ALTERNATIVE BILLING DATA SCREENS

Once all data were received from the grantees, we developed data screens to clean the billing data for analysis. The goal of screening is to remove any potentially erroneous billing data from the final modeling dataset to avoid biasing the estimation results. Though a variety of data screens were tried on the models as a sensitivity test, none altered the results or statistical significance of the results greatly, so we opted to use the data screens explained in Appendix B.4.2.

Table E-1 provides a definition of the different electric filters that we used, and Table E-4 provides a definition of the different natural gas filters that we used. Table E-2 and Table E-3 provide summaries of the model output for each of these electric filters for residential and commercial buildings, and Table E-5 and Table E-6 provide the model output summaries for each of the natural gas filters for residential and commercial buildings.

Table E-1: Electric Model Filter Definitions

FILTER	REQUIREMENTS
NONE	N/A
MIN BILLS	PRE_SUM>=12 & POST_SUM>0
RELIABLE BILLS	BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=100 & NORM_FUELQTY<=10000
PRELIMINARY	PRE_SUM>=12 & POST_SUM>0 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=100 & NORM_FUELQTY<=10000
MORE POST	PRE_SUM>=12 & POST_SUM>=6 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=100 & NORM_FUELQTY<=10000
EVEN MORE POST	PRE_SUM>=12 & POST_SUM>=12 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=100 & NORM_FUELQTY<=10000
CONSISTENT BILLS	PRE_MEAN_NORM_FUELQTY>=200 & PRE_MEAN_NORM_FUELQTY<=5000 & PRE_SUM>=12 & POST_SUM>=12 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=100 & NORM_FUELQTY<=10000
NO DRAMATIC INCREASE	PCT_CHANGE_MEANQTY<1 & PRE_MEAN_NORM_FUELQTY>=200 & PRE_MEAN_NORM_FUELQTY<=5000 & PRE_SUM>=12 & POST_SUM>=12 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=100 & NORM_FUELQTY<=10000
REQUIRE INSTALLATIONS	FLAG_ELECT_SAVINGS==1 & PCT_CHANGE_MEANQTY<1 & PRE_MEAN_NORM_FUELQTY>=200 & PRE_MEAN_NORM_FUELQTY<=5000 & PRE_SUM>=12 & POST_SUM>=12 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=100 & NORM_FUELQTY<=10000

Table E-2: Electric Regression Results with Different Filters – Residential

FILTER	RESIDENTIAL MODEL SUMMARY								
	OBS	HH	POST COEFF (β)	STND ERROR	PROB [|Z|>z]	95% CI	ADJ R^2	MEAN USAGE (kWh)	PERCENT SAVINGS
NONE	581,529	20,879	-118.993	32.201	0.0002	(-182.11, -55.88)	0.0005	1,024.61	11.6%
MIN BILLS	485,026	15,262	-120.575	37.439	0.0013	(-193.96, -47.19)	0.0004	1,032.16	11.7%
RELIABLE BILLS	508,254	19,289	-83.073	1.348	0.0000	(-85.72, -80.43)	0.2255	1,001.15	8.3%
PRELIMINARY	417,307	13,743	-82.523	1.456	0.0000	(-85.38, -79.67)	0.2203	1,003.78	8.2%
MORE POST	305,128	9,124	-80.946	1.547	0.0000	(-83.98, -77.91)	0.2069	1,016.86	8.0%
EVEN MORE POST	183,491	4,845	-66.007	1.866	0.0000	(-69.66, -62.35)	0.2089	1,053.87	6.3%
CONSISTENT BILLS	176,839	4,666	-60.598	1.796	0.0000	(-64.12, -57.08)	0.2372	931.42	6.5%
NO DRAMATIC INCREASE	174,468	4,599	-70.920	1.773	0.0000	(-74.39, -67.45)	0.2466	927.79	7.6%
REQUIRE INSTALLATIONS	160,199	4,220	-76.273	1.849	0.0000	(-79.9, -72.65)	0.2570	938.61	8.1%

Table E-3: Electric Regression Results with Different Filters – Nonresidential

FILTER	NONRESIDENTIAL MODEL SUMMARY								
	OBS	HH	POST COEFF (β)	STND ERROR	PROB [|Z|>z]	95% CI	ADJ R^2	MEAN USAGE (kWh)	PERCENT SAVINGS
NONE	61,462	1,352	-5639.03	752.574	0.0000	(-7114.1, -4164.0)	0.0142	61,979.9	9.1%
MIN BILLS	53,792	1,051	-5794.26	767.555	0.0000	(-7298.7, -4289.9	0.0126	58,599.1	9.9%
RELIABLE BILLS	36,869	1,035	-403.675	14.233	0.0000	(-431.6, -375.8)	0.1829	3,624.2	11.1%

Continued…

FILTER	NONRESIDENTIAL MODEL SUMMARY								
	OBS	HH	POST COEFF (β)	STND ERROR	PROB [|Z|>z]	95% CI	ADJ R^2	MEAN USAGE (kWh)	PERCENT SAVINGS
PRELIMINARY	31,898	785	-425.924	14.499	0.0000	(-454.3, -397.5)	0.1839	3,662.9	11.6%
MORE POST	27,591	665	-430.757	14.913	0.0000	(-460.0, -401.5)	0.1899	3,696.5	11.7%
EVEN MORE POST	19,282	442	-433.749	16.497	0.0000	(-466.1, -401.4)	0.2048	3,677.0	11.8%
CONSISTENT BILLS	12,511	241	-254.690	15.834	0.0000	(-285.7, -223.7)	0.2393	2,258.6	11.3%
NO DRAMATIC INCREASE	12,373	238	-269.188	15.591	0.0000	(-299.8, -238.6)	0.2493	2,253.9	11.9%
REQUIRE INSTALLATIONS	12,023	231	-274.358	16.009	0.0000	(-305.7, -243.0)	0.2511	2,266.2	12.1%

Table E-4: Natural Gas Model Filter Definitions

FILTER	REQUIREMENTS
NONE	N/A
MIN BILLS	PRE_SUM>=12 & POST_SUM>0
RELIABLE BILLS	BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=5 & NORM_FUELQTY<=300
PRELIMINARY	PRE_SUM>=6 & POST_SUM>=2 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=5 & NORM_FUELQTY<=300
MORE PRE	PRE_SUM>=12 & POST_SUM>=2 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=5 & NORM_FUELQTY<=300
MORE POST	PRE_SUM>=12 & POST_SUM>=6 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=5 & NORM_FUELQTY<=300
EVEN MORE POST	PRE_SUM>=12 & POST_SUM>=12 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=5 & NORM_FUELQTY<=300
CONSISTENT BILLS	PRE_MEAN_NORM_FUELQTY>=20 & PRE_MEAN_NORM_FUELQTY<=250 & PRE_SUM>=12 & POST_SUM>=12 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=5 & NORM_FUELQTY<=300

Continued…

FILTER	REQUIREMENTS
NO DRAMATIC INCREASE	PCT_CHANGE_MEANQTY<1 & PRE_MEAN_NORM_FUELQTY>=20 & PRE_MEAN_NORM_FUELQTY<=250 & PRE_SUM>=12 & POST_SUM>=12 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=5 & NORM_FUELQTY<=300
REQUIRE INSTALLATIONS	FLAG_GAS_SAVINGS==1 & PCT_CHANGE_MEANQTY<1 & PRE_MEAN_NORM_FUELQTY>=20 & PRE_MEAN_NORM_FUELQTY<=250 & PRE_SUM>=12 & POST_SUM>=12 & BILLDAYS>=28 & BILLDAYS<=35 & NORM_FUELQTY>=5 & NORM_FUELQTY<=300

