DOE/EE-1204

Final Report

Drivers of Success in the Better Buildings Neighborhood Program – Statistical Process Evaluation

Final Evaluation Volume 3

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.

Prepared For:
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This research project was initiated and directed by Jeff Dowd of the U.S. Department of Energy's (DOE) Office of Energy Efficiency & Renewable Energy (EERE). Project management and technical oversight was provided by Edward Vine, Staff Scientist, of Lawrence Berkeley National Laboratory (LBNL), and Yaw Agyeman, Project Manager at LBNL.

Our team of evaluators would like to thank Jeff and Ed for their support and guidance on this project. We would also 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. 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.

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GLOSSARY

Within the body of this report, there are several technical terms that require explanation, as their meanings are specific to energy efficiency activity.

ARRA	American Recovery and Reinvestment Act; provided funding for BBNP
Audit	A process that obtains information on building (including home) features that affect energy use, identifies energy efficiency measures that appear to be appropriate for the building, and estimates potential annual energy savings; can be conducted on-line or through someone walking through the building. Audits culminate in an audit report describing the findings and opportunities. Also called “energy audit.”
BBNP program	Refers to both the federal Better Buildings Neighborhood grant program administered by DOE and to the local programs grant recipients administered in their target markets. To avoid confusion, the text refers to DOE for the federal program and to the grantees for the local programs.
Direct install	Installation of energy efficiency measures by program representatives, typically during a building audit.
Funding Opportunity Announcement (FOA)	Issued by DOE to inform the public of the opportunity to apply for BBNP grant funding and outline the application requirements.
Grant	BBNP funding provided by DOE. Grant funding requires recipients to make best efforts and adhere to fraud-prevention practices but, unlike contracts, does not require the recipient to deliver a specified outcome.
Grantee	A recipient of an ARRA-funded, DOE-administered BBNP grant.
Latent profile analysis (LPA)	A statistical approach that aims to identify categories, or clusters, of entities (grantees and sub-grantees), based on continuous indicators (performance metrics) (Lazarsfeld and Henry, 1968).
Market effects	A change in the structure of a market or the behavior of participants in a market that is reflective of an increase in the adoption of energy efficient products, services, or practices and is causally related to market intervention(s) (Eto, Prahl, and Schlegel, 1996).
MMBtu	Millions (MM = one thousand thousands) British thermal units of energy, used in this context to quantify energy savings.
Program administrator	An entity (i.e., BBNP grant recipient, utility, or energy efficiency agency) that administers energy efficiency programs by offering its target market information, supporting services, incentives, and/or financing for energy efficiency, renewable energy, and/or related outcomes, and conducts the activities necessary to deliver these offerings.
Retrofit	See “upgrade.”
Subgrantee	An entity that received BBNP funding from a grantee to administer or support local BBNP programs.

Upgrade	Change to a building (including home) that reduces its annual energy consumption, typically by increasing its energy efficiency; the change can be to the building shell (insulation, air sealing) and/or to equipment or systems (HVAC, refrigeration, hot water, appliances, thermal solar, photovoltaic, etc.). Also called “retrofit.”

PREFACE

This evaluation report is one of a suite of six 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 (*Research Into Action and NMR Group, 2012a*)* (December 28, 2012; appendices in a separate volume) (Research Into Action and NMR Group, 2012b)
- *Preliminary Energy Savings Impact Evaluation: Better Buildings Neighborhood Program* (Research Into Action, Evergreen Economics, Nexant, and NMR Group, 2013)

Four firms conducted the multi-faceted evaluation:

- Research Into Action, Inc. (Research Into Action) 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 *Drivers of Success in the Better Buildings Neighborhood Programs – Statistical Process Evaluation*. Research Into Action was the principal author and evaluator; Evergreen Economics provided database support.

The Research Into Action team was led by Jane S. Peters and Marjorie McRae, supported by Jordan Folks (who conducted most of the statistical analysis and writing), Meghan Bean, Mersiha McClaren, Alexandra Dunn, and Jun Suzuki. Amber Stadler and Sara Titus provided production support.

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 is one of a suite of six reports providing 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 designed and 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. Research Into Action authored this volume.

This study statistically identifies factors associated with successful **residential** upgrade programs conducted by organizations receiving BBNP grants. In order to identify such factors, we needed a way to measure relative grantee success. We identified grantee program success *relative* to the residential performance of all other grantees with residential programs. We calculated 12 quantitative performance metrics estimated from grantee achievements Q4 2010 to Q3 2013. Thus, this study identifies factors associated with successful residential upgrade programs as based on grantee achievements during the three-year evaluation period.

This volume contributes to an understanding of the approaches grantees took to developing sustainable energy efficiency upgrade programs. This report also provides information about successful residential upgrade programs that is used in two companion reports: *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4) and *Spotlight on Key Program Strategies from the Better Buildings Neighborhood Program* (Final Evaluation Volume 6).

RESEARCH OBJECTIVES AND METHODS

Despite respective evaluations of individual BBNP-funded programs, little is known with confidence as to what broadly characterizes successful programs or what drives or derails programmatic success regardless of program design intricacies or the varying environments in which the program takes place. Thus, this volume attempts to answer the questions:

1. What defines a successful program?
2. What programmatic elements help avoid poor program performance, regardless of program design specifics or regional characteristics?
3. What programmatic elements lead to successful program outcomes, regardless of program design specifics or regional characteristics?

This study statistically explores 12 quantitative indicators of successful program outcomes and identifies the drivers and detractors of success based on data from a diverse set of comprehensive residential upgrade programs funded through BBNP. Due to the stark differences in program offerings among a given grant recipient's subgrantees (for example, the Southeast Energy Efficiency Alliance [SEEA]), we performed our quantitative analyses at the subgrantee level to capture the full diversity of program models, outcomes, and market characteristics. Specifically, 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. Due to the inclusion of subgrantee-ran programs, the number of programs included in our analyses (n = 54) exceeds the number of primary BBNP grantees (N = 41). Thus, we analyzed data from 54 widely varying residential programs conducted by grantees and their subgrantees. For simplicity, throughout this volume we refer to both grantees and subgrantees as "grantees."

First, we defined several potential measurements of success, basing these elements on both theory and data availability. We then conducted latent profile analysis (LPA) to cluster programs into groups that exhibited similar performance on the 12 metrics of success included in the LPA model. LPA yielded three groups (or clusters) whose average group values on the 12 metrics were consistent with an interpretation of a most successful group, an average group, and a least successful group. Using binary logistic regression, we sought to statistically identify predictors of success – specifically the factors distinguishing programs that fell into the least successful group and those that fell into the most successful group.

KEY FINDINGS AND CONCLUSIONS

This study identified factors associated with relative program success among grantees offering residential programs, as based on grantee achievements during the three-year evaluation period. Our rigorous analysis of a wealth of information confirms many residential program design and implementation approaches identified as effective by the industry literature and commonly reported experience of program administrators. Further, our analysis found that grantee success was not driven by whole home program experience prior to the grant period; grantee programs that built on the experiences of an existing program were not found to be more successful than those grantee programs that had no predecessor program to build on. Instead, elements related to program design and implementation were found to be the strongest predictors of program success.

The findings provide the energy efficiency community with greater confidence in its understanding of how to make upgrade programs successful.

- Grantees demonstrated three tiered levels of relative success, revealing that grantees clustered into either a most successful, average, or least successful group, based on a comparative assessment of the performance metrics we examined. Grantees in the most successful group performed substantially better in terms of market penetration, savings-to-investment ratios (SIR), present value of lifetime cost savings, present value of lifetime cost savings per upgrade, number of total contractor job hours invoiced, and percent of projects that were comprehensive. Least successful grantees performed markedly worse in progress towards their set goals, average MMBtu savings per project, program cost per upgrade, program cost per dollar of work invoiced, program cost per MMBtu saved, and program cost per contractor job hour. Average grantees generally demonstrated mid-range values on the performance metrics.
- We found several respective programmatic elements that related to being in either the most successful or the least successful group. Specifically:
  - **Offering contractor training helps avoid poor program outcomes.** Programs that offered any form of contractor training were significantly less likely to be in the least successful cluster. In order to deliver residential energy efficiency services effectively, programs rely on contractors with the skills needed to sell and perform the audit and upgrade work. However, some regions may lack a sufficiently large base of qualified contractors with experience and expertise in energy efficiency building science. Further, even if a strong contractor base exists in a region, participating contractors may benefit from sales training and need instruction on program processes and requirements if they are to effectively deliver program services.
  - **Offering multiple pathways to participation and for achieving energy savings is critical to achieving successful program outcomes.** Specifically, programs that included direct install options, offered multiple audit types, and allowed larger numbers of contracting firms to perform upgrades were significantly more likely to be in the most successful cluster. Further, these elements are predictors of being in the most successful cluster regardless of exogenous factors, such as population size, energy costs in a program's service region, or housing stock- and weather-oriented constraints on energy use and ways of achieving savings opportunities.
    - **Direct install activities are a key component of successful programs.** Regression analyses revealed conducting direct install of low-cost measures was the strongest predictor of membership in the most successful cluster. Grantees reported direct install options, which were often included in the audit prior to a more comprehensive upgrade project, could serve as both a source of significant energy savings, as well as being a "sweetener" to encourage participation in the audit or a subsequent upgrade project. Directly installing low-cost measures during an audit allows programs to claim direct energy savings prior to a comprehensive upgrade project (as well as garnering savings from audit participants that do not pursue an upgrade project); this can increase program cost-effectiveness.
    - **Increased audit-type offerings can help garner successful program outcomes.** Offering multiple audit types, such as online, mail-in, phone-based, walk-through, or in-depth, provides potential participants with a variety of ways to begin engaging with a program and identifying ways

that they can save energy. Since certain audit types may be more appropriate for or appealing to different homeowners, offering multiple audit types successfully accommodates potential participants' varying wants and needs, increasing the types of customers appealed to, and potentially increasing program-wide participation and conversion rates.

- **Having a large number of contractors eligible to conduct upgrades contributes to high levels of programmatic success.** Having a large number of firms that are eligible to complete program upgrade projects makes it easier for participants to find a qualified contractor. Moreover, having a large number of eligible contracting firms maximizes the number of projects that can be conducted at a given time and also can magnify program and energy efficiency upgrade awareness via contractor-led advertising and outreach efforts. However, program administrators should be wary of relying on overly lax contractor eligibility criteria, which may maximize the number of eligible contractors, yet reduce the project quality on average. Proper quality assurance and quality control (QA/QC) techniques can mitigate quality of work issues; in addition, our regression analysis demonstrates the value of providing training opportunities to program contractors in order to avoid subpar program outcomes. Thus, large pools of trained eligible upgrade contractors are key to the most successful programs.

- **The findings of this study provide a blueprint for designing successful residential energy efficiency upgrade programs.** Since this study analyzed program data from 54 diverse grantees and subgrantees spanning widely varied regions and demonstrated that exogenous elements neither explained nor confounded variation in success, the statistical findings are particularly insightful for the energy efficiency industry, as they elucidate what can make or break a residential program regardless of broader contextual factors.

RECOMMENDATIONS

We offer the following recommendations for residential program design and implementation.

- **Provide contractor training.** Program administrators should ensure contractors wanting to participate in the residential program have access to a variety of trainings, including building science training relevant to auditing, measure installation, and selling energy efficiency upgrades. Program administrators might also consider training or support related to running a business.

- **Offer multiple pathways to participation and achievement of energy savings, specifically:**
  - **Incorporate direct install activities into program designs.** Program administrators should offer direct install measures to participants.
  - **Offer multiple types of audits.** Program administrators should offer multiple audit types of varying complexity –such as online, mail-in, phone-based, walk-through, or in-depth – as some participants may be unwilling to have an in-depth audit performed in their home, yet may be open to a less invasive and lower cost option.
  - **Ensure a large number of upgrade contractor firms are eligible to conduct program upgrades.** Program administrators should ensure there are a large number of qualified contractors eligible to perform upgrades through the program. This approach ensures there are a sufficient number of

qualified tradespeople available to serve a program's region and may result in increased uptake via contractor-led advertising efforts and contractors' pre-existing relationships with homeowners. In order to maximize the number of participating contractors, programs should minimize the programmatic burden on participating contractors (such as simplifying and minimizing participation steps and paperwork), conduct outreach to nonparticipating contractors, and minimize qualification criteria (while relying on proper QA/QC techniques and training courses to ensure work quality).