Table E-5: Natural Gas Regression Results with Different Filters – Residential

FILTER	RESIDENTIAL MODEL SUMMARY								
	OBS	HH	POST COEFF (β)	STND ERROR	PROB [|Z|>z]	95% CI	ADJ R^2	MEAN USAGE (therm)	PERCENT SAVINGS
NONE	411,566	12,783	2.293	10.113	0.8207	(-17.53, 22.12)	0.0045	173.77	-1.3%
MIN BILLS	368,167	10,297	-15.482	1.461	0.0000	(-18.35, -12.62)	0.0321	91.29	17.0%
RELIABLE BILLS	365,006	12,226	-6.097	0.121	0.0000	(-6.33, -5.86)	0.7352	68.26	8.9%
PRELIMINARY	326,652	9,840	-6.162	0.123	0.0000	(-6.4, -5.92)	0.7362	68.04	9.1%
MORE PRE	314,980	9,207	-6.122	0.126	0.0000	(-6.37, -5.88)	0.7378	68.22	9.0%
MORE POST	227,083	5,860	-6.514	0.135	0.0000	(-6.78, -6.25)	0.7258	64.91	10.0%
EVEN MORE POST	134,069	3,257	-7.605	0.167	0.0000	(-7.93, -7.28)	0.7289	66.42	11.4%
CONSISTENT BILLS	131,850	3,178	-7.928	0.166	0.0000	(-8.25, -7.6)	0.7374	66.85	11.9%
NO DRAMATIC INCREASE	131,183	3,160	-8.156	0.165	0.0000	(-8.48, -7.83)	0.7399	66.87	12.2%
REQUIRE INSTALLATIONS	126,713	3,052	-8.418	0.168	0.0000	(-8.75, -8.09)	0.7401	66.74	12.6%

Table E-6: Natural Gas Regression Results with Different Filters – Nonresidential

FILTER	NONRESIDENTIAL MODEL SUMMARY								
	OBS	HH	POST COEFF (β)	STND ERROR	PROB [|Z|>z]	95% CI	ADJ R^2	MEAN USAGE (therm)	PERCENT SAVINGS
NONE	25,583	677	209.929	249.633	0.4004	(-279.35, 699.21)	0.0016	691.00	-30.4%
MIN BILLS	23,206	546	191.815	269.080	0.4759	(-335.58, 719.21)	0.0013	632.90	-30.3%
RELIABLE BILLS	12,714	620	1.269	1.505	0.3991	(-1.68, 4.22)	0.4991	90.29	-1.4%
PRELIMINARY	11,696	507	0.893	1.537	0.5611	(-2.12, 3.91)	0.5048	90.32	-1.0%
MORE PRE	11,319	477	0.900	1.564	0.5649	(-2.17, 3.97)	0.5082	90.69	-1.0%
MORE POST	9,787	417	2.500	1.731	0.1485	(-0.89, 5.89)	0.5107	90.82	-2.8%
EVEN MORE POST	7,522	297	3.782	2.065	0.0671	(-0.27, 7.83)	0.5126	89.29	-4.2%
CONSISTENT BILLS	4,887	154	4.612	2.241	0.0396	(0.22, 9)	0.6268	83.97	-5.5%
NO DRAMATIC INCREASE	4,789	149	3.418	2.256	0.1299	(-1, 7.84)	0.6317	84.03	-4.1%
REQUIRE INSTALLATIONS	339	10	-11.436	8.272	0.1678	(-27.65, 4.78)	0.5719	89.30	12.8%

APPENDIX F. FUEL PRICES

Table F-1: Commercial Energy Prices

STATE	ELECTRICITY (KWH)*	NATURAL GAS (THERM)**
Colorado	$ 0.09	$ 0.80
Georgia	$ 0.10	$ 1.06
Massachusetts	$ 0.14	$ 1.11
Michigan	$ 0.10	$ 0.92
North Carolina	$ 0.08	$ 0.96
New Hampshire	$ 0.14	$ 1.19
Ohio	$ 0.10	$ 0.81
Texas	$ 0.09	$ 0.71
Virginia	$ 0.08	$ 0.96
Washington	$ 0.07	$ 1.04

* 2011 average price per kWh: *http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_b.pdf*.

** Average Price per therm from January 2011 through June 2012: *http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm*.

Table F-2: Residential Energy Prices

STATE	ELECTRICITY (KWH) *	NATURAL GAS (THERM) **	FUEL OIL – TYPE 2 (GALLON) ***	PROPANE/LPG (GALLON) ***
Alabama	$ 0.11	$ 1.75	$ 3.80	$ 2.65
Arizona	$ 0.11	$ 1.71	$ 3.80	$ 2.65
California	$ 0.15	$ 0.98	$ 3.80	$ 2.65
Colorado	$ 0.11	$ 0.97	$ 3.80	$ 2.65
Connecticut	$ 0.18	$ 1.53	$ 3.80	$ 2.65
Florida	$ 0.12	$ 1.92	$ 3.80	$ 2.65
Georgia	$ 0.11	$ 1.90	$ 3.80	$ 2.65
Illinois	$ 0.12	$ 1.02	$ 3.80	$ 2.65
Indiana	$ 0.10	$ 1.12	$ 3.80	$ 2.65
Massachusetts	$ 0.15	$ 1.38	$ 3.80	$ 2.65
Maine	$ 0.15	$ 1.50	$ 3.80	$ 2.65

Continued…

STATE	ELECTRICITY (KWH) *	NATURAL GAS (THERM) **	FUEL OIL – TYPE 2 (GALLON) ***	PROPANE/LPG (GALLON) ***
Michigan	$ 0.13	$ 1.13	$ 3.80	$ 2.65
Missouri	$ 0.10	$ 1.60	$ 3.80	$ 2.65
North Carolina	$ 0.10	$ 1.56	$ 3.80	$ 2.65
New Hampshire	$ 0.17	$ 1.54	$ 3.80	$ 2.65
Nevada	$ 0.12	$ 1.13	$ 3.80	$ 2.65
New York	$ 0.18	$ 1.52	$ 3.80	$ 2.65
Ohio	$ 0.11	$ 1.30	$ 3.80	$ 2.65
Oregon	$ 0.10	$ 1.24	$ 3.80	$ 2.65
Pennsylvania	$ 0.13	$ 1.44	$ 3.80	$ 2.65
Tennessee	$ 0.10	$ 1.25	$ 3.80	$ 2.65
Texas	$ 0.11	$ 1.24	$ 3.80	$ 2.65
Virginia	$ 0.11	$ 1.51	$ 3.80	$ 2.65
Vermont	$ 0.16	$ 1.80	$ 3.80	$ 2.65
Washington	$ 0.08	$ 1.30	$ 3.80	$ 2.65
Wisconsin	$ 0.13	$ 1.04	$ 3.80	$ 2.65

* 2011 Average price per kWh, EIA website: *http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf*.

** Average Price per therm from January 2011 through June 2012, EIA website: *http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_m.htm* .

***Average U.S. prices per gallon from the end of 2010 through Q2 of 2012 from the EIA website.

APPENDIX G. WEATHER DATA

Table G-1: Degree Days and Full Load Hours

GRANTEE	STATE	DEGREE DAYS		CDH (F)	RESIDENTIAL FULL LOAD HOURS		N-FACTOR
		HDD (F)	CDD (F)		Heating	Cooling	
Hartselle	AL	3445	1609	12961	1606	1464	22.1
Decatur	AL	3445	1609	12961	1606	1464	22.1
Birmingham	AL	2713	1819	14693	1562	1557	22.1
Phoenix	AZ	4822	1009		1116	2141	19.4
Los Angeles County	CA	1198	435	420	1070	1530	22.1
Boulder County	CO	5664	984	9668	2255	628	16.7
Eagle County	CO	7905	167	—	—	—	—
Connecticut	CT	5792	795	5820	2358	942	16.7
St Lucie County	FL	684	3074	—	504	3288	19.4
Jacksonville	FL	1324	2345	19841	1020	2086	19.4
Atlanta	GA	2826	1722	14577	1686	1484	19.4
Chicago	IL	6206	943	—	2459	683	16.7
Indianapolis	IN	5709	1146	—	2152	948	16.7
Lowell	MA	5808	660	1753	2734	453	16.7
Maine	ME	7390	396	—	2728	321	16.7
Detroit	MI	6105	999	4690	2670	642	16.7
Grand Rapids	MI	6828	580	3979	2771	595	16.7
Marquette	MI	7920	354	2421	3130	222	16.7
Kansas City	MO	4210	2046	11533	2149	1032	16.7
Missouri	MO	5176	1287	—	2048	1050	16.7
Greensboro	NC	3780	1427	9968	1978	1203	19.4
New Hampshire	NH	8503	172	4383	2641	385	16.7
Las Vegas	NV	2329	3316	43976	1642	1773	19.4
Reno	NV	5538	769	11111	2631	317	19.4