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 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.

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 is one of a suite of six reports providing 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 designed and 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. Research Into Action authored this volume.

1.1. STUDY OVERVIEW

This study seeks to identify factors that drove or inhibited relative program success during the three-year evaluation period among residential upgrade programs conducted by organizations receiving grants from DOE BBNP.

Despite respective evaluations of individual BBNP-funded programs, little is known with confidence as to what broadly characterizes successful programs or what drives or derails programmatic success regardless of program design intricacies or the varying environments in which the program takes place. Thus, this volume attempts to answer the questions:

1. What defines a successful program?
2. What programmatic elements help avoid poor program performance, regardless of program design specifics or regional characteristics?
3. What programmatic elements lead to successful program outcomes, regardless of program design specifics or regional characteristics?

This study statistically explores 12 quantitative indicators of successful residential program outcomes and identifies the drivers and detractors of success based on data from a diverse set of comprehensive residential upgrade programs funded through BBNP. Due to the stark differences in program offerings among a given grant recipient's subgrantees (for example, the Southeast Energy Efficiency Alliance [SEEA]), we performed our quantitative analyses at the subgrantee level to capture the full diversity of program models, outcomes, and market characteristics. Specifically, 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. Due to the inclusion of subgrantee-ran programs, the number of programs included in our analyses (n = 54) exceeds the number of primary BBNP grantees (N = 41). Thus, we analyzed data from 54 widely varying residential programs conducted by grantees and their subgrantees. For simplicity, throughout this volume we refer to both grantees and subgrantees as "grantees."

First, we defined several potential measurements of success, basing these elements on both theory and data availability. We then conducted latent profile analysis (LPA) to cluster programs into groups that exhibited similar performance on the 12 metrics of success during the three-year evaluation period. LPA yielded three groups (or clusters) whose average group values on the 12 metrics were consistent with an interpretation of a most successful group, an average group, and a least successful group. Using binary logistic regression, we sought to statistically identify predictors of success – specifically the factors distinguishing programs that fell into the least successful group and those that fell into the most successful group.

This statistical process evaluation volume has a companion report *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4), which identifies effective approaches and provides an overall assessment of the degree to which the BBNP met its objectives and goals relating to program processes. This volume reports on a multivariate analysis of BBNP data, while Volume 4 reports on a bivariate analysis of the data.

Despite respective evaluations of individual BBNP-funded programs, little is known as to what broadly characterizes successful programs, or what drives or derails programmatic success – regardless of program design intricacies or the varying environments in which the program takes place. Thus, this volume attempts to answer these questions:

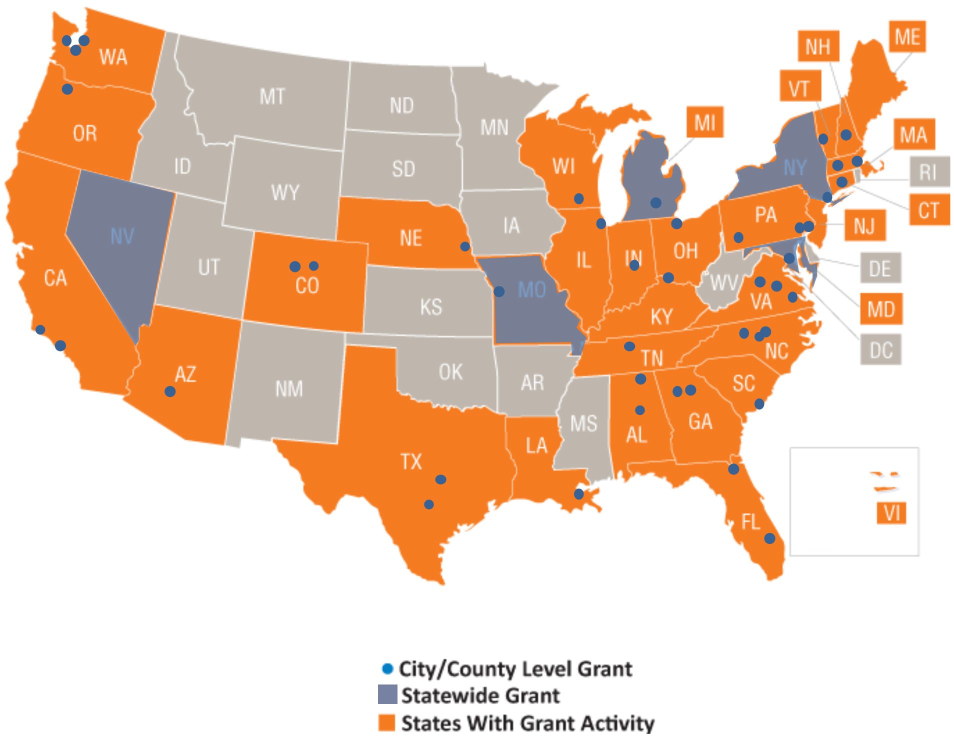
1. What defines a successful program?
2. What programmatic elements help avoid poor program performance, regardless of program design specifics or regional characteristics?
3. What programmatic elements lead to successful program outcomes, regardless of program design specifics or regional characteristics?

Using both data that grantees reported to DOE in partial fulfillment of their grant requirements and data collected by us, 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. We conducted analyses of program success achieved during the three-year evaluation period for the single-family residential sector due to greater availability of data than for the nonresidential and multifamily sectors. Further, focusing on the single-family residential sector has significant merit; running a successful residential whole-house retrofit program constitutes a challenge for many program administrators.

1.2. BBNP DESCRIPTION, GOALS, AND OBJECTIVES

DOE administered BBNP to support programs promoting whole building energy upgrades. BBNP distributed over $500 million to support efforts in hundreds of communities served by 41 grantees, as illustrated in Figure 1-1. While the federal government has issued periodic funding opportunities for energy efficiency, none has been on the scale of BBNP.

Figure 1-1: BBNP Grantees by Location



DOE issued two competitive funding opportunity announcements 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. DOE awarded grants between May and October 2010, intended to provide funding over a three-year period ending September 30, 2013, a period that DOE subsequently extended by a year for programs that included a BBNP-funded financing mechanism to operate 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 upgrades resulting in significant energy improvements (upgrades 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 Funding Opportunity Announcement (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 designed BBNP to meet the three principal ARRA goals (Table 1-1), as well as seven objectives developed by DOE staff to guide the BBNP initiative (Table 1-2). This report provides findings for the process evaluation, as do two companion reports: *Process Evaluation of the Better Buildings Neighborhood Program* (Final Evaluation Volume 4) and *Spotlight on Key Program Strategies from the Better Buildings Neighborhood Program* (Final Evaluation Volume 6). This volume contributes to an understanding of the approaches grantees took to developing sustainable energy efficiency upgrade programs.

Table 1-1: ARRA Goals

GOALS
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 1-2: BBNP Objectives

OBJECTIVES
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

2. METHODOLOGY

2.1. OVERVIEW

Using 12 diverse indicators of success, we identified successful program outcomes during the three-year evaluation period – and their drivers – across a diverse set of comprehensive residential upgrade programs from across the country. The research began by defining numerical performance metrics corresponding to BBNP's multi-faceted objectives. We then conducted latent profile analysis (LPA) to cluster programs into groups with similar performance on the 12 indicators of success. LPA is a statistical approach that aims to identify categories, or clusters, of entities (grantees and sub-grantees), based on continuous indicators (performance metrics) (Lazarsfeld and Henry, 1968). We used latent profile analysis to identify clusters of grantees that represent different domains or levels of relative program success. We sought to identify clusters that were both theoretically sound and provided a valid representation of relative residential program success among the BBNP grantees.

LPA revealed that programs clustered into three groups; their average group values on the 12 metrics were consistent with an interpretation of a most successful group, an average group, and a least successful group. After clustering programs into the groups described above, we used binary logistic regression to identify the respective factors that distinguished programs that fell into the least successful group and those that fell into the most successful group. The following sections further describe the methodology employed in our analysis of factors that drive or inhibit program success. Appendix B provides additional description of the quantitative methodology.

2.2. UNIT OF ANALYSIS

This study uses grantees and subgrantees (that had single-family residential program offerings) as the unit of analysis (n = 54). Since each program present in the analysis represents their corresponding grantee, the terms "grantees" and "programs" are used interchangeably to refer to the base unit of analysis. Due to the stark differences in program offerings amongst a given grant recipient's subgrantees (for example, SEEA); we performed our quantitative analyses at the subgrantee level to capture the full diversity of program models, outcomes, and market characteristics. Specifically, 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. This method was particularly appropriate as subgrantees from a given grantee exhibited varied success groupings.

2.3. DEFINING SUCCESS VIA LATENT PROFILE ANALYSIS

First, we identified quantifiable metrics of success for residential energy efficiency programs based on BBNP's objectives and data availability, outlined in Chapter 4 of this volume. We then compiled performance metric data from the three-year evaluation period for each grantee and subgrantee and conducted LPA on the resulting dataset.[1] We used LPA as an exploratory approach to measuring relative grantee success – a comparative assessment based on the performance metrics we examined. While we had hypotheses as to how clusters of grantees may have demonstrated similar performance on the performance metrics, prior to executing the LPA we did not actually know

[1] We conducted analyses of 2-, 3-, and 4-cluster models on the final set of twelve performance metrics. We found that the 3-cluster model yielded the most parsimonious and theoretically valid results.

how grantees would cluster together. Thus, LPA allowed us to assess if grantees fell into tiered levels of success or if they fell into clusters representative of different domains of success (for example, a high cost effectiveness cluster, a large energy savings cluster, etc.). In sum, we used LPA to explore how grantees cluster along the performance metrics and subsequently defined the respective clusters based on their members' average performance on the performance metrics in the LPA model.

2.4. PREDICTOR VARIABLES AND DATA REDUCTION TECHNIQUES

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 critical control variables, such as weather metrics, average energy price, median income, and other variables that may affect energy use, savings, and participation rates. Due to the large number of predictor variables, we conducted a factor analysis on all continuous variables as a means of data reduction and to identify latent variables present in the dataset.[2] This statistical method also helps us address potential multicollinearity issues.[3]

The factor analysis revealed that three latent concepts (or factors) were present in the data, two of which were derived from exogenous variables (Table 2-1; the first two rows describe exogenous variables).[4] After identifying these factors, we constructed indexes using the underlying variables that loaded onto each respective factor and used these indexes as predictor variables in subsequent regression models.

Table 2-1: Predictor Variable Factors and the Associated Underlying Variables

FACTOR	UNDERLYING VARIABLES
Socioeconomic status of population in grantee's service area	Percent of population (25 years and older) in grantee's service area with a high school degree Percent of population (25 years and older) in grantee's service area with a bachelor's degree Unemployment rate of population (16 years and older) in grantee's service area Median income of households in grantee's service area
Constraints on energy use and savings opportunities	Heating degree days Cooling degree days Average age of housing stock in grantee's service area
Timing of peak performance	How quickly a program was able to begin functioning at its best (as reported by grantees) Length of time best functioning period lasted (as reported by grantees)

2 Factor analysis is a statistical method that identifies sets of variables that co-vary together and collectively constitute underlying constructs (or "latent variables"), which in turn informs the construction of index variables which represent these latent variables.

3 Multicollinearity issues occur when two or more predictor variables in a multivariate regression model are highly correlated and interferes with proper regression modeling techniques.

4 Factor analysis yields "factors," which represent the latent concepts (or, underlying constructs) that exist in the relationships between a set of variables.

2.5. REGRESSION MODELING

Next, we explored which programmatic elements were significant predictors to grantee success, controlling for exogenous variables. Our analysis aimed to identify both the drivers and detractors of success among residential programs. Thus, we used two mutually exclusive sets of binary regression models to explore these relationships, where each set of regression models employed a different dependent variable (but tested for relationships with the same set of predictor variables): one set of models sought to identify which elements predicted membership in the least successful cluster and the other aimed to identify the elements predicting membership in the most successful cluster. Since standard maximum likelihood estimate-based logistic regression models perform poorly on small samples (Firth 1993), and the number of records in our dataset (n = 54) is considered a “small sample” (Long 1997), we used penalized maximum likelihood logistic regression, which corrects for small sample bias (Heinze & Ploner 2004) (Firth, 1993; Long, 1997; Heinze and Ploner, 2004).