Continued…

GRANTEE	STATE	DEGREE DAYS		CDH (F)	RESIDENTIAL FULL LOAD HOURS		N-FACTOR
		HDD (F)	CDD (F)		Heating	Cooling	
Bedford	NY	5272	599	—	2337	1089	16.7
Albany	NY	6516	595	3774	2598	515	16.7
Buffalo	NY	6579	479	2449	2765	571	16.7
Rochester	NY	6462	614	4082	2685	554	16.7
Syracuse	NY	6529	542	3652	2586	552	16.7
New York City	NY	4874	1077	6484	2337	1089	16.7
Binghamton	NY	6992	386	2410	2754	440	16.7
Massena	NY	7828	400	2789	—	—	16.7
Cincinnati	OH	4815	1072	—	2134	996	19.4
Toledo	OH	6307	705	—	2464	649	16.7
Portland	OR	4158	370	3080	2681	379	19.4
Fayette County	PA	5668	554	5102	2380	737	16.7
Philadelphia	PA	4710	1260	—	2328	1032	16.7
Nashville	TN	3665	1738	—	1768	1375	19.4
Austin	TX	1699	2946	—	1142	2412	16.7
San Antonio	TX	1479	3051	—	1101	2237	16.7
Virginia	VA	3849	1448	12954	1980	1188	19.4
Charlottesville	VA	3849	1448	12954	1980	1188	19.4
Rutland	VT	7336	570	3550	2651	455	16.7
Bainbridge Island	WA	4257	214	985	2956	282	19.4
Seattle	WA	4257	214	985	2956	282	16.7
Wisconsin	WI	6999	523	—	2547	487	16.7
Madison	WI	7608	639	—	2547	487	16.7
Milwaukee	WI	7281	553	—	2548	513	16.7

* Calculated from TMY data from nearest weather station to grantee site.

APPENDIX H. COMMON MEASURE SAVINGS SOURCES AND EQUATIONS

H.1. LIST OF SOURCES

Table H-1: Formula Sources

MEASURE	PRIMARY REFERENCE	SECONDARY REFERENCE (IF NEEDED)
Lighting	UMP	PA TRM for commercial HOU and CF
Lighting Controls	UMP	PA TRM for commercial HOU and CF
Boiler Replacement	UMP	Regional reference documents and TMY3 calculations for EFLH
Furnace Replacement	UMP	Regional reference documents and TMY3 calculations for EFLH
Air Conditioner Replacement	UMP	Regional reference documents and TMY3 calculations for EFLH
Air Sealing	Regional reference document	Ohio TRM
Duct Sealing	Regional reference document	Ohio TRM
Insulation	Regional reference document	Ohio TRM
Photovoltaics	PV Watts v.1	—
Water Heater Replacement	Regional reference document	Illinois TRM
Direct Install	Illinois TRM	—
Duct Sealing	Mid-Atlantic TRM, Option 2	—
Windows	Regional reference document	Best fit to other regional references matched by HDD/CDD
Refrigeration	Wisconsin Deemed Savings Manual	—
Chiller	Ohio TRM	—

H.2. LIGHTING-RESIDENTIAL

$$kWh_{saved} = NUMMEAS * \left(\frac{\Delta W}{1000}\right) * HRS * IRS * INTEF$$

- Where:

NUMMEAS = Number of measures sold or distributed through the program

ΔW: = Baseline wattage minus efficient lighting product wattage

HRS: = Annual operating hours

ISR: = In-service rate

INTEF: = Cooling and heating interactive effects

H.3. LIGHTING-COMMERCIAL

$$kWh_{savings} = \sum_u \left(\frac{W_{base} * qty_{base}}{1000} * HOU_{base}\right)_u - \sum_u \left(\frac{W_{ee} * qty_{ee}}{1000} * HOU_{ee}\right)_u$$

- Where:

W = Fixture wattage

Qty = Fixture quantity

U = Usage group, a collection of fixtures sharing the same operating hours. (ex: hallway, office, warehouse, etc.)

HOU = Annual hours of use

ee = Energy-efficient equipment

Base = Baseline equipment

H.4. FURNACE/BOILER REPLACEMENT – RESIDENTIAL

$$Savings_{b-e} = Capicity_{input-e} * EFLH_{e-installed} * \left(\frac{AFUE_e}{AFUE_{base}} - 1\right)$$

- Where:

$Capacity_{input-e}$ = Heating input capacity of both the baseline and installed Unit

$EFLH_{e-installed}$ = Full Load Equivalent Hours of the installed high efficiency Unit

H.5. AC, CENTRAL – RESIDENTIAL AND SMALL COMMERCIAL

For units with a capacity of more than 5.4 tons:

$$kWh_{saved} = S * \left(\frac{1}{EER_b} - \frac{1}{EER_i}\right) * EFLH$$

For units having a capacity fewer than 5.4 tons:

$$kWh_{saved} = S * \left(\frac{1}{SEER_b} - \frac{1}{SEER_i}\right) * EFLH$$

- Where:

S = Cooling capacity of Unit (kBTU/hr)

EER_b = Energy-Efficiency ratio of the baseline unit, as defined by local code

EER_i = Energy-Efficiency ratio of the specific high efficiency unit

$SEER_b$ = Seasonal energy-efficiency ratio of the baseline unit, as defined by local code

$SEER_i$ = Seasonal Energy-Efficiency ratio of the specific high efficiency unit

EFLH = Equivalent full-load hours for cooling

H.6. AIR SEALING

Cooling Savings (central A/C):

$$kWh_{savings} = \left(\left(\frac{\Delta CFM}{NF}\right) * 60 * CDH * DUA * 0.018\right) / 1000 / SEER$$

$$Peak\ kW = \left(\frac{\Delta kWh}{cFLH}\right) * CF$$

Heating Savings:

Electric Heating

$$kWh_{savings} = (\left(\left(\frac{\Delta CFM}{NF}\right) * 60 * 24 * HDD * 0.018\right) / 1{,}000{,}000 / COP) \ * 293.1$$

Fossil Fuel Savings

$$MMBTu_{savings} = \left(\left(\frac{\Delta CFM}{NF}\right) * 60 * 24 * HDD * 0.018\right) / (AFUE * 1{,}000{,}000)$$

- Where:

ΔCFM = The initial and final tested leakage rates at 50 psi

SEER = Cooling Equipment Efficiency

COP = Electric Heating Equipment Efficiency

AFUE = Fossil Fuel Heating Equipment Efficiency

CDH = Cooling Degree Hours

HDD = Heating Degree-Days

cFLH = Cooling Full Load Hours

CF = Coincidence Factor

DUA = Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 75°F

NF = N-Factor

H.7. INSULATION

Cooling Savings:

$$kWh_{saving} = \left(\left(\frac{1}{R_{exist}} - \frac{1}{R_{new}}\right) * CDH * 0.75 * Area\right) / \ 1000 / \ SEER$$

$$Peak\ kW = \frac{\Delta kWh}{FLHcool} * 0.5$$

Space Heating Savings:

Fossil Fuel Savings

$$MMBTU_{saving} = \left(\left(\frac{1}{R_{exist}} - \frac{1}{R_{new}}\right) * HDD * 24 * Area\right) / 1{,}000{,}000 / \ AFUE$$

Electric Savings

$$kWh_{saving} = (\left(\left(\frac{1}{R_{exist}} - \frac{1}{R_{new}}\right) * HDD * 24 * Area\right) / 1{,}000{,}000 / \ COP) * 293.1$$

- Where:

R_{exist} = R-value of existing Insulation (should include total assembly)

R_{new} = R-value of new Insulation (should include the total assembly and any existing insulation)

HDD = Heating Degree Days

CDH = Cooling Degree Hours

Area = Total insulated area (square feet)