We used bivariate logistic regression 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 using the independent variables identified as meaningful predictors ($p < 0.10$) in the aforementioned bivariate models.[5] We used a stepwise approach to add these variables into the respective models in order to derive optimal models (that is, until adding additional variables no longer improved the model). Finally, we used Tjur’s R-Squared to measure the predictive power of each model. Tjur’s R-Squared is more appropriate for penalized likelihood logistic regression, as it relies on the mean differences of the predicted probabilities of the model (as compared to other pseudo R-Squares, which rely on the maximum likelihoods that characterize standard logistic regression models) (Tjur, 2009).

2.6. LIMITATIONS

All of the program data that we examined were reported by grantees, either to DOE, or to us through our data collection activities.[6] None of the data are independently verified.[7] Reporting inaccuracies and omissions may have reduced our ability to find statistically significant relationships among the data. We think it is unlikely that the reported data suffer from systematic biases that would confound the analysis, such as would be the case if the grantees we identified as most successful typically had reporting errors that led to inflated performance estimates (estimated performance metric values) and, conversely, low success grantees had reporting errors that led to understated metric values.

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5 While we employed $p < 0.05$ as the threshold for statistical significance in this study, we retained predictors demonstrating $p < 0.10$ at the bivariate level for subsequent multivariate modeling in order to see if their relationship with the dependent variable strengthened when controlling for other factors.

6 However, exogenous data, such as data on weather and demographics, was not grantee-reported data. Rather, these data came from sources such as the U.S. Census Bureau, the U.S. Energy Information Administration, and the National Oceanic and Atmospheric Administration.

7 Companion *Savings and Economic Impacts of the Better Buildings Neighborhood Program* (Final Evaluation Volume 2) provides verified savings estimates for the federal BBNP program; the study did not generate grantee-specific verified savings estimates.

While we included nearly 100 theory-driven independent variables in our analysis, there may be other variables that explain grantee success clustering, including variables that we deemed as theoretically relevant yet were unable to collect [quality] data on.[8] If there are such variables and these omitted variables are correlated with the explanatory variables in our final models, then our results suffer from omitted-variable bias. Thus, we caution readers that there may be other drivers and detractors of success we were unable to investigate and that, if so, inclusion of these variables in our models would change our results.

We believe the limitation with the most potential to affect our results concerns our quantification of highly qualitative concepts among our independent variables. We based our efforts in survey research, where respondents provided qualitative information that we coded into a numerical format for quantitative analysis. Yet grantees' responses to some of these questions did not comport with our understanding of the grantees based on interviews.

For example, based on our qualitative understanding, we suspect prior energy efficiency program experience contributes to grantee success, although our statistical analysis does not support this assertion. By experience, we mean experience among program administrator and support contractor staff, as well as market experience – contractors and customers familiar with energy efficiency. We attempted to quantify experience in terms of years of experience among program staff, whether the BBNP program built on a pilot or other program preceding the BBNP grant, and the American Council for an Energy-Efficient Economy (ACEEE) state energy efficiency scorecard. Yet we continue to suspect we have inadequately accounted for qualitative differences among grantee experience.

Finally, we note that this analysis investigates grantee success as of third quarter 2013, the formal end of the three-year grant period. Were these programs to operate for ten years and our success analysis to investigate performance in years eight through ten, we might reach somewhat different conclusions.

That said, our analysis found that grantee success was not driven by whole home program experience prior to the grant period; grantee programs that built on the experiences of an existing program were not found to be more successful than those grantee programs that had no predecessor program to build on. Instead, elements related to program design and implementation were found to be the strongest predictors of program success.

8 See Table B-1 in Appendix B for the complete list of desired predictor variables that we were unable to collect [quality] data on.

3. THE MEASURE OF SUCCESS

We used LPA as a means of measuring the multi-faceted concept of "success" among residential energy efficiency upgrade programs. First, we compiled grantee data on 12 diverse metrics of programmatic success to be used for the LPA. The performance metrics covered program/market saturation, cost effectiveness, program effectiveness, and wider economic impacts. Table 3-1 exhibits these 12 performance metrics, and includes definitions for each, the corresponding unit of analysis, and the minimum and maximum observed values for each metric.[9] Since the performance metric data are based on grantee level data aggregated from each grantee's project level data, the ranges presented below reflect how program-wide outcomes varied in respect to the 12 performance metrics. For example, the range reported for *program cost per upgrade* illustrates how grantees varied widely in the number of upgrades performed in relation to the grant amount awarded.

Table 3-1: Definitions, Units, and Value Ranges of Program Performance metrics

PROGRAM PERFORMANCE METRICS	DEFINITION	UNIT	RANGE*
PROGRAM / MARKET SATURATION METRICS			
Market penetration of program's upgrades	Ratio of upgrades completed to number of single-family households in the grantee's target area	Ratio of number of projects to number of households	0.002% to 11%
Program's progress toward goal	Ratio of upgrades completed to upgrade target	Percent of projects	2% to 206%
PROGRAM COST METRICS			
Program cost per upgrade	Ratio of program costs (award amount devoted to residential program offerings) to number of upgrades completed	$	1,296 to 105,984
Program cost per MMBtu saved	Ratio of program cost to total site MMBtu saved	$	32 to 3,978
Total program-wide present value of lifetime cost savings	Total program-wide annual energy savings multiplied by the net present value factor	$	339,927 to 133,463,892
Program's per-upgrade average of present value of lifetime savings	Ratio of program-wide present value lifetime cost savings to number of upgrades	$	2,401 to 59,254

Continued...

9 While two of the metrics – *program's total contractor job hours invoiced* and *total program-wide present value of lifetime cost savings* – were not normalized to reflect the grantee's award amount (or more specifically, their residential outlays), correlations between either of these two metrics and residential outlays were both below 0.75, revealing that performance on these metrics were not direct functions of residential outlays. Further, when regressed on success cluster variables, these two metrics either did not predict (p > .5) or only marginally predicted (odds ratios = 1.00000) membership in any of the successful clusters.

PROGRAM PERFORMANCE METRICS	DEFINITION	UNIT	RANGE*
Program's savings-to-investment ratio (SIR)	Ratio of program-wide present value of lifetime cost savings to program cost	Ratio of dollars saved to dollars spent	0.2 to 4
Program cost per dollar of work invoiced	Ratio of program costs to total invoiced upgrade cost	$	0.2 to 11
PROGRAM EFFECTIVENESS METRICS			
Program's average MMBtu savings per project	Ratio of total site MMBtu saved to number of projects	MMBtu	5 to 45
Percent of program's projects meeting comprehensiveness proxy	See section B.2.3 in Appendix B for information on the comprehensiveness proxy	Percent of projects	0% to 96%
PROGRAM'S WIDER ECONOMIC IMPACT METRICS			
Program's total contractor job hours invoiced	Total number of job hours invoiced on program projects	Hours	782 to 1,136,470
Program cost per contractor job hour	Ratio of program costs to total job hours invoiced	$	23 to 1,672

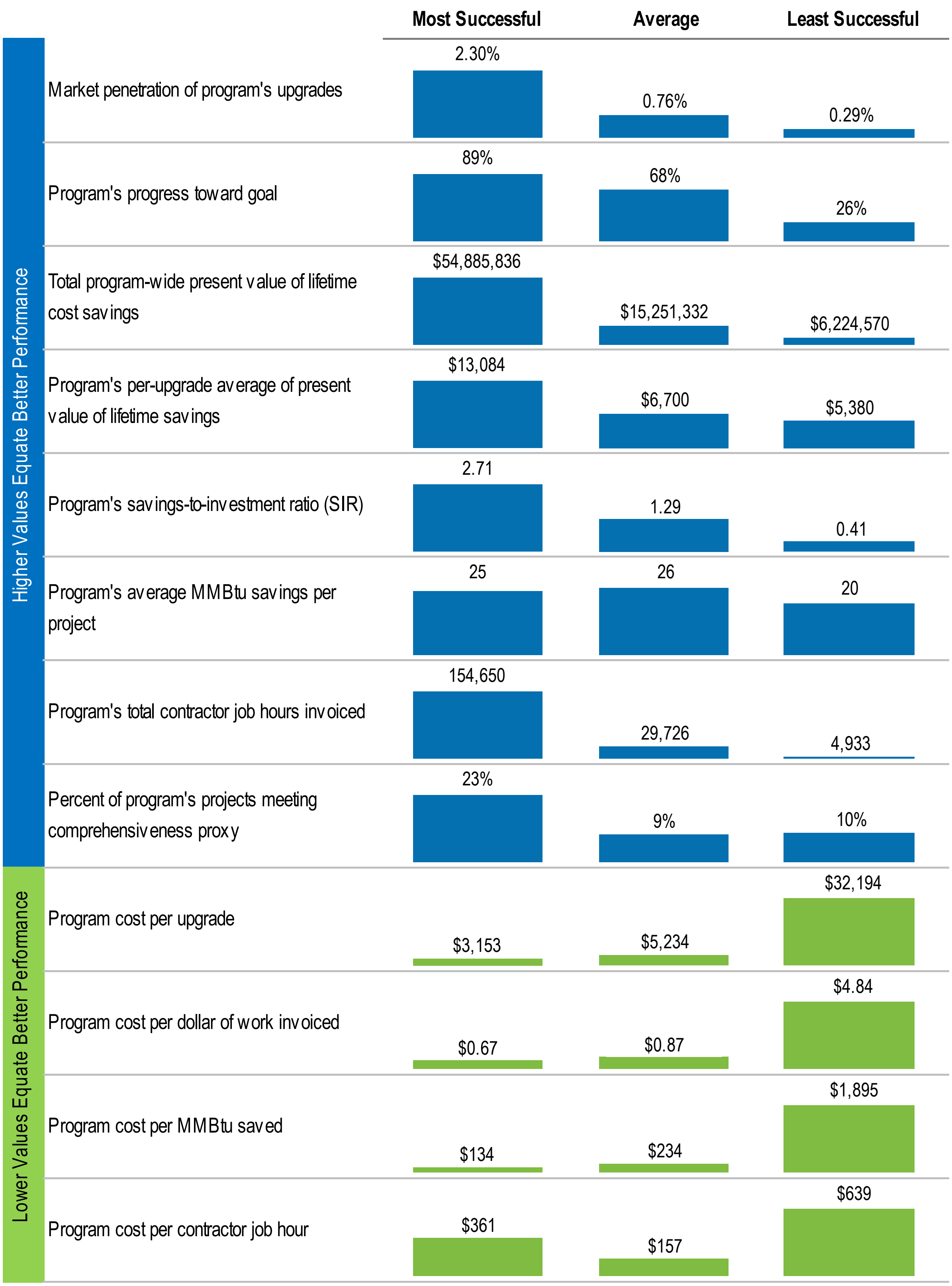
* Values greater than 1 are rounded to the nearest whole number.

LPA is an exploratory technique, and our analyses sought to identify groups, or clusters, of grantees that differed meaningfully in their relative performance on 12 metrics of program success. Results of the LPA revealed grantees clustered into three groups, and our analysis of each group's performance on the 12 performance metrics demonstrated that one group generally performed best on each of the metrics (the "most successful" cluster), another group generally performed worst on the metrics (the "least successful" cluster), and a third group demonstrated mid-range metric values (the "average" cluster). Thus, the LPA revealed clusters of grantees that were more or less successful relative to one another. Figure 3-1 demonstrates these tiered levels of grantee success by exhibiting the cluster means for each performance metric.[10]

While most indicator variables yielded mean cluster values that were consistent with a most, average, and least successful groupings interpretation, three indicator variables exhibited cluster means that deviated from this interpretation. Specifically, the most successful cluster had a somewhat higher program costs per job hour than the average group, the least successful cluster had a negligibly higher proportion of comprehensive projects that the average group (a difference of 0.22%), and the average cluster had a negligibly higher average MMBtu savings per project compared with the most successful group (a difference of 0.45).

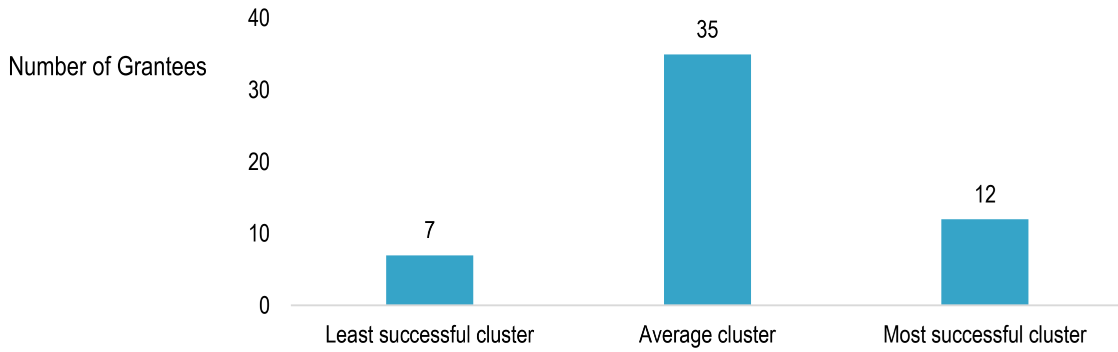
10 See Appendix B of this volume for additional detail.

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



As seen in Figure 3-2, grantee cluster membership yielded a normal distribution; most grantees clustered into the average group and a minority of grantees clustered into either the least successful or most successful groupings.

Figure 3-2: Number of Grantees in Each Success Cluster (n = 54)



4. DRIVERS OF SUCCESS

We present two sets of results in this section: 1) significant predictors of membership in the least successful grantee cluster; and 2) significant predictors of membership in the most successful grantee cluster.

4.1. PREDICTING MEMBERSHIP IN THE LEAST SUCCESSFUL CLUSTER

First, we ran bivariate regression models to explore whether any of the proposed predictor variables predicted membership in the least successful cluster. Tested predictor variables included both programmatic elements (covering such areas as program design and financing) as well as exogenous controls (such as demographics and weather patterns of the grantee service area); see Table B-2 in Appendix B for a complete list of predictor variables included in bivariate models (as we only report results from predictor variables that yielded p values of .1 or less). We then retained any variables that predicted membership in the least successful cluster (as evidenced by $p < .1$) for further multivariate modeling, which served to expose what elements *collectively* related to poor program performance. Ultimately, our regression analyses indicate that offering contractor training is a critical step to avoiding poor program outcomes. Table 4-1 presents the results from these bivariate regression models.

Bivariate logistic regression models revealed that grantees who offered contractor training were 96% less likely to be in the least successful group, which explains about one-third of the likelihood of belonging to the least successful cluster (as evidenced by the odds ratio of 0.04 and an R-square of 0.32).[11] Further, offering specific training types (training on program procedures, sales training, or business training) or offering any of those types of training to specific contractor types (auditors and upgrade contractors) also predicted membership in the least successful cluster; grantees that offered any of these specific training types or offered any type of training to auditors or contractors were less likely to be in the least successful cluster. Additionally, the number of these training types offered also predicted membership in the least successful cluster; for every additional type of training offered, grantees were significantly less likely to be in the least successful cluster. In addition to contractor training variables, the number of audit types offered (such as online, mail-in, phone-based, walk-through, in-depth,[12] or none) also was a bivariate predictor of belonging to the least successful group; for every additional audit type offered, grantees were less likely to be in the least successful group. No other programmatic elements or exogenous control variables significantly predicted membership in the least successful group.

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11 An odds ratio is a measure of association between one or multiple independent variables and an outcome (that is, belonging to the least successful group or not). Odds ratios below 1 mean a lower likelihood of being in the least successful group when accounting for all of the independent variables in the model and odds ratios above 1 mean an increased likelihood of being in the least successful group. Tjur's R-Squared represents the percentage of variance explained by all the independent variables in the model. The higher the Tjur's R-Squared value, the more predictive/explanatory power the independent variables have.

12 There is no industry standard terminology for what we term in this paper "in-depth audits." By in-depth audit, we mean the most comprehensive of audit types, which typically use diagnostic equipment (such as blower door equipment and infrared cameras) to improve the identification and quantification of energy savings opportunities. Consistent with the lack of industry standard terminology, this audit approach itself is unstandardized. Software and diagnostic tools used in these audits vary from program to program and even project to project within a given program.

Table 4-1: Significant Bivariate Predictors of Membership in the Least Successful Cluster (n = 54)

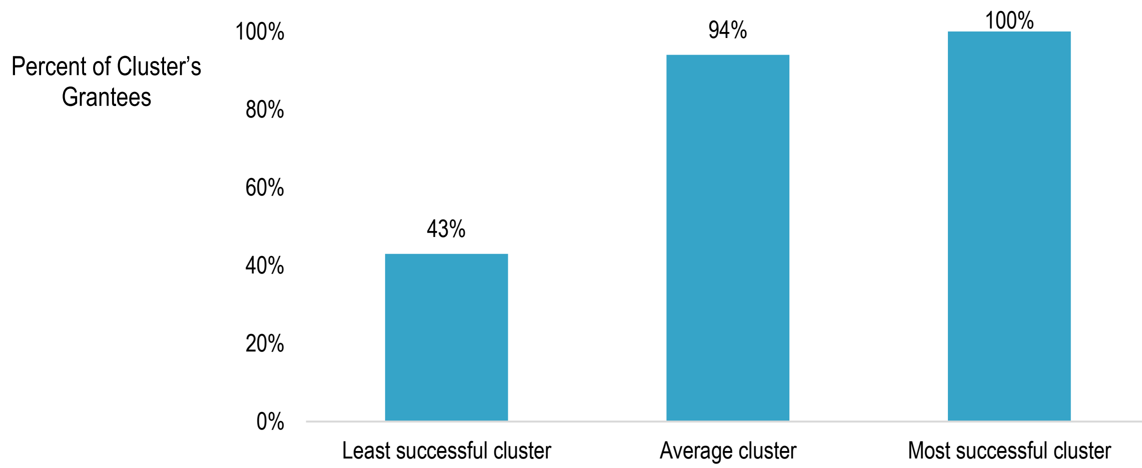
INDEPENDENT VARIABLE	DESCRIPTION OF VARIABLE	ODDS RATIO	BIVARIATE TJUR'S R^2
Any contractor training offered	Whether auditors and/or upgrade contractors were able to receive training on at least one of the following topics: sales, business, or program requirements and processes	0.04 [d]	0.32
Count of training types offered	The number of the following training opportunities offered by the program (range of 0-6): auditor sales training, auditor business training, auditor training on program requirements and processes, upgrade contractor sales training, upgrade contractor business training, and upgrade contractor training on program requirements and processes	0.47 [c]	0.31
Any upgrade contractor training offered	Whether upgrade contractors were able to receive training on at least one of the following topics: sales, business, or program requirements and processes	0.07 [c]	0.24
Upgrade contractor program training offered	Whether upgrade contractors were able to receive training on program requirements and processes	0.10 [c]	0.18
Upgrade contractor sales training offered	Whether upgrade contractors were able to receive sales training	0.24 [a]	0.07
Any auditor training offered	Whether auditors were able to receive training on at least one of the following topics: sales, business, or program requirements and processes	0.08 [c]	0.21
Auditor program training offered	Whether auditors were able to receive training on program requirements and processes	0.10 [c]	0.18
Auditor sales training offered	Whether auditors were able to receive sales training	0.11 [c]	0.14
Any program training offered	Whether auditors and/or upgrade contractors were able to receive training on program requirements and processes	0.08 [c]	0.21
Any sales training offered	Whether auditors and/or upgrade contractors were able to receive sales training	0.14 [b]	0.13
Any business training offered	Whether auditors and/or upgrade contractors were able to receive business training	0.17 [b]	0.08
Number of audit types offered	The number of the following audit types offered by the program (range of 0-4): online, walk-through, in-depth, other, or none	0.16 [b]	0.18

[a] $p < .1$; [b] $p < .05$; [c] $p < .01$; [d] $p < .001$

Next, we performed multivariate regression modeling to examine what elements *collectively* related to lackluster program outcomes, using meaningful ($p < .1$) bivariate predictions of least successful cluster membership as the selection criteria for subsequent multivariate modeling. However, only two conceptual areas – contractor training and audit types – yielded any meaningful bivariate relationships. While several variables related to contractor training predicted membership in the least successful group at the bivariate level, we determined that "any contractor training offered" was the optimal variable to include in subsequent multivariate modeling attempts, since multicollinearity and assumptions of independence concerns prevented us from including multiple contractor training variables in the same multivariate model. Further, the lack of contractor training offerings was the strongest predictor of belonging to the least successful cluster (Tjur's $R^2 = 0.32$). Thus, multivariate models predicting membership in the least successful cluster just included *any contractor training offered* and *number of audit types offered* as predictors.

As seen in Figure 4-1, all grantees in the most successful cluster and most (94%) average grantees offered some form of contractor training, compared to less than half (43%) of grantees in the least successful cluster.

Figure 4-1: Percent of Grantees that Offered Contractor Training, by Cluster (n = 54)



Multivariate results suggest offering any form of contractor training is the best way to mitigate lackluster program performance, regardless of other program elements or exogenous factors. As seen Table 4-2, grantees that offered contractor training were significantly less likely to be in the least successful cluster (Model 1). Further, while the number of audit types offered initially predicted membership in the least successful cluster (Model 2), this relationship is no longer statistically significant when *any contractor training offered* also is included in the model (Model 3). These results demonstrate lack of contractor training is the strongest predictor of membership in the least successful cluster. Further, none of the exogenous control variables (such as energy prices or regional economic indicators) were associated with belonging to the least successful cluster or confounded contractor training's relationship with membership in the least successful cluster.

Table 4-2: Multivariate Logistic Regression Modeling of Least Successful Cluster Membership (n = 54)

VARIABLE	MODEL 1	MODEL 2	MODEL 3
Number of audit types offered	—	0.16 [a]	0.56
Any contractor training offered	0.04 [c]	—	0.07 [a]
Wald test	9.56 [b]	3.52 [a]	9.04 [a]
Tjur's R^2	0.32	0.18	0.34

[a] $p < .05$; [b] $p < .01$; [c] $p < .001$

4.2. PREDICTING MEMBERSHIP IN THE MOST SUCCESSFUL CLUSTER

We conducted our regression analysis predicting membership in the most successful cluster in the same manner as reported for predicting membership in the least successful group; first we performed bivariate logistic regression models, and then we ran multivariate regression models with the variables that yielded meaningful ($p < .1$) bivariate predictions.

Bivariate models predicting membership in the most successful cluster yielded several different programmatic elements and exogenous control variables as significant predictors (Table 4-3). Specifically, bivariate regression models indicated grantees were more likely to be in the most successful group if they offered direct install options or did not require savings thresholds at the project level. Additionally, increased numbers of eligible upgrade contracting firms and audit type offerings also were associated with increased likelihood of being in the most successful group. The *timing of peak performance index* (representing how quickly a program was able to begin functioning at its best and then how long it was able to sustain its peak performance) as well as the program's *ramp-up time* (the length of time between the grant award date and the start of the aforementioned 'peak performance' period) also exhibited bivariate relationships with the most successful dependent variable. Thus, in a short-duration program such as BBNP, programs need to get off the ground quickly and continue to function well as time goes on in order to be highly successful; programs that were slow to ramp up had limited time to garner success. Staff experience also predicted success: grantees with at least one staff member with 15 years or more of relevant experience were significantly more likely to be in the most successful group. Further, three exogenous control variables – population of grantee's target area, the average cost of electricity in the grantee's state, and the constraints on energy use and savings opportunities index – also predicted membership in the most successful cluster. No other programmatic elements or exogenous control variables significantly predicted membership in the most successful group.