COP = Electric heating equipment efficiency value

SEER = Cooling equipment efficiency value

AFUE = Fossil Fuel equipment efficiency value

FLHcool = Cooling full load hours

APPENDIX I. FUEL CONVERSIONS

Table I-1: Fuel Conversions

ESTIMATED & EXPECTED ENERGY SAVINGS REPORTED ARE CONVERTED TO SOURCE MMBtu USING THE FOLLOWING CONVERSION FACTORS		
Electricity	1 kWh	0.0034 (kWh to MMBtu) x 3.365 (site to source)
Natural Gas	1 ccf	0.103 (ccf to MMBtu) x 1.092 (site to source)
Natural Gas	1 therm	0.100 (therms to MMBtu) x 1.092 (site to source)
Fuel Oil (Type 2)	1 gallon	0.139 (gallons to MMBtu) x 1.158 (site to source)
Propane/LPG	1 gallon	0.0917 (gallons to MMBtu) x 1.151 (site to source)
Kerosene	1 gallon	0.135 (gallons to MMBtu) x 1.205 (site to source)
Wood	1 cord	22.0 (cords to MMBtu) x 1 (site to source)

Source Energy Factors for Energy Use in Buildings *http://www.nrel.gov/docs/fy07osti/38617.pdf*

APPENDIX J. RESIDENTIAL AND COMMERCIAL VERIFICATION SURVEYS

J.1. RESIDENTIAL PARTICIPANT: BETTER BUILDINGS NEIGHBORHOOD PROGRAMS TELEPHONE SURVEY

J.1.1. GENERAL INFORMATION (FROM GRANTEE DOCUMENTATION)

Participant Name:	____________	Grantee Name:	____________
Project Ref Number:	____________	Project Completion Date:	____________
Contact Address:	____________	City:	____________
State:	____________	Zip:	____________
Electric Utility:	____________	Nat. Gas Utility	____________
Other Fuel Source:	____________	Nexant Caller:	____________
Date:	____________	Time:	____________
Notes:	____________		

J.1.2. PROJECT MEASURE INFORMATION (FROM GRANTEE DOCUMENTATION)

<u>Circle all that apply</u>

Weatherization Measures:	Air/Duct Sealing, Insulation, Doors, Windows, Programmable Thermostat
Appliance Measures:	Water Heater, Furnace, Boiler, Air Conditioner, Evaporative Cooler, Heat Pump, Refrigerator, Freezer, Dishwasher, Clothes Washer
Lighting Measures:	CFLs, Linear Fluorescents, LEDs
Renewable Energy	Solar Photovoltaic, Solar Thermal
Other Measures:	List:

Hello, my name is <*Your Name*> from Nexant and I'm calling on behalf of the < *Name of grantee/subgrantee and umbrella program* > and the U.S. Department of Energy. We are conducting a national level study to assess the energy savings associated with program participants who implemented energy upgrade projects. May I please speak with <*Contact Name*>?

IF CONTACT NOT AVAILABLE, LEAVE MESSAGE: I am calling because as a participant in <*Name of grantee/subgrantee and umbrella program*>, we would like your feedback as part of a short survey. Your responses will contribute to the national study of the Better Building Neighborhood Program (BBNP), which is the Department of Energy's (DOE) program that funded <*Name of grantee/subgrantee and umbrella program*>. We would greatly appreciate your participation in this voluntary survey. Please give me a call back at your earliest convenience so that we can complete a short telephone survey. <*Give Contact Information including Phone Number*>

IF CONTACT NOT AVAILABLE, LEAVE MESSAGE WITH SOMEONE ELSE: I am calling because as a participant in <*Name of grantee/subgrantee and umbrella program*>, we would like your feedback as part of a short survey. Your responses will contribute to the national study of the Better Building Neighborhood Program (BBNP), which is the Department of Energy's (DOE) program that funded <*Name of grantee/subgrantee and umbrella program*>. Are you familiar with this program and the energy upgrades completed at your house?

a) [If no]: Would you please have <*Contact Name*> call me back at their earliest convenience so that we can set up a time to speak? My phone number is <*Your Phone Number*>.

b) [If yes]: Would you be willing to participate in this voluntary survey? Your feedback will not affect your incentive and is simply used to learn how DOE may improve future programs. All information provided will remain private to the extent permitted by law

   i. [If yes] Thank you! Knowing that this is voluntary, we appreciate that you are willing to be interviewed. If you have any additional questions regarding this study, please contact Kevin Afflerbaugh, Project Manager at Nexant at 303-998-2462 or Dr. Edward Vine at the Lawrence Berkeley National Laboratory (LBNL) at 510-486-6047.

   ii. [If no]: Would you please have <*Contact Name*> call me back at their earliest convenience so that we can set up a time to speak? My phone number is <*Your Phone Number*>.

IF CONTACT NO LONGER AT SITE: *[Questions will not apply, thank the person for their time and move on to the next participant]*

AFTER LOCATING PROPER CONTACT:

I am calling because as a participant in <*Name of grantee/subgrantee and umbrella program*>, we would like your feedback as part of a short survey. This survey will be used to verify information regarding your project funded by DOE. Your responses will contribute to the national study of the Better Building Neighborhood Program (BBNP), which is the Department of Energy's (DOE) program that funded <*Name of grantee/subgrantee and umbrella program*>. We would greatly appreciate your participation in this voluntary survey. Your feedback will not affect your incentive and is simply used to learn how DOE may improve future programs. All information provided will remain private to the extent permitted by law.

Could I ask you a few questions about the measures you installed through the program? This will take approximately 10 minutes.

a) [If yes] Thank you! Knowing that this is voluntary, we appreciate that you are willing to be interviewed. If you have any additional questions regarding this study, please contact Kevin Afflerbaugh, Project Manager at Nexant at 303-998-2462 or Dr. Edward Vine at the Lawrence Berkeley National Laboratory at 510-486-6047.

b) [If no] *[If they don't agree, ask them if there is another time that would be more convenient for them. If they still say no, thank them for their time, and move on.]*

IF PARTICIPANT IS FROM A GRANTEE SELECTED FOR ONSITE VISITS:

As an additional part of the study, we also will be conducting onsite visits at a selection of project sites. These onsite visits last an average of thirty minutes, and a trained professional engineer will conduct a walk-through of your residence to gather additional information on the measures you installed. As an incentive for allowing us to conduct an onsite visit, we will provide a $50 Visa gift card at the completion of the site visit. Would you be willing to let one of our engineers come to your home for this purpose?

a) [If yes] Excellent! Before we start the survey, let's schedule the visit. We are currently scheduling visits the week of *<insert week>. [Let's give them a few times to work with.]*

[Record Scheduled Time & Date:] ________________________________

Again, the visit will take approximately ½ hour. We will need access to the areas of your house where you had the work done. The field engineer will provide you with proper identification from Nexant upon arrival. Who will be the contact for this visit?___________________

Is there anything the engineer needs to be aware of before arriving at your home? *[Prompt examples if necessary: Dogs, security code for neighborhood entry, etc.]*

____

If you need to reschedule or cancel, please contact ______ at ____________

b) [If no] That's fine. Let's get started with the survey.

>>> start the survey<<<<

General Energy Upgrade Questions

1. I would now like to verify what energy upgrade measures you had installed. According to program records you had the following measures installed: *<describe measures from project information>*. Is this correct?

2. [If no] What was actually installed? ___________________*[Be sure to ask survey questions appropriate for the measures actually installed]*

General Information

Now I am going to ask a few questions regarding your home.

3. What year was your home built?______________

4. What is the total conditioned square footage of your home? _______________

5. How many people live in your home? ______ Has there been any change to that number in the last 3 years? ______

6. How many bedrooms? ________

7. How many bathrooms? _______

8. Have there been any modifications to your home in the last 3 years? If so, please describe.____

Heating System Info

The next few questions will focus on your heating system.

9. What is your primary heating fuel--------------------------→	Natural Gas Electricity Propane Fuel Oil Kerosene Wood Geothermal Other:
10. What is your primary heat system type:------------------→	Gas Furnace Electric Furnace Wood Stove Gas Stove Ground Source Heat Pump Air Source Heat Pump Space Heater Gas boiler--Baseboard

Gas boiler—Radiant

Gas boiler – other

Baseboard--Electric

Radiant--Electric

Other:

If participant did not receive a new heating system (furnace/boiler/etc.) as part of the energy upgrade, ask questions 11-15. Otherwise skip to Question 16. If they received a new heating system, this information will be gathered in the appropriate section detailing their new heating system.

Can you please verify the age, make, model number, and size of the new furnace? This information is often located on a label on the frame of the furnace. *(Make sure they know they may have to take off the panel where all this info is located.)*

11. Age of primary heat system:____________
12. Primary heat system make:_____________
13. Primary heat system model:____________
14. Efficiency (AFUE): _______________
15. Size (btuh): In_______Out_______ *(the unit might only list one)*
16. Do you have a secondary heating system? (Yes/No) [If no, skip to question 21]
17. Secondary Heat System Type:----------------------→

Fireplace (wood/gas)

Gas Furnace

Electric Furnace

Wood Stove

Gas Stove

Ground Source Heat Pump

Air Source Heat Pump

Space Heater

Gas boiler

Baseboard (electric/hydronic)

Radiant (electric/hydronic)

Other:

18. Age of secondary heat system? ________

19. Approximately how often is secondary heat source used? _________

20. Approximately how much square footage is heated by secondary heat source? ________

21. What type of thermostat do you use? (Programmable / non-programmable)

22. Approximate heating-season thermostat settings:

Weekday Daytime	Weekday evening	Weekday Overnight	Weekend Daytime	Weekend evening	Weekend overnight

Cooling System

23. Do you currently have a cooling system? (that is, central air, room air conditioning, evaporative cooler) *[If no, skip to first section with applicable measure installed by participant that requires verification.]*

24. Primary Cooling System Type:-----------------------------→

- Central Air Conditioner
- Window Air Conditioner
- Evaporative cooler
- Air Source Heat Pump
- Ground Source Heat Pump
- Other:

If participant did not receive a new cooling system as part of their energy upgrade (air conditioner/evap cooler/etc), ask questions 25 – 29. Otherwise skip to Question 30. If they received a new cooling system, this information will be gathered in the appropriate section detailing their new cooling system.

25. What is the approximate age of the primary cooling unit? ________

Can you please verify the make, model number, capacity, and efficiency of the cooling system? This information is often located on a label on the side of the air conditioner

26. Primary cooling unit make? _________

27. Primary cooling unit model: _________

28. Primary cooling unit tonnage: __________

29. Primary cooling unit SEER/CFM: ____________

30. In addition to your primary cooling system, do you have any additional cooling systems? [If no, skip to question 35]

31. Secondary Cooling System Type (if applicable): ------→

Central Air Conditioner

Window Air Conditioner

Evaporative Cooler

Air Source Heat Pump

Ground Source Heat Pump

Other:

32. Age of secondary cooling system: ______

33. Approximately how often is secondary cooling system used? ________

34. Approximately how much square footage is cooled by secondary cooling system? _______

35. Approximate cooling-season thermostat settings:

Weekday Daytime	Weekday evening	Weekday Overnight	Weekend Daytime	Weekend evening	Weekend overnight

Weatherization Measures

Insulation

Wall Insulation

36. What is the total area (sq. ft.) of the walls that were insulated? __________

37. Type of insulation prior to upgrade ----------------→

None
Rigid Foam
Blanket Batts
Vermiculite
Rockwool
Fiberglass
Cellulose Fiber

38. Approximate inches of wall insulation that existed prior to the upgrade ________

39. Value prior to upgrade (if known): ____________

40. Type of insulation added ----------------------------→

- None
- Rigid Foam
- Blanket Batts
- Vermiculite
- Rockwool
- Fiberglass
- Cellulose Fiber

41. How many inches of insulation were added? _____________

42. Retrofit R-Value (if known): ______________

Attic Insulation

43. What is the area of the attic floor that was insulated (sq. ft.):

44. Type of insulation prior to upgrade -----------------------→

- None
- Rigid Foam
- Blanket Batts
- Vermiculite
- Rockwool
- Fiberglass
- Cellulose Fiber

45. Inches of attic insulation prior to upgrade: ___________

46. R-Value prior to upgrade (if known): _____________

47. Type of insulation added --------------------------------→

- None
- Rigid Foam
- Blanket Batts
- Vermiculite
- Rockwool
- Fiberglass
- Cellulose Fiber

48. How many inches were added? ____________

49. Retrofit R-Value (if known): ________________

Crawl Space Insulation

50. What is the total area (sq. ft.) of the crawl space wall, floor, and ceiling that were insulated? _________________

51. Type of insulation prior to upgrade -----------------------------→
    - None
    - Rigid Foam
    - Blanket Batts
    - Vermiculite
    - Rockwool
    - Fiberglass
    - Cellulose Fiber
    - ____________________

52. Inches of crawl space insulation prior to upgrade: ______________

53. R-Value prior to upgrade (if known): ________________

54. Type of insulation added ---→
    - None
    - Rigid Foam
    - Blanket Batts
    - Vermiculite
    - Rockwool
    - Fiberglass
    - Cellulose Fiber
    - ____________________

55. How many inches were added? _______________

56. Retrofit R-Value (if known): _____________

Rim Joist Insulation

57. What is the total sq. ft. of rim joists insulated? _________

58. Type of insulation prior to upgrade ----------------------→
    - None
    - Rigid Foam
    - Blanket Batts
    - Vermiculite
    - Rockwool
    - Fiberglass
    - Cellulose Fiber
    - ____________________

59. Inches of rim joist insulation prior to upgrade: _________

60. R-Value prior to upgrade (if known): ______________

61. Type of insulation added ---------------------------------→
    - None
    - Rigid Foam
    - Blanket Batts
    - Vermiculite
    - Rockwool
    - Fiberglass
    - Cellulose Fiber
    - ____________________

____

62. How many inches were added? _______________

63. Retrofit R-Value (if known): _________________

Windows

64. Energy ratings of each new type of window installed:

Type 1

U Factor:______

Solar Heat Gain Coefficient: _____

Type 2 (if applicable)

U Factor:______

Solar Heat Gain Coefficient: _____

Type 3 (if applicable)

U Factor:______

Solar Heat Gain Coefficient: _____

65. Quantity of each type of new window installed:

Type 1: _____Type 2:________Type 3:______

66. Total size in sq. ft. of each type of new window:

Type 1: _____Type 2:________Type 3:______

67. # of Panes: (single, dual, etc) Type 1: _____Type 2:________Type 3:______

68. What type of window was replaced?_____________________________

69. How many panes did they have? ________________________________

70. What was the framing material?_________________________________

Doors

71. Quantity of new doors installed: ______________________

72. Size of each: __________________

73. Material of each (wood, glass, fiberglass, etc..): __________________

74. What were the old doors? ______________________

Duct and Air Sealing

75. What part of your home was sealed? (Ducts/Windows/Door/Attic)

76. Quantity of each item sealed? (feet of ducts/number of doors or windows/sq. ft. of attic/crawlspace)
____

77. What air sealing measures were performed for each area? (ex. Spray foam, caulk, mastic etc):
____

Programmable Thermostat

We discussed your current set points earlier in this survey, now I would like to understand the settings associated with your old thermostat.

78. With your previous thermostat, were the settings the same as the new thermostat?

79. [If no] What were the settings?

Summer

Weekday Daytime	Weekday evening	Weekday Overnight	Weekend Daytime	Weekend evening	Weekend overnight

Winter

Weekday Daytime	Weekday evening	Weekday Overnight	Weekend Daytime	Weekend evening	Weekend overnight

Appliance Measures

Water Heaters

80. What type of water heater did you purchase?------------------→ Tankless / Storage

81. What is the fuel type? ---→ Electric / Gas / Propane

	Fuel Oil Solar
82. Where is the water heater located?-------------------------------→	Garage Basement Closet Laundry Room

83. Is the water heater in a conditioned space? ____________

84. Is the water heater wrapped with an insulating material? ________

85. Can you please verify the make, model number, capacity, and efficiency of the water heater? This information is often located on a label on the frame of the water heater.