Table 4-3: Significant Bivariate Predictors of Membership in the Most Successful Cluster (n = 54)

INDEPENDENT VARIABLE	DESCRIPTION OF VARIABLE	ODDS RATIO	BIVARIATE TJUR'S R2
Direct install options offered	Whether the grantee offered direct install options	12.85 [d]	0.28
Number of eligible upgrade contractor firms	The number of upgrade contractor firms eligible to perform upgrades through the program at the time the program was most active in conducting upgrades (self-reported)	1.02 [c]	0.19
Savings threshold required for qualified projects	Whether the program required projects to meet an energy savings threshold in order to qualify for incentives	0.13 [c]	0.19
Ramp-up time	Time (in years) between grant award date and when the program began functioning at its best (as reported by grantees)	0.22 [c]	0.18
Timing of peak performance index	A measurement of how quickly the program was able to begin functioning at its best and the length of time this best functioning period lasted. Higher index scores indicate longer lengths of time the program functioned at its best and shorter lengths of time between program launch and when the program began to function at its best (variable is based on self-reported data)	1.58 [b]	0.14
Constraints on energy use and savings opportunities index	A measurement of the weather patterns (as indicated by the average yearly numbers of heating degree days and cooling degree days) and the average age of housing stock in grantee's service area. Higher index scores indicate older housing stock and colder climates	1.43 [b]	0.11
State-level average electricity cost (cents per kWh)	The average electricity cost (in cents per kWh) for the state the program operated in	1.26 [b]	0.10
Population size of grantee's service area	The number of single-family homes (1-unit attached, 1-unit detached, and mobile homes) in grantee's service area	1.00 [b]	0.10
At least one program staff member had 15 years or more of relevant previous experience	At the time of program launch, at least one program staff member had 15 years or more of previous experience in at least one of the following areas: program design, program implementation, building trades or green building (other than program implementation), financial institution engagement or involvement, or managing federal grants and funds	4.61 [b]	0.09
Number of audit types offered	The number of the following audit types offered by the program (range of 0-4): online, walk-through, in-depth, other, or none	2.21 [a]	0.07

[a] $p < .1$; [b] $p < .05$; [c] $p < .01$; [d] $p < .001$

While there were several significant bivariate predictors of being in the most successful cluster, *direct install options offered* exhibited the strongest bivariate relationship with the most successful dependent variable; explaining more than one-quarter of the variance in the dependent variable (as evidenced by a R-square value of 0.28). Thus, about one-quarter of a grantee's likelihood of being in the most successful cluster is due to their offering of direct install options. Further, the magnitude of this variable's effect on the likelihood of being in the most successful group was also substantially larger than any other predictor presented in Table 4-3; grantees that offered direct install options were nearly 13 times more likely to be in the most successful cluster than grantees that did not (as evidenced by an odds ratio of 12.85). Finally, we have the highest confidence in this relationship (as compared to the other bivariate relationships exhibited in Table 4-3), as *direct install options offered* was the only bivariate predictor of being in the most successful group that had a p value less than .001. Basic descriptive statistics help illustrate the strength of the relationship between grantee success and direct install activities: 75% of grantees in the most successful group offered direct install options, compared to only 11% of average- and 43% of least successful grantees.

After identifying meaningful ($p < .1$) bivariate predictors of membership in the most successful group, we conducted multivariate logistic regression analysis using those predictors. We employed the following stepwise approach to multivariate regression. Going in order from highest bivariate R-square value to lowest, we entered bivariate predictors of most successful group membership one at a time into a multivariate regression model. After each subsequent addition, we would retain significant ($p < .05$) predictors and remove any insignificant variables for the next variable entry iteration. We continued this iterative process until all previously identified bivariate predictors had been tested in the multivariate model. It quickly became apparent that three particular variables collectively predicted most successful cluster membership, at which point our iterations simply entailed adding and subsequently removing the rest of the independent variables one at a time (as no other variables ultimately retained significance nor explained away any of the three significant predictors when added to the model). As a result, our multivariate regression tables reported in this volume start with the "final model" (Model 1), and then subsequently demonstrate how the other previously meaningful ($p < .1$) predictors are no longer meaningful or significant once they are included in a multivariate model with the three primary predictors of most successful cluster membership (Table 4-4 and Table 4-5).[13] Since all of these models do not fit on one page, we divided the models into two tables: one exhibiting the effect of adding exogenous controls (Table 4-4) and one demonstrating the effect of adding additional programmatic elements to the model (Table 4-5). The interpretation of the multivariate regression results are as follows.

Multivariate modeling reveals *offering multiple pathways to participation and achievement of energy savings* is critical to achieving the most successful program outcomes, regardless of other program elements or exogenous factors. Specifically, programs that include direct install options, offer multiple audit types, and allow larger numbers of contracting firms to perform upgrades are more likely to be in the most successful cluster. Further, these elements are predictors of being in the most successful group net of exogenous control variables, suggesting that offering multiple pathways to participation and achievement of energy savings ensure program success, regardless of the population size, energy costs in a program's service region, or housing stock- and weather-oriented constraints on energy use and savings opportunities (Table 4-4).[14]

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13 However, there is one exception: while *program administered by a governmental organization* retained a meaningful ($p < .1$) p value after being added to the variables included in Model 1, it did not meet the threshold used in this study for statistically significant ($p < .05$) multivariate findings.

14 Multivariate modeling demonstrates the number of eligible upgrade contractors as a predictor of most success is not a function of population size; thus, population size is not confounding this relationship.

Table 4-4: Multivariate Logistic Regression Modeling of Most Successful Cluster Membership, Testing Additions of Exogenous Controls (n = 54)

VARIABLE	MODEL						
	1	2	3	4	5	6	7
Constraints on energy use and savings opportunities index	—	1.43 b	1.06	—	—	—	—
State-level average electricity cost (cents per kWh)	—	—	—	1.26 b	1.3	—	—
Population of grantee's service area	—	—	—	—	—	1.00 b	1.00
Direct install options offered	24.82 d	—	21.12 d	—	25.43 d	—	24.72 d
Number of audit types offered	3.89 b	—	3.68 b	—	4.75 b	—	3.92 b
Number of eligible upgrade contractor firms	1.02 c	—	1.02 c	—	1.02 a	—	1.02 b
Wald test	11.81 c	3.74 a	12.04 b	4.157 b	11.54 b	3.58 a	11.94 b
Tjur's R^2	0.55	0.11	0.56	0.10	0.61	0.10	0.58

Note: Cells lacking numerical values indicate the variable corresponding to that row was not included in the model corresponding to that column.

[a] *p* < .1; [b] *p* < .05; [c] *p* < .01; [d] *p* < .001

Further, multivariate modeling demonstrates that program elements associated with providing multiple pathways to participation and *achievement of energy savings* are the key programmatic predictors of belonging to the most successful cluster, as other programmatic elements (specifically: savings threshold requirements, ramp-up time, the peak performance index, and staff experience) were no longer significant when included in multivariate models alongside the *multiple pathways* indicators (Table 4-5). Additionally, we explored interaction effects with the three independent variables in Model 1, to assess if the effect of *direct install options offered* was modified by either *number of audit types offered* or *number of eligible upgrade contractor firms*. The resulting analysis demonstrated that the independent variables in Model 1 did not interact with each other and thus did not modify the effect of *direct install options offered*.

Table 4-5: Multivariate Logistic Regression Modeling of Most Successful Cluster Membership, Testing Additions of Programmatic Elements (n = 54)

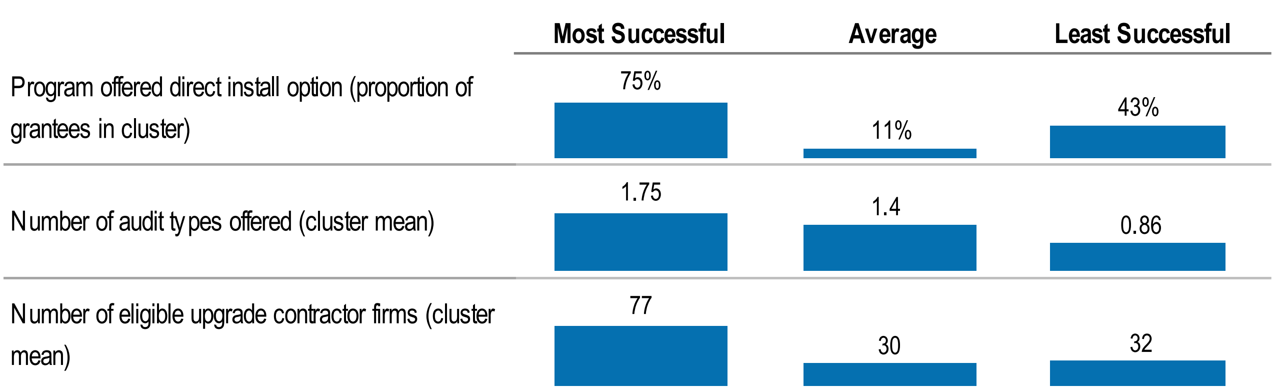
VARIABLE	MODEL								
	1	8	9	10	11	12	13	14	15
Savings threshold required for qualified projects	—	.13[c]	0.26	—	—	—	—	—	—
Ramp up time	—	—	—	0.22[c]	0.39	—	—	—	—
Timeliness index	—	—	—	—	—	1.58[b]	1.47	—	—
At least one team member had 15 years or more of relevant previous experience	—	—	—	—	—	—	—	4.61[b]	1.82
Direct install options offered	24.82[d]	—	17.80[c]	—	22.32[d]	—	27.67[d]	—	18.14[d]
Number of audit types offered	3.89[b]	—	4.37[b]	—	3.86[b]	—	4.12[b]	—	3.77[b]
Number of eligible upgrade contractor firms	1.02[c]	—	1.02[c]	—	1.02[b]	—	1.02[b]	—	1.02[c]
Wald test	11.81[c]	8.17[c]	11.45[b]	5.95[b]	12.09[b]	4.91[b]	11.65[b]	3.82[a]	12.40[b]
Tjur's R^2	0.55	0.19	0.58	0.18	0.59	0.14	0.60	0.09	0.56

Note: Cells lacking numerical values indicate the variable corresponding to that row was not included in the model corresponding to that column.

[a] $p < .1$; [b] $p < .05$; [c] $p < .01$; [d] $p < .001$

As seen in Figure 4-2, grantees in the most successful cluster were more likely to offer direct install options and had more audit type offerings and higher numbers of eligible upgrade contractor firms, on average, than average and least successful grantees.

Figure 4-2: Descriptive Statistics for Variables Predicting Most Successful Cluster Membership in Model 1 (n = 54)



5. FINDINGS

Our analyses of grantee accomplishments during the three-year BBNP evaluation period suggest residential energy efficiency programs can mitigate poor performance outcomes by providing contractor training opportunities and, further, can achieve successful program outcomes by offering homeowners multiple pathways through which they can engage with the program and achieve energy savings. This chapter explores how these programmatic elements may contribute to program success.

5.1. AVOIDING POOR PERFORMANCE VIA CONTRACTOR TRAINING

In order to deliver residential energy efficiency services effectively, programs rely on contractors with the skills needed to sell and perform the audit and upgrade work (State and Local Energy Efficiency Action Network Residential Retrofit Working Group, 2011). However, some regions may lack a sufficiently large base of qualified contractors with experience and expertise in energy efficiency building science. Further, grantee experience suggest that even when a strong contractor base exists in a region, participating contractors can benefit from sales training, technical training, and training on program processes and requirements. Several studies support these findings. For example, one study found that contractors believed BPI certification was often a strong selling point when attempting to attract customers, and a report from SEE Action found it is imperative to offer sales training to contractors because of the important role they play in outreach (GDS Associates, Inc., 2009; State and Local Energy Efficiency Action Network Residential Retrofit Working Group, 2011). Given these benefits, programs have frequently found contractors to be extremely interested in program-related training (Energy Market Innovations, Inc., 2012; NMR Group, Inc., 2012).

Thus, contractor training is a critical step to successfully delivering program services. Without contractor training, residential energy efficiency programs may suffer from lackluster results; the least successful grantees – who were significantly less likely to offer training than average and most successful grantees – achieved comparably lower market penetration, energy savings, and progress toward upgrade count goals than more successful grantees. Further, the least successful grantees had higher program costs per upgrade than average and most successful grantees; combining these findings on cost and training, we speculate these higher costs may owe in part to a lower quality contractor base that ineffectively or inefficiently delivered audit and upgrade services.

5.2. CRAFTING SUCCESSFUL PROGRAMS BY OFFERING MULTIPLE PATHWAYS TO PARTICIPATION AND ACHIEVEMENT OF ENERGY SAVINGS

The results of the regression analysis demonstrate the importance of offering multiple pathways to participation and achievement of energy savings in order to achieve the most successful program outcomes. Allowing participants to enter the program and achieve energy savings in a variety of ways makes participation easier for customers and takes advantage of the strengths of various program design structures, while mitigating their limitations. Specifically, our regression analyses suggest providing multiple audit types, direct install options, and larger numbers of contracting firms that can perform upgrades are key components of the most successful residential upgrade programs. These three elements constitute multiple pathways to participation and achievement of energy savings; the following sections further explore the benefits associated with these specific predictors of successful program outcomes.

5.2.1. OFFERING MULTIPLE AUDIT TYPES

Offering multiple audit types, such as online, mail-in, phone-based, walk-through, or in-depth, provides potential participants with a variety of ways to begin engaging with a program and identifying ways that they can save energy. Since certain audit types may be more appropriate for or appealing to different homeowners, offering multiple audit types successfully accommodates potential participants' varying wants and needs.