Make:_____________ Model:_________________

Capacity (gallons):_____________ Efficiency (Energy Factor 0 to 1): _______________

ENERGY STAR Label _______ R-Value of Tank ________

86. What was the temperature set point on your water heater prior to the retrofit? _______

87. What is the temperature set-point on your new water heater? ________________

88. What type of water heater did you replace? (Tankless / Storage)

89. Can you approximate its age? ______________

90. Was it the same fuel type as the new one? ___________

91. [If no] What was the fuel used by the old water heater? __________

92. Was it in good working condition when you replaced it? ___________

93. How did you dispose of the old water heater? (examples: sold / recycled / trashed / contractor removed it)

Furnace

94. Can you please verify the make, model number, and input capacity of the new furnace? This information is often located on a label on the frame of the furnace. *(Make sure they know they will likely have to take off the panel where all this info is located.)*

Make:_____________ Model:_________________
Efficiency (AFUE): _______________

Size (btuh): In_______Out_______ *(the unit might only list one)*

95. What heating system type was replaced by the new furnace? (gas furnace, electric furnace, gas boiler, etc)

96. How old was your previous heating system? _________

97. Was it in good working order when it was replaced? ______

98. What was the efficiency of your old furnace? ______

99. Why was it replaced? ____

100. How was it disposed of? (examples: sold / recycled / trashed)

101. Did the temperature set points on your programmable thermostat change after you installed the new furnace? ______

102. [If yes] Please describe how they changed _______________________________

Boiler

103. Can you please verify the make, model number, and efficiency of the boiler? This information is often located on a label on the frame of the boiler.

Make:_____________ Model:_________________

Efficiency (AFUE): _______________ Rated heating input (Btu/hr) _______

104. What heating system type was replaced by the new boiler? (examples: gas furnace, electric furnace, gas boiler, etc)

105. How old was your previous heating system? _________

106. Was it in good working order when it was replaced? _______

107. What was the heat output (efficiency) rating of your old boiler? ______

108. Why was it replaced? ____

109. How was it disposed of? (examples: sold / recycled / trashed)

110. Did the temperature set points on your thermostat change after you installed the new boiler? _______

111. [If yes] Please describe how they changed __________________________________

Central Air Conditioner

112. Can you please verify the make, model number, size and efficiency rating of the new air conditioner? This information is often located on a label on the side of the air conditioner.
Make:_____________ Model:_________________
Tonnage: _______________ SEER: _____

113. Did you have a cooling system prior to the installation of your new air conditioner? ____ [If no, this section is complete.]

114. What type of system? (examples: central air conditioner, evaporative cooler, window air conditioner)

115. Was it in good working order when it was replaced? _______

116. How old was your previous cooling unit? _________

117. Why was it replaced? ______

118. How was it disposed of? (examples: sold / recycled / trashed)

119. What was the SEER rating of your old air conditioner? ______

120. Did you have the same thermostat with the old cooling system? _____________

121. Did the temperature set points on your thermostat change after you installed the new AC? __________

122. [If yes] Please describe how they changed ____________________________________

Evaporative Cooler

123. Can you please verify the make, model number, size and efficiency of the new evaporative cooler? This information is often located on a label on the frame of the cooler.

Make:_____________ Model:_________________

CFM: _____ Type: Whole house/Room

124. Did you have a cooling system prior to the installation of your new evaporative cooler? _____________ [If no, this section is complete]

125. What type of system? (examples: central air conditioner, evaporative cooler, window air conditioner)

126. Was it in good working order when it was replaced?___________

127. How old was your previous cooling unit? _________

128. Why was it replaced? _______________

129. How was it disposed of? (examples: sold / recycled / trashed)

130. What was the efficiency rating of the prior system (SEER or CFM)? __________

131. Did the temperature set points on your thermostat change after you installed the new cooler? ________

132. [If yes] Please describe how they changed _____________________________________

Heat Pump

133. Can you please verify the make, model number, and efficiency of the heat pump?

Make:_____________ Model:_________________

SEER: _______________ Heating Seasonal Performance Factor (HSPF): _______

Tonnage: ______

134. What type of heat pump was installed: Ground Source or Air Source

135. What is the heat pump used for: Heating/Cooling/Both

136. What heating/cooling system did this heat pump replace? (Gas furnace, central air conditioner, lower efficiency heat pump, other)

137. How old was your previous heating/cooling unit? _________

138. Was it in good working order when it was replaced? _________

139. Why was it replaced? __________

140. How was it disposed of? (examples: sold / recycled / trashed)

141. Did the temperature set points on the thermostat change after you installed the new heat pump? ______

142. [If yes] Please describe how they changed ____________________________________

Refrigerator

143. First, can you please verify the make and model number of the refrigerator? The model number is often located on a label on the inside wall of the refrigerator.

Make _________________ Model _____________

144. What are the characteristics of your new refrigerator? [Circle applicable features below]

Appliance Characteristics (Choose One in Each Applicable Category Below)					
FRIDG: Configuration	Top Freezer	Side-by-Side	Bottom Freezer	Single Door	
Frost Type	Frost-Free	Manual			
Through Door Features	Water and/or Ice	None			
Location	Kitchen	Garage	Porch/Patio	Basement	Other: _______

Air Conditioning in room?	Central AC	Room AC	None		
Is the refrigerator located in a heated space?	Heated	Unheated			

145. How many cubic feet is the new refrigerator? __________

146. What was the approximate age of the refrigerator that was replaced? __________

147. Was it in good working order when you got rid of it? ______________

148. How did you dispose of it? (examples: sold/ recycled/ trashed/ did not get rid of it) ____________

149. If you still have it, where is it located? ___________

150. What is the make _____________and model ___________of the old refrigerator?

Freezer

151. First, can you please verify the brand and model number of the freezer? The model number is often located on a label on the inside wall of the freezer.

Make______________ Model ______________

152. What type of freezer is it? (Upright/Chest)

153. How many cubic feet is the freezer? __________

154. Is the freezer located in an air conditioned room? __________

155. What was the approximate age of the freezer that you replaced? __________

156. Was it in good working order when you got rid of it? __________

157. How did you dispose of it? (examples: sold/ recycled/ trashed/did not get rid of it)

158. If you still have it where is it located? __________

159. What is the brand __________ and model __________?

Dishwasher

160. First, can you please verify the brand and model number of the dishwasher that you purchased? The model number is often located on a label on the inside frame of the dishwasher just as you open the door.

Make __________ Model __________

161. About how many loads per week do you run? __________

162. Do you use heated dry? __________

163. What cycle do you normally set on your dishwasher (light/ normal/ heavy)? __________

164. Has your use of the dishwasher changed since you purchased the new unit? __________

165. [If yes] About how many loads per week did you run the old dishwasher? __________

166. What was the approximate age of the old dishwasher? __________

167. Was it in good working order when you got rid of it? __________

168. How did you dispose of it? (examples: sold/ recycled/ trashed)

Energy efficient dishwashers save both electricity and water, so I'd like to ask a few questions about your water heater. *[If you already asked these questions as the participant replaced their existing water heater as part of the program, skip these questions]*

169. How is your water heater fueled? (Electric/ Natural Gas / Propane/Fuel Oil)

170. How old would you say your water heater is? __________

Clothes Washer

171. First, can you please verify the make and model number of the new clothes washer you purchased? The model number is often located on a label on the inside of the washer just as you open the door.

Make __________ Model __________

172. Is it front loading or top loading? __________

173. About how many loads per week do you wash? __________

174. How many loads also go through the dryer? All / some / none

175. Has your use of the clothes washer changed since you purchase the new unit? _________

176. [If yes] About how many loads per week did you wash? __________

177. Can you approximate the age of the unit that was replaced? __________

178. Was it in good working order when you got rid of it? __________

179. How did you dispose of it? (Sold/ Recycled/ Trashed)

Energy efficient clothes washers also save energy from clothes drying and water heating, so I'd like to ask a few questions about your water heater and dryer.