Further, prior research has shown that "there is no…'correct' model of retrofit decision-making… Nor is such a model likely to emerge in the future. Like most other types of behavior, energy related decision-making is multi-faceted" (Sanstad et al., 2010). Thus, offering prospective participants multiple audit types increases the types of customers appealed to, thus potentially increasing program-wide participation and conversion rates.[15]

While in-depth audits – which typically use diagnostic equipment, such as blower door equipment and infrared cameras – are commonly viewed as the gold standard, studies have found similar conversion rates across various audit types (Scott, Kociolek, and Castor, 2014; EcoNorthwest, 2010).

Further, there are many benefits associated with offering less intensive audits in tandem with in-depth audits. Walk-through audits conducted by experienced contractors can identify considerable savings recommendations and identify "hot leads" in a more cost-effective manner than in-depth audits, for example. In addition, multiple grantees reported in-depth audits constituted barriers to participation due to: lack of familiarity with blower-door and infrared testing, energy modeling, and other tools typically used in in-depth audits; homeowner inability to stay home during the duration of the audit, cost to the participant (despite audit incentives); and skepticism regarding the value of audits relative to the cost.[16]

These barriers are less pertinent to less comprehensive audits, such as online, mail-in, phone-based, or walk-through audits. Skeptical or frugal homeowners may be more likely to pursue a lower cost audit option, which may be perceived as less of a financial risk. Further, costly in-depth audits may constitute an equity issue; offering lower cost audit options expands the pool of homeowners that can afford to participate, increasing the amount of program-wide savings as it facilitates the participation of the traditionally hard-to-reach low- and middle-income populations.[17]

5.2.2. PROVIDING DIRECT INSTALLATION OF LOW-COST MEASURES

Regression analyses revealed conducting direct install of low-cost measures (such as LEDs, showerheads, and faucet aerators) was the strongest predictor of membership in the most successful cluster. Grantees reported direct install options, which were often included in the audit prior to a more comprehensive upgrade project, could serve as both sources of significant energy savings as well as "sweeteners" to encourage participation in the audit or a

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15 We interpret the finding that offering multiple audit types is associated with grantee success as suggesting its value lies in increasing the types and therefore number of customers that pursue an audit. Our data provide no insight into possible variations among audit types in rates of conversion to upgrades or in resulting upgrade savings.

16 See the companion volume to this report: *Process Evaluation of the Better Buildings Neighborhood Programs* (Final Evaluation Volume 4), Chapter 4 Audits.

17 Offering free in-depth audits remedies any cost-to-participant-related barriers. However, the provision of free audits result in higher program costs. Some grantees concluded free audits lowered conversion rates; willingness to pay an audit was associated with greater likelihood of pursuing the upgrade.

subsequent upgrade project.[18] Directly installing low-cost measures during an audit allows programs to claim direct energy savings prior to a comprehensive upgrade project (as well as garnering savings from audit participants that do not pursue an upgrade project), which can increase program cost effectiveness. Direct installations also serve a quality control function, as trained building science experts, rather than homeowners, install measures and ensure that they are installed correctly. Additionally, research has found direct install activities have high customer satisfaction, may motivate customers to participate in a program who may not have participated otherwise, were associated with efficient lighting remaining in sockets longer, and were more likely than other delivery methods to result in the installation of lighting measures (Peters, Moran, and Frank, 2010).

5.2.3. ENSURING A LARGE NUMBER OF CONTRACTORS ARE ELIGIBLE TO CONDUCT UPGRADES

Having a large number of firms that are eligible to complete program upgrade projects makes it easier for participants to find a qualified contractor; in addition, some participants may appreciate the ability to shop for contractors in order to find the best quote. A recent baseline study of a whole house retrofit program in California found most homeowners who had recently completed renovation projects costing at least $3,000 (including participants and nonparticipants from various energy efficiency programs) chose contractors that they had previously worked with, had prior relationships with, or found via word of mouth (DNV GL, 2014). Additionally, the study found that only about half of those completing renovations contacted more than one contractor. Since homeowners primarily rely on existing relationships and referrals when selecting upgrade contractors, having a large number of contractors eligible to conduct upgrades increases the probability that a homeowner's preferred contractor is performing upgrades through the program, which, in turn, increases the likelihood that a homeowner will complete an upgrade project through their local energy efficiency program. Moreover, having a large number of eligible contracting firms maximizes the number of projects that can be conducted at a given time. Increased numbers of eligible contractors also can magnify program and energy efficiency upgrade awareness via contractor-led advertising and outreach efforts.[19] These findings suggest increases in the number of eligible upgrade contracting firms can result in more program-wide energy savings.

Programs seeking to maximize the number of eligible upgrade contractors have a variety of avenues for doing so. Since contractors may be deterred from participating in programs that are overly complex and burdensome, easing the contractor experience (such as simplifying and minimizing participation steps and paperwork) may help increase the number of contractors seeking program eligibility. Further, program-to-contractor outreach can raise awareness of the program among nonparticipating contractors, which could in turn increase contractor participation. However, we caution program administrators against relying on overly lax contractor eligibility criteria, which may maximize the number of eligible contractors, yet reduce the project quality on average. While proper quality assurance (QA) and

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18 As stated, the success strategy of direct measure installation was typically coupled with onsite audits. However, grantee experience suggests the strategy is not limited to onsites; a few grantees directly installed measures at times other than onsite audits.

19 Residential nonparticipant awareness of their local BBNP program was significantly higher among the most successful grantees (37%) than among average (32%) and least successful grantees (21%). About one-quarter of surveyed residential participants reported learning about the program from their contractors (compared to 66% for publicity sources such as advertising and 37% for program sources). See the companion volume *Market Effects of the Better Buildings Neighborhood Program* (Final Evaluation Volume 5).

quality control (QC) techniques could minimize quality of work issues, our regression analysis demonstrates programs should provide training opportunities for their contractors in order to avoid sub-par program outcomes. Thus, large pools of trained eligible upgrade contractors are key to the most successful programs.

6. CONCLUSIONS AND RECOMMENDATIONS

This study defined and quantified a multi-faceted measurement of relative residential program success among BBNP grantees during the three-year evaluation period (Q4 2010 to Q3 2013) and statistically identified factors associated with achieving success. Using LPA as an exploratory technique, our analyses sought to identify groups, or clusters, of grantees that differed meaningfully in their performance on 12 metrics of program success. Results of the LPA revealed grantees clustered into three groups, and our analysis of each group's performance on the 12 performance metrics demonstrated that one group generally performed best on each of the metrics, another group generally performed worst on the metrics, and a third group demonstrated mid-range values on the performance metrics. Regression analyses demonstrated four programmatic elements predict cluster membership.

Specifically, our regression analyses revealed that not providing contractor training was the strongest predictor of membership in the least successful cluster, and program designs that allowed for multiple pathways to participation and achievement of energy savings predicted membership in the most successful cluster. Regression results identified the following as critical components of multiple pathways to participation and achievement of energy savings: offering direct install options and multiple audit types, and having a large number of eligible contractors than can perform upgrades. Since this study analyzed program data from 54 diverse grantees and subgrantees spanning widely varied regions and demonstrated that exogenous elements neither explained nor confounded variation in success, the statistical findings are particularly insightful for the energy efficiency industry as they elucidate what can make or break a residential program regardless of broader contextual factors. The importance of the factors identified in this research also is supported by the fact that grantee success was not driven by whole home program experience prior to the grant period.

Further demonstrating the value of this volume's findings, the regression results are intuitive, reinforced by other qualitative and quantitative grantee findings, and supported by the literature. Our rigorous analysis of a wealth of information confirms many program design and implementation approaches identified as effective by the industry literature and program administrator experiences. The findings provide the energy efficiency community with greater confidence in its understanding of how to make residential upgrade programs successful.

Based on the conclusions presented above, we offer the following recommendations for designing and implementing successful comprehensive residential energy efficiency upgrade programs.

- **Provide contractor training.** Program administrators should ensure contractors wanting to participate in the program have access to a variety of training. There should be distinct training opportunities for both auditors and installers. In addition to training that aims to develop and bolster technical expertise in energy efficiency building science, contractor training courses should also cover "making the sale" as well as program rules and processes. Program administrators might also consider training or support related to running a business.
- **Offer multiple pathways to participation and achievement of energy savings.** Programs administrators should ease participant's ability to navigate the program by offering participants multiple ways in which they can begin engaging with the program and multiple avenues by which they can achieve energy savings. More specifically:
    - **Incorporate direct install activities into program designs.** Program administrators seeking to maximize energy savings, cost effectiveness, participation rates, and conversion rates should offer

direct install measures to participants. Programs may find in-home audits an ideal opportunity to achieve noteworthy energy savings and encourage further participation in a comprehensive retrofit project via directly installing energy saving measures.

- **Offer multiple types of audits.** Program administrators should offer multiple audit types of varying complexity, as some participants may be unwilling to have an in-depth audit performed in their home yet may be open to a less invasive and lower cost option. Thus, in addition to in-depth audits, programs may benefit from offering less comprehensive audits, such as online, mail-in, telephone, and walk-through audits. Offering less comprehensive audit types – as well as in-depth audits – may expand the number of participants that engage with the program, particularly among low- to moderate-income households. Further, some participants that begin with a less comprehensive audit may later decide to pursue an in-depth audit.
- **Ensure a large number of upgrade contractor firms are eligible to conduct program upgrades.** Program administrators seeking substantial market penetration and participation rates may benefit from having a large number of contractors eligible to perform upgrades through the program. This approach ensures that there is a sufficient number of qualified tradespeople available to serve a program's region and may result in increased uptake via contractor-led advertising efforts and contractors' pre-existing relationships with homeowners. In order to maximize the number of participating contractors, programs should minimize the programmatic burden on participating contractors (such as simplifying and minimizing participation steps and paperwork), conduct outreach to nonparticipating contractors, and minimize criteria that unduly limit contractor eligibility. Note that a policy of encouraging broad contractor participation must be accompanied by strategies to ensure work quality, including training and the execution of effective QA/QC protocols.

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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 Resources 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
Seattle, WA	$20,000,000
Southeast Energy Efficiency Alliance	$20,000,000

Continued…

GRANTEE NAME	TOTAL GRANTED
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
Kansas City, MO	$20,000,000
State of Maryland	$20,000,000
Portland, OR	$20,000,000
Seattle, WA	$20,000,000

Continued…

GRANTEE NAME	TOTAL GRANTED
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
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. METHODOLOGY

This appendix provides additional details on our analysis of factors that predict success for comprehensive residential energy efficiency upgrade programs. Specifically, we describe the steps that we took to identify elements and predictors of program success, to clean and verify data, to determine how Better Buildings Neighborhood Program (BBNP) grantees varied in programmatic success, and to assess what grantee and program characteristics predict success.

Three BBNP grantees, Boulder County, LA County, and the Southeast Energy Efficiency Alliance, had programs available in multiple geographic areas that were implemented by subgrantees. We chose to examine program success at the subgrantee level to capture the full diversity of program models, outcomes, and market characteristics. Further, we conducted analyses of program success for the single-family residential sector due to greater availability of data than for the nonresidential and multifamily sectors. The final set of programs included in these analyses included 54 grantees and subgrantees.

B.1. INPUTS FOR PREDICTING GRANTEE SUCCESS

B.1.1. PERFORMANCE METRICS AND RATIONALE

The first goal of our analysis was to develop quantitative metrics representing program success. We used the following three steps to address this goal:

- Step 1: Identify elements of whole-home energy efficiency upgrade program success;
- Step 2: Operationalize and propose meaningful metrics for each element of success to U.S. Department of Energy (DOE); and
- Step 3: Conduct data quality investigations and internal peer review of metrics to determine whether each proposed metric could or should be included in the subsequent analyses.[20]

Table B-1 presents our three-step approach and provides the final metrics used in the success analyses, which we discuss in Section B.3 below. We were unable to use some of the proposed metrics, as some of them suffered from data quality or availability issues or were determined to be out of the study's scope; these unused metrics are given in italic font in Table B-1 and include a description of the reason for not being used.

[20] The evaluation advisory team, a group of experts within the energy efficiency industry, reviewed and contributed to the metrics.