180. Was the clothes dryer also replaced? Electric or natural gas?
____

181. [If no] What is the approximate age of your current dryer? __________

182. [If yes] What condition was it in when you replaced it? __________

Energy efficient clothes washers save both electricity and water, so I'd like to ask a few questions about your water heater. *[If you already asked these questions as the participant replaced their existing water heater as part of the program, skip these questions]*

183. How is your water heater fueled? (Electric/ Natural Gas / Propane/ Fuel Oil)

184. How old would you say your water heater is? __________

Lighting

CFLs

185. Wattage of new lights ______________________________

186. Quantity of each type: ______________________________

187. Location of new lights: ______________________________

188. What wattage were the replaced lights? ______________________________

Linear Fluorescent

189. Type of new lights (T-8, T-5, etc) ______________________________

190. Wattage of new lights for each type ______________________________

191. Quantity of each type: ______________________________

192. Location of new lights:

193. What wattage were the replace lights? ______________________________

LEDs

194. Wattage of new lights for each type ______________________________

195. Quantity of each type: ______________________________

196. Location of new lights: ______________________________

197. What wattage were the replaced lights? ______________________________

Solar Thermal

198. What is the make __________ and model _______________of your solar thermal system?

199. What is the size of the system? __________

200. What is the system used for? (domestic hot water or space heating)

201. [If hot water for domestic hot water] Can you tell me what type of system was previously in place to heat domestic hot water?_______________

202. [If hot water for domestic hot water] Is the same system in place to serve as a back-up for the solar thermal system or was another type of back-up technology added in its place?
____

203. [If hot water for domestic hot water] Can you please verify the make, model number, capacity, and efficiency of this back up system?

Make:_____________ Model:_________________

Capacity (gallons):_____________ Efficiency (Energy Factor 0 to 1): _______________

ENERGY STAR Label _______ R-Value of Tank ________

204. [If hot water for space heating] I'd like to ask a few questions about your space heating system

   a. What type of heating system did you have before the solar thermal system was installed? ___________________________

   b. Is the same system in place to serve as a back-up for the solar thermal system, or was another type of back-up technology added in its place?
   ____

   c. Did the temperature set points on your thermostat change after you installed the solar thermal system? ________________________

   d. [If yes] Please describe how they changed. __________________

Solar Photovoltaic

205. What is the make ___________ and model __________ of the panels?

206. What is the make ______________ and model _________________ of the inverters?

207. What is the size (kW) of the system? ______________

208. Has the system ever been off-line? _____________

209. [If yes] How long? ___________

210. Have you cleaned the panels? _________________

211. [If yes] How often?_____________

212. Does the PV system have the ability to log the amount of energy it generates over time?

   a. [If yes] Would you be able to provide us with the data? This might be available digitally or through access to a web portal. ______

b. [If yes] What duration of energy measurements have been logged by the device? ___________________

c. [If yes] What is the cumulative kWh (energy generated) by the system? ______

Other Measures

Other Measure #1

213. Please describe the other measure:
____
____

214. Did this measure replace existing equipment?_______

215. [If yes] Please describe the measure it replaced:____________________

216. [If yes] Was it in good working order when it was replaced?___________

217. [If yes] Why was it replaced? _______________

Other Measure #2

218. Please describe the other measure:
____
____

219. Did this measure replace existing equipment?_______

220. [If yes] Please describe the measure it replaced:____________________

221. [If yes] Was it in good working order when it was replaced?___________

222. [If yes] Why was it replaced? _______________

Net-to-Gross

Free-Ridership

223. I would like to ask about the role that various things had in your decision to do the upgrade you did. For each thing I mention, please tell me how much of a role it played in your decision, where "1" indicates it played "no role at all" and "5" indicates it played "a major role." Let me know if an item doesn't apply to your situation. [SKIP ITEMS DETERMINED NOT TO BE RELEVANT]

a. [ASK IF RECEIVED AUDIT] The energy audit (also called an assessment or appraisal) done at your home or business to identify things to include in the upgrade ____

b. A salesperson or contractor, other than the one who did the audit (or assessment or appraisal) at your home or business _____

c. [ASK IF RECEIVED LOAN] Any loan that [PROGRAM] provided or arranged for you _____

d. [ASK IF RECEIVED MONEY FROM PROGRAM] The incentive, rebate, or grant you received from [PROGRAM] ______

e. [ASK IF RECEIVED MONEY OR TAX CREDIT FROM ANOTHER SOURCE] The incentive, rebate, grant, or tax credit you from a source other than [PROGRAM] _____

f. [PROGRAM] representative or energy coach or advisor or advocate ____

g. Information on [PROGRAM]'s website _____

h. Endorsement or discussion of [PROGRAM] by a trusted source, such as a neighbor, newspaper article, community group, leader in the community___

i. Advertising and other information from [PROGRAM] _____

224. Which of the following alternatives best describes what you most likely would have done had not participated in [PROGRAM] to complete an energy upgrade? Would you have:

a. Not taken any upgrade action for at least a year

b. Gone ahead a done a remodel to improve your space, but *without any* of the energy savings features you got through [PROGRAM], and paid the full cost yourself

c. Done a remodel with *less extensive* energy-saving upgrades than you did – something that would have cost less but probably would have saved less energy, and paid the full cost yourself

d. Had the *exact same energy-saving upgrades* done anyway, and paid the full cost yourself

e. Done something else (specify) ___________________

f. Don't know

225. Did you replace any equipment through [PROGRAM]?

a. Yes

b. No

226. [IF REPLACED EQUIPMENT; ELSE, SKIP TO NEXT] Which of the following alternatives best describes what you most likely would have done about this equipment not participated in [PROGRAM] to complete an energy upgrade? Would you have:

a. Not replaced any equipment for at least a year

b. Gone ahead replaced the equipment, but not installed the same type as you got through [PROGRAM], and paid the full cost yourself

c. Had the exact same equipment installed, and paid the full cost yourself

d. Done something else (specify) ___________________

e. Don't know

Spillover

227. Since participating in [PROGRAM], have you purchased and installed any energy efficiency items without an incentive from [PROGRAM]? (For example, compact fluorescent lights – or "swirly" lights, energy efficient appliances, insulation, efficient windows, motors, or any other efficiency items)

a. Yes

b. No

c. Don't Know

228. [IF YES, ELSE END SURVEY] What efficiency measures did you install without an incentive – remember, these are things you purchased and installed that were not part of the upgrade that [PROGRAM] provided you an incentive for? For each thing you installed, please estimate the number or amount you installed. (For example, if you installed insulation without an incentive, please estimate how many square feet you had installed.)
[INSTRUCTION FOR PHONE/IN-PERSON SURVEY: IF NEEDED, PROMPT WITH FOLLOWING LIST AND FOLLOW WITH "HOW MANY" WHERE APPROPRIATE. PROBE TO UNTIL RESPONDENT INDICATES NOTHING ELSE.] PROBE: Anything else, such as efficient lighting other than CFLs, high efficiency appliances, windows, or electronics, insulation, or other efficiency items?

Type of item	Number installed	Square feet installed	Other comment
Compact fluorescent ("swirly") lights			
High efficiency refrigerator			
High efficiency dishwasher			
High efficiency clothes washer			
High efficiency clothes dryer			
Ceiling insulation			
Wall insulation			
Floor insulation			
High efficiency windows			
Other – please describe: ____________			

229. [IF REPORTED SPILLOVER, ELSE END SURVEY] Even though you installed these items without assistance from [PROGRAM], we'd like to know how much, if at all, [PROGRAM] influenced your decision to install them. Please rate [PROGRAM]'s influence with a five-point scale, where 1 means "no influence," and 5 means "major influence."

a. Record Response: ________

Thank you for participating in this survey!

APPENDIX K. RESIDENTIAL AND COMMERCIAL PRE-NOTIFICATION LETTERS

K.1. RESIDENTIAL LETTER

Nexant

6/14/2013

Participant Name
Address
City, State, Zip

Dear *Participant*

We are reaching out to you today due to your participation in the *Program Name*. As part of this program, you installed measures to improve the energy efficiency of your home.

In the coming weeks, you may be contacted by phone and asked to participate in a 10 minute, voluntary survey that will be used to verify information regarding these energy efficient measures. In addition, you may also be asked to allow researchers from our team to conduct an on-site visual inspection of the energy efficiency measures installed. This visit typically lasts a half an hour and involves researchers verifying and potentially photographing the measure installation.

Your responses will contribute to a national study measuring the energy saving impacts of the Department of Energy's (DOE) Better Buildings Neighborhood Program, which funded the *Program Name*. The DOE has contracted with an independent research firm, Nexant, Inc. to conduct this study. Your feedback will not affect any incentive you may have received and any information provided will be used by the DOE to help improve their programs for future years. No identifiable information specific to your house will be reported to the DOE or stored by Nexant.

We would greatly appreciate your participation in this voluntary survey. If you have any additional questions regarding this study, please contact Kevin Afflerbaugh, Project Manager at Nexant at 303-998-2462 or Dr. Edward Vine at the Lawrence Berkeley National Laboratory at 510-486-6047.

Sincerely,

Kevin Afflerbaugh
Project Manager
Nexant, Inc
303-998-2462
kafflerbaugh@nexant.com

Nexant, Inc.

1401 Walnut St Ste 400
Boulder, CO 80302-5332 USA

tel | +1 303.402.2480
fax | +1 303.440.6644

www.nexant.com

K.2. COMMERCIAL LETTER

6/14/2013

Participant Name
Business Name
Address
Address

Dear Participant Name:

We are reaching out to you today due to your participation in the PROGRAM NAME. As part of this program, you installed measures to improve the energy efficiency of your building.

In the coming weeks, you may be contacted by phone and asked to participate in a short, voluntary survey that will be used to verify information regarding these energy efficient measures. Your responses will contribute to a national study measuring the energy saving impacts of the Department of Energy's (DOE) Better Buildings Neighborhood Program, which funded the PROGRAM NAME. The DOE has contracted with an independent research firm, Nexant, Inc to conduct this study.

Your feedback will not affect any incentive your business may have received and any information provided will be used by the DOE to help improve their programs for future years. No identifiable information specific to your business will be reported to the DOE or stored by Nexant.

We would greatly appreciate your participation in this voluntary survey. If you have any additional questions regarding this study, please contact Kevin Afflerbaugh, Project Manager at Nexant at 303-998-2462 or Dr. Edward Vine at the Lawrence Berkeley National Laboratory at 510-486-6047.

Sincerely,

Kevin Afflerbaugh
Project Manager
Nexant, Inc
303-998-2462
kafflerbaugh@nexant.com

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APPENDIX L. GRANTEE LEVERAGING QUESTIONS INTERVIEW GUIDE

L.1. INTERVIEW DETAILS

Program name:

Date of interview:

Name(s) of program staff interviewed:

Name of Interviewer:

L.2. RESPONSE MATRIX

Leveraging IDIs workbook contains:

1) Table for recording responses in this guide ("Leverage IDI responses" worksheet)

2) List of grantees to interview with DOE leveraged funds data ("Grantees" worksheet),

3) Answers to previous interview questions about possible sources of leveraged funds ("Web survey IDIs" worksheet)

L.3. INTRO

INTRODUCE SELF AND ROLE AS BBNP EVALUATOR FOR DOE, THANK FOR ASSISTANCE SO FAR.

We are following up with the Better Buildings Neighborhood Program grantees with some questions about leveraged funds.

We understand your program has reported leveraged funds to DOE. We plan to include an analysis of grantee leveraged funds in our report. We'll also highlight certain types of non-federal leveraged funds in our report, and I'd like to ask you some questions specifically about those.

During our call today, I'm interested in hearing about any partners or others that:

- Contributed some kind of value in the form of funding, staff, services, materials, or other things, and
- Started an activity as the result of working with your program. In other words, I don't need to hear about activities that were already happening before your program came into existence. I'm mainly interested in things that started while your program was operating.

I don't need to hear about sources of funds that:

- Are government agencies (or others) using only taxpayer funds, or
- Are financial institutions, or
- Are subgrantees using only BBNP funds, or

- Are program participants—owners of homes or buildings who used their own funds to help pay for retrofits.

Do you have any questions before we get started?

L.4. SOURCES

First, please tell me the names of your program's partners or others who supported your program's activities in some way. Again, please keep in mind that I'm interested in those that started an activity while your program was operating, and are not government agencies or financial institutions.

LIST EACH SOURCE BY NAME. FOR EACH SOURCE, RECORD ANSWERS TO REMAINING QUESTIONS.

L.5. ACTIVITIES

[FOR EACH SOURCE MENTIONED] Now, let's talk about [SOURCE].

What activities are conducted with the resources or funds provided by [NAME OF SOURCE]? [LIST INDICATES QUALIFYING ACTIVITIES; DO NOT READ]

<u>Primary and related program activities</u>

1. Marketing or outreach
2. Training for staff
3. Training for contractors (workforce development)
4. Applications processing
5. Customer support (answering questions, guiding through process, etc.)
6. Audits or assessments
7. Loans or other financing to customers
8. Loans or other financing to installation contractors
9. Installing measures
10. Quality control (test out)
11. Incentives—providing funding
12. Incentives—processing
13. Program management or administration
14. Something else* (specify): ___________________________________

- IF THE MONEY/RESOURCE IS USED FOR AT LEAST ONE PRIMARY OR RELATED PROGRAM ACTIVITY ON THE LIST, CONTINUE. OTHERWISE, GO TO NEXT SOURCE. IF NO MORE SOURCES, GO TO CLOSE (F).

* QUALIFIES IF MEETS ONE OF THESE CONDITIONS:

- **Primary activities** achieve the limited specified purposes of the program pursuant to statute, regulation or administration policy.
- **Related activities** are broadly consistent with achieving the general goals and direction of the program, but not the specific focus as determined above.

DOES NOT QUALIFY IF FOR R&D OR OTHER ACTIVITIES THAT ARE NOT REQUIRED TO CONDUCT PROGRAM (ANYTHING NOT RELATED TO GENERATING UPGRADES OR JOBS). IF IN DOUBT, CONTINUE.

L.6. TIMING OF PROGRAM'S CONTRIBUTION

1. When did [SOURCE] start doing this activity, relative to when your program started?

〉 IF THE SOURCE STARTED THE ACTIVITY AS THE RESULT OF / AFTER WORKING WITH THE BBNP PROGRAM, CONTINUE.

〉 IF THE SOURCE STARTED THE ACTIVITY BEFORE WORKING WITH THE BBNP PROGRAM, GO TO NEXT SOURCE, OR IF NO MORE SOURCES, GO TO CLOSE (F).

L.7. CHARACTER OF PROGRAM'S CONTRIBUTION

1. Who primarily came up with the idea for the activity—your program, [SOURCE], or someone else?
2. [ASK IF PROGRAM DID NOT COME UP WITH THE IDEA] What was your program's role in defining the nature of this activity?
3. To what degree, if at all, was your program's contribution unique or otherwise vital to the activity? In other words, if your program didn't exist, how likely is it that this activity would have occurred in the same way?

〉 IF THE BBNP PROGRAM CAME UP WITH THE IDEA, HAD A MAJOR ROLE IN DEFINING THE ACTIVITY, AND/OR CONTRIBUTED SOMETHING UNIQUE/VITAL, CONTINUE. OTHERWISE, GO TO NEXT SOURCE, OR IF NO MORE SOURCES, GO TO CLOSE (F).

L.8. RESOURCES CONTRIBUTED BY PROGRAM

1. What is the value of the resources that [SOURCE] has contributed to this activity so far? Your best estimate is fine.
2. And what is the value of the resources that your program has provided to the activities supported by [SOURCE] so far?
3. Did any other sources contribute to this activity? [IF YES:] What is the value of their contribution so far?

So to summarize, the total value of the resources contributed to this activity so far is [SUM OF 1-3]. Is that correct?

- 〉 GO TO NEXT SOURCE (B), OR IF NO MORE SOURCES, GO TO CLOSE (F).

  [NOTE FOR FOLLOW-UP INTERVIEWS: The lower the proportion of the total funds provided by the program, the more justification for claims of leverage need to be found in the character or timing of the contribution.]

L.9. CLOSE

1. IF ANSWERED E (AMOUNT OF RESOURCES CONTRIBUTED BY PROGRAM) FOR ANY SOURCE: Thanks very much for your time and your responses today. We would like to contact your partner(s) at SOURCE(S) to ask some additional questions. Can you please provide me with a name, phone number and email address?

2. IF DID NOT ANSWER E (AMOUNT OF RESOURCES CONTRIBUTED BY PROGRAM) FOR ANY SOURCES: Thanks very much for your time and your responses. Those are all of my questions.