Table B-1: Identifying Metrics of BBNP Success

PROPOSED METRICS Metrics Presented in Italics Were Not Used In The Analyses	DATA QUALITY STATUS AND REVIEWERS' COMMENTS
ELEMENT OF SUCCESS: Achieving market penetration and saturation of whole home energy efficient upgrades	
AWARENESS METRICS:	
a. Nonparticipant awareness (percent of nonparticipants aware of the program)	*Was determined to be more appropriate as a predictor variable, discussed elsewhere in report*
b. Contractor awareness (percent of contractors aware of the program)	*Data not available for a large enough sample of grantees, discussed elsewhere in report*
c. Participant awareness of eligible contractors (percent participants aware of how to find qualified upgrade contractors)	*No data*
PROGRAM/MARKET SATURATION METRICS:	
a. Market penetration of program's upgrades (ratio of upgrades completed to eligible households in the grantee's target area)	
b. Program's progress toward goal (ratio of upgrades completed to upgrade target)	
c. Market penetration of audits (ratio of audits completed eligible households in the grantee's target area)	*Data quality issues for audits, discussed elsewhere in report*
d. Market penetration of whole home upgrades (ratio of whole home energy efficiency upgrades completed to eligible households in the grantee's target area)	*No data*
e. Market penetration of upgrades over time (longitudinal analysis of ratio of upgrades to eligible households in the grantee's target area)	*Beyond the scope of the analysis*
f. Market penetration of upgrades over time (longitudinal analysis of upgraded and non-upgraded homes in the sales and rental markets)	*Beyond the scope of the analysis*
SPILLOVER BEHAVIOR METRICS:	
a. Spillover among participants (percent of program participants who completed un-incented energy efficiency upgrades that they reported were motivated by the grantee's program)	*Data not available for a large enough sample of grantees, discussed elsewhere in report*
b. Spillover among contractors (percent of participating contractors who changed their standard practices because of the grantee's program)	*Data not available for a large enough sample of grantees, discussed elsewhere in report*
c. Spillover among nonparticipants (proportion of nonparticipants in the grantee's target market who completed energy efficient upgrades they reported were motivated by the grantee's program)	*Data not available for a large enough sample of grantees, discussed elsewhere in report*

Continued…

PROPOSED METRICS Metrics Presented in Italics Were Not Used In The Analyses		DATA QUALITY STATUS AND REVIEWERS' COMMENTS
MARKET PERCEPTION METRICS:		
a.	*Contractors' market perceptions (percent of contractors who perceive energy efficiency upgrades to be a profitable line of business)*	*No data*
PROGRAM COST METRICS:		
a.	Program cost per upgrade (ratio of program costs (award amount devoted to residential program offerings) to number of upgrades completed)	
b.	Program cost per MMBtu saved (ratio of program cost to total site MMBtu saved)	
c.	Program's savings-to-investment ratio (SIR; ratio of program-wide present value of lifetime cost savings to program cost)	
d.	Total program-wide present value of lifetime cost savings (total program-wide annual energy savings multiplied by the net present value factor)	
e.	Program's per-upgrade average of present value of lifetime savings(ratio of program-wide present value lifetime cost savings to number of upgrades)	
f.	Program cost per dollar of work invoiced (ratio of program costs to total invoiced upgrade cost)	
g.	*Total cost (program, participant, other funds) per upgrade (ratio of total costs to number of upgrades completed)*	*No data*
h.	*BBNP cost per dollar of work invoiced (ratio of BBNP expenditure to total invoiced upgrade costs)*	*No way to determine with existing data*
i.	*Participant cost per dollar of work invoiced (ratio of upgrade cost paid by participants to total invoiced upgrade costs)*	*A possible explanatory variable for success; not relevant as a metric of what constitutes success*
j.	*Non-BBNP expenditures per program expenditures (ratio of sum of non-BBNP federal, non-federal, and capital for lending to total expenditures)*	*No data*
k.	*Proportion of program costs spent on individual program elements (ratios of administrative, marketing, incentive, and other costs to total program costs)*	*Data quality issues for cost breakdowns across program elements*
l.	*Ratio of net estimated energy savings to gross estimated energy savings*	*Redundant with other metrics*
m.	*Total resources cost (TRC)*	*No data*

Continued…

PROPOSED METRICS Metrics Presented in Italics Were Not Used In The Analyses	DATA QUALITY STATUS AND REVIEWERS' COMMENTS
ELEMENT OF SUCCESS: Providing efficient, cost-effective services	
PROGRAM EFFECTIVENESS METRICS:	
a. Program's average MMBtu savings per project (ratio of total site MMBtu saved to number of projects)	
b. Percent of program's projects meeting comprehensiveness proxy (see Comprehensiveness B.2.3)	
c. Audit conversion rate (ratio of upgrades to audits)	*Data quality issues for audits, discussed elsewhere in report*
FUTURE PLANS METRICS:	
a. Grantee plans at the end of Quarter 3 2013	*Not quantifiable for statistical analysis, discussed elsewhere in report*
b. Whether grantee has established long-term funding	*Not quantifiable for statistical analysis, discussed elsewhere in report*
ELEMENT OF SUCCESS: Being sustainable in the long-term	
CONSUMER SATISFACTION METRIC:	
a. Participants' average self-reported satisfaction with program services	*Data not available for a large enough sample of grantees, discussed elsewhere in report*
ENGAGING MARKET ACTORS METRICS:	
a. Number of program partners engaged in promotion of program services	*Redundant with other metrics*
b. Depth of actor engagement (ratio of participating contractors to total number of contractors in the grantee's target area)	*Data not available for a large enough sample of grantees*
c. Average number of contractor training events per year	*Data quality issues for contractor training*
d. Number of trained workers	*Data quality issues for contractor training*
e. Contractors' average self-reported ratings of the effectiveness of training	*Data not available for a large enough sample of grantees*
SCALABILITY METRICS:	
None identified	*Too soon to measure*
EQUITY METRIC:	
Proportion of upgrades completed in hard-to-reach segments (ratio of upgrades completed in hard-to-reach segments to total number of upgrades completed)	*No data*

Continued…

PROPOSED METRICS Metrics Presented in Italics Were Not Used In The Analyses	DATA QUALITY STATUS AND REVIEWERS' COMMENTS
PROGRAM'S WIDER ECONOMIC IMPACT METRICS:	
a. Program's total contractor job hours invoiced	
b. Program cost per contractor job hour (ratio of program costs to total contractor job hours invoiced)	
c. Economic output (IMPLAN model value of production)	*No data*
d. Number of jobs created	*Data quality issues for job creation*
e. Person-years of employment created (number of jobs created and retained)	*No data*
f. Tax revenue generated (IMPLAN values for federal, state, and local taxes)	*No data*
g. Actors' personal or business income (sum of wages and business income)	*No data*
h. Lifetime energy savings (effective useful life of equipment installed multiplied by annual energy savings)	*No data*
i. Fuel cost savings associated with energy saved	*No data*
j. Change in number of whole-home certified contractors (number of certified contractors at program end minus number of certified contractors at program start)	*No data*
ENVIRONMENTAL IMPACT METRIC:	
Avoided greenhouse gas emissions (verified energy savings multiplied by emission factor)	*No data*

B.1.2. PREDICTOR VARIABLES AND RATIONALE

We also identified grantee and program characteristics that may predict program success and developed a list of quantitative predictor variables representing these characteristics. Further, we identified market factors deemed as important control variables for multivariate regression models predicting grantee success.[21] We then assessed whether adequate data was available for each variable.

Table B-2 presents the complete list of variables we considered as predictor and control variables and displays the final set that were included in the success analyses. We were unable to use some of the proposed metrics, as some of them suffered from data quality or availability issues; these unused metrics are given in italic font in Table B-2 and include a description of the reason for not being used.

21 Control variables represent non-programmatic exogenous variables that may significantly relate to grantee success rankings (and the prerequisite inputs) but constitute elements that a grantee has no control over (such as their region's weather patterns). It is important to include control variables in multivariate regression models as they enable us to identify significant predictors of success, net of exogenous factors.

Table B-2: Identifying Meaningful Predictors of Success*

PROGRAM ELEMENT	PROPOSED METRICS *Metrics Presented in Italics Were Not Used In The Analyses*	DATA QUALITY ISSUES
Prior experience with energy efficiency programs	Whether program was based on a prior energy efficiency program or pilot (yes/no)	
	Proportion of audit contractors with prior energy efficiency program experience	
	Proportion of upgrade contractors with prior energy efficiency program experience	
	Number of years of relevant experience among most experienced staff members in the following areas: program design, program implementation, building trades or green building (other than program implementation), financial institution engagement or involvement, or managing federal grants and funds	
	Whether program was in an area where existing energy efficiency programs were present (yes/no)	*No data*
Ramp-up time	Time between grant award date and when program was functioning at its best	
	Time between program launch and when program was functioning at its best	
	Length of time program functioned at its best	
Program administration and design	Ratio of program funding to target population	
	Whether the program was administered by a governmental organization	
	Number of organizations that coordinated to deliver program elements	
	Whether a third party program evaluation was conducted during the grant period (yes/no)	
	Whether the grantee targeted the low income sector (yes/no)	
	BBNP program manager	
	Number of residential programs worked with	
	Whether audits and upgrades were conducted by the same contractor (yes/no)	*No data*
	Proportion of total program funds provided by BBNP	*No data*
	Whether program hired an implementer (yes/no)	*Not quantifiable for statistical analysis*

Continued…

PROGRAM ELEMENT	PROPOSED METRICS *Metrics Presented in Italics Were Not Used In The Analyses*	DATA QUALITY ISSUES
Marketing and outreach	Whether program hired a marketing contractor (yes/no)	
	Count of mailers and other marketing materials	*Data quality issues for marketing efforts*
	Overall population size subject to market outreach efforts	*No data*
	Whether a community-based organization served as an outreach partner	*No data*
	Whether program engaged in community outreach	*Not quantifiable for statistical analysis*
Financing	Whether grantee had a preexisting relationship with a financing institution they approached about offering financing (yes/no)	
	Whether participants had the ability to repay loans via on-bill or PACE (yes/no)	
	Proportion of upgrades financed with loans	
	Average interest rate of loans made to participants, compared with average interest rates in grantee territory	*No data*
	Whether grantees had more relaxed qualification criteria for program participants than is typically offered (yes/no)	*Data not available for a large enough sample of grantees*
Audits	Type(s) of audits conducted (online, walk-through, comprehensive, or other)	
	Number of audit types offered	
	Average audit cost	
	Whether assessments were conducted by upgrade contractors (yes/no)	
	Whether grantee required audits (yes/no)	*No data*
	Whether contractors received a flat fee for audits (yes/no)	*No data*

Continued…

PROGRAM ELEMENT	PROPOSED METRICS *Metrics Presented in Italics Were Not Used In The Analyses*	DATA QUALITY ISSUES
Upgrades	Whether an energy coach was available to participants (yes/no)	
	Type of energy coach available to participants (none, passive, active)	
	Direct install options offered (yes/no)	
	Savings threshold required for qualified projects (yes/no)	
	Proportion of upgrades performed by new contractors that were inspected by the program	
	Proportion of upgrades performed by experienced contractors that were inspected by the program	
	Average rebate amount	*Data quality issues for incentives/rebates*
Contractors	Any contractor training offered (yes/no)	
	Any upgrade contractor training offered (yes/no)	
	Upgrade contractor program training offered (yes/no)	
	Upgrade contractor sales training offered (yes/no)	
	Upgrade contractor business training offered (yes/no)	
	Any auditor training offered (yes/no)	
	Auditor program training offered (yes/no)	
	Auditor sales training offered (yes/no)	
	Auditor business training offered (yes/no)	
	Any program training offered (yes/no)	
	Any sales training offered (yes/no)	
	Any business training offered (yes/no)	
	Count of training types offered (yes/no)	

Continued…

PROGRAM ELEMENT	PROPOSED METRICS *Metrics Presented in Italics Were Not Used In The Analyses*	DATA QUALITY ISSUES
	Number of firms eligible to conduct audits	
	Number of eligible upgrade contractor firms	
	Proportion of audit contractors with high skills	
	Proportion of upgrade contractors with high skills	
	Proportion of projects conducted by BPI-certified contractors	*No data*
Nonparticipants and Spillover	Percent of nonparticipants that were aware of grantee's program	
	Average rated influence of grantee's program on recent nonparticipant energy efficiency upgrades	
	Average rated influence of grantee's program on planned nonparticipant energy efficiency upgrades	
Market factors (control variables)	Average age of housing stock in grantee's target area	
	State-level energy efficiency funding per capita	
	State Energy Efficiency Scorecard Score	
	Education level in grantee's target level Percent with a high school degree Percent with a bachelor's degree	
	Unemployment rate in grantee's target area	
	Median income in grantee's target area	
	Population of grantee's service area	
	Percent of population in grantee's target area living in an urban area	
	State-level average electricity cost (cents per kWh)	
	Weather (heating degree days and cooling degree days)	

* While the list above presents all concepts included in predictor variables, we computed multiple versions of some predictor variables (such as recoding predictor variable bins or computing indexes from multiple variables). Thus, the number of predictor variables tested exceeds the number of non-grey rows presented above.

B.2. DATA SOURCES AND PREPARATION

We compiled data for the analyses from sources provided by U.S. Department of Energy (DOE), survey and interview data collected by us, relevant web sources, and third-party evaluations of grantee programs that occurred during the BBNP grant period. All data represent program activities through the Third Quarter of 2013. Table B-3 and Table B-4 provide summaries of the data sources and elements used to create the performance metrics and predictor variables, respectively.

Table B-3: Summary of Data Elements and Data Sources for Associated Performance Metrics

DATA ELEMENTS	DATA SOURCES	ASSOCIATED METRICS
Count of single-family upgrade projects	BBNIS project-level database	Market penetration of upgrades; Progress toward goal; Program cost per upgrade; Average MMBtu savings per project
Total single-family site-level MMBtu savings	BBNIS project-level database	Program cost per upgrade; Program cost per MMBtu saved; Average MMBtu savings per project; Program cost per job hour created
Total single-family upgrade invoiced cost	BBNIS project-level database	Program cost per dollar of work invoiced
Total single-family job hours	BBNIS project-level database	Total contractor job hours invoiced; Program cost per job hour created
Total non-single-family site-level MMBtu savings	BBNIS project-level database	Program cost per upgrade; Program cost per MMBtu saved; Program cost per job hour created
Installed single-family measures	BBNIS project-level database	Comprehensiveness
Count of single-family target upgrades	DOE Grantee Quarterly Upgrade Targets Report	Progress toward goal
Total outlays	DOE Better Buildings Quarterly Summary	Program cost per upgrade; Program cost per MMBtu saved; Program cost per job hour created
Saving-to-investment ratio	DOE Performance Metrics	Savings-to-investment ratio
Present value of lifetime cost savings	DOE Performance Metrics	Present value of lifetime cost savings
Total number of upgrades (all sectors)	DOE Performance Metrics	Present value of lifetime cost savings per upgrade
Count of households in target area	U.S. Census Bureau	Market penetration of upgrades

Table B-4: Summary of Predictor Variables and Associated Data Sources

PROGRAM ELEMENT	PREDICTOR VARIABLES	DATA SOURCES
Prior experience with energy efficiency programs	Whether program was based on a prior energy efficiency program or pilot	Grantee web survey
	Proportion of audit contractors with prior energy efficiency program experience	Grantee web survey
	Proportion of upgrade contractors with prior energy efficiency program experience	Grantee web survey
	Number of years of relevant experience among most experienced staff members in the following areas: program design, program implementation, building trades or green building (other than program implementation), financial institution engagement or involvement, or managing federal grants and funds	Grantee web survey
Ramp-up time	Time between grant award date and when program was functioning at its best	Grantee web survey
	Time between program launch and when program was functioning at its best	Grantee web survey
	Length of time program functioned at its best	Grantee web survey
Program administration and design	Ratio of program funding to target population *(individual data elements below)*	
	Single-family total site-level MMBtu savings	BBNIS project-level database
	Non-single-family total site-level MMBtu savings	BBNIS project-level database
	Total outlays	DOE Better Building Quarterly Summary
	Count of households in target area	U.S. Census Bureau
	Whether the program was administered by a governmental organization	Coded from qualitative sources
	Number of organizations that coordinated to deliver program elements	Grantee web survey
	Whether a third party program evaluation was conducted during the grant period	Coded from qualitative sources
	Whether the grantee targeted the low income sector	Grantee web survey
	BBNP program manager	DOE Salesforce database
	Number of residential programs worked with	Grantee web survey

Continued…

PROGRAM ELEMENT	PREDICTOR VARIABLES	DATA SOURCES
Marketing and outreach	Whether program hired a marketing contractor	Grantee web survey
Financing	Whether grantee had a preexisting relationship with a financing institution they approached about offering financing	Grantee web survey
	Whether participants had the ability to repay loans via on-bill or PACE	Coded from qualitative sources
	Proportion of upgrades financed with loans	BBNIS project-level database
Audits	Type(s) of audits conducted (online, walk-through, comprehensive, or other)	Grantee web survey
	Number of audit types offered	Grantee web survey
	Average audit cost (individual data elements below)	
	Single-family total audit invoiced cost	BBNIS project-level database
	Count of single-family upgrade projects	BBNIS project-level database
	Whether assessments were conducted by upgrade contractors	Coded from qualitative sources
Upgrades	Whether an energy coach was available to participants	Coded from qualitative sources
	Type of energy coach available to participants (non, passive, active)	Coded from qualitative sources
	Direct install options offered	Grantee web survey
	Savings threshold required for qualified projects	Grantee web survey
	Proportion of upgrades performed by new contractors that were inspected by the program	Grantee web survey
	Proportion of upgrades performed by experienced contractors that were inspected by the program	Grantee web survey

Continued…

PROGRAM ELEMENT	PREDICTOR VARIABLES	DATA SOURCES
Contractors	Any contractor training offered	Grantee web survey
	Any upgrade contractor training offered	Grantee web survey
	Upgrade contractor program training offered	Grantee web survey
	Upgrade contractor sales training offered	Grantee web survey
	Upgrade contractor business training offered	Grantee web survey
	Any auditor training offered	Grantee web survey
	Auditor program training offered	Grantee web survey
	Auditor sales training offered	Grantee web survey
	Auditor business training offered	Grantee web survey
	Any program training offered	Grantee web survey
	Any sales training offered	Grantee web survey
	Any business training offered	Grantee web survey
	Count of training types offered	Grantee web survey
	Number of firms eligible to conduct audits	Grantee web survey
	Number of eligible upgrade contractor firms	Grantee web survey
	Proportion of audit contractors with high skills	Grantee web survey
	Proportion of upgrade contractors with high skills	Grantee web survey
Nonparticipants and Spillover	Percent of nonparticipants that were aware of grantee's program	Nonparticipant survey
	Average rated influence of grantee's program on recent nonparticipant energy efficiency upgrades	Nonparticipant survey
	Average rated influence of grantee's program on planned nonparticipant energy efficiency upgrades	Nonparticipant survey

Continued…

PROGRAM ELEMENT	PREDICTOR VARIABLES	DATA SOURCES
Market factors (control variables)	Average age of housing stock in grantee's target area	U.S. Census Bureau
	State-level energy efficiency funding per capita	American Council for an Energy-Efficient Economy (ACEEE)
	State Energy Efficiency Scorecard Score	ACEEE
	Education level in grantee's target level	
	Percent with a high school degree	U.S. Census Bureau
	Percent with a bachelor's degree	U.S. Census Bureau
	Unemployment rate in grantee's target area	U.S. Census Bureau
	Median income in grantee's target area	U.S. Census Bureau
	Population of grantee's service area*	U.S. Census Bureau
	Percent of population in grantee's target area living in an urban area	U.S. Census Bureau
	State-level average electricity cost (cents per kWh)	U.S. Energy Information Administration
	Weather (heating degree days and cooling degree days)	National Oceanic and Atmospheric Administration

* Sum of 1-unit attached, 1-unit detached, and mobile homes in grantee's geographic target area.

B.2.1. DATA DISAGGREGATION

Because DOE collected data at the prime-grantee level, we disaggregated the data to the subgrantee level (among grantees with subgrantees) for the subsequent analyses. Disaggregation methods differed across data sources. Specifically, we disaggregated data from the Better Buildings Neighborhood Information System (BBNIS) project-level database by matching project zip codes with the zip codes in each subgrantee's target area. We disaggregated other DOE data using information in reports submitted by prime grantees, including the Final Technical Reports and third party program evaluations conducted during the grant period.

We did not disaggregate savings-to-investment ratio, present value of lifetime cost savings, and present value of lifetime cost savings per upgrade to the subgrantee level or for the residential sector because we were unable to disaggregate all input data. For these variables, we assigned all subgrantees their prime grantee's program-wide value.

B.2.2. DATA CLEANING PROCEDURES & IMPUTATION METHODS

Before conducting analyses, we conducted data quality checks on all variables and cleaned and imputed data points as necessary. One subgrantee had a large proportion of missing data and was not included in the success analyses. Our data cleaning and imputation methods differed across data sources.

BBNIS Project-level Data

We observed a large number of data issues across grantees, presumably due to data entry errors. Data issues included missing data points, zero ("0") values when zero is not possible (for example, $0 invoiced cost for a project with known measure installation), and outliers. We used the following general data cleaning procedure for each variable:

1. **Validate zeros.** Using other project information in the database, we determined whether a zero ("0") value was intended to be a "0" or, instead, indicated a missing value. If the latter, we replaced the zero with a missing value.

2. **Validate missing values.** Using other project information in the database, we determined whether missing values were intended to be "0" or whether they were truly missing. We replaced missing values with a "0" if other project information suggested the former.

3. **Remove unrealistic values.** For some variables, we trimmed data that seemed unrealistic (for example, $0 - $100 for total invoiced costs). In these cases, we determined a cutoff value and assumed that all values below the cutoff value were errors and changed them to a missing value.

4. **Identify outliers.** To identify outliers, we calculated the mean and standard deviation of all validated values at the prime grantee level and within each set of subgrantees. We considered values more than 2.5 standard deviations below or above the mean to be outliers and changed them to missing values.

5. **Impute missing values.** We replaced missing values, except for those that had been outliers, with mean values. Missing values were replaced with the mean from other projects conducted with the same grantee.

Data from the Grantee Web survey

Some grantees did not complete the grantee web survey, and others did not provide responses to all questions. Our method for replacing missing data differed for categorical and continuous variables. For categorical variables and some continuous variables, we determined the correct response using information available in grantees' Final Technical Reports and third party program evaluations. For continuous variables that we were unable to impute via grantees' Final Technical Reports and third party program evaluations, we replaced prime grantees' missing responses with the overall mean across programs and replaced subgrantees' missing responses with the mean of the other subgrantees that shared their prime grantee. For categorical variables that we were unable to impute via grantees' Final Technical Reports and third party program evaluations, we replaced prime grantees' missing responses with the overall mode across programs and replaced subgrantees' missing responses with the mode of the other subgrantees that shared their prime grantee.

B.2.3. OTHER CALCULATIONS & DATA GATHERING METHODS

Variables Coded from Qualitative Sources

Some variables of interest did not exist in numeric form at the start of the analysis process (that is, there was no quantitative data representing the variables). For these variables, we coded information from in-depth interviews with program staff and financial partners, final technical reports, BBNP and program websites, and third-party program evaluations and assigned numerical values to grantees that represented the information found in these sources. In each case, one team member coded sources and assigned values to grantees and another team member checked the assigned values to confirm their accuracy.

Comprehensiveness

In order to determine the proportion of grantees' projects that were comprehensive, we created a comprehensiveness proxy metric and applied it to all projects in the BBNIS project-level database. Our comprehensiveness proxy defined projects as comprehensive if they included measures from at least five measure categories, of which at least four must be core measure categories; we define "core" as essential to the concept of a comprehensive upgrade. Table B-5 provides a summary of all the measures included in the comprehensiveness calculation, as well at each measure's category and whether or not it is a core measure.

Some measures counted toward more than one measure category. For example, heat pumps counted toward both the heating and cooling measure categories. A measure category could only count towards the comprehensiveness metric once, however, even if an upgrade included multiple measures in that measure category. For example, sealing could only contribute to the measure and core measure counts once, even if an upgrade included both air sealing and duct sealing.

Table B-5: Measures Included in the Comprehensiveness Proxy Calculation

MEASURE	MEASURE CATEGORY	CORE OR NONCORE
Installed air conditioning equipment	Cooling	Core
Conducted air conditioning tune-up	Cooling	Core
Installed boiler	Heating	Core
Installed furnace	Heating	Core
Installed HVAC upgrade	Heating	Core
Installed packaged unit for heating	Heating	Core
Installed ventilation system	Heating	Core
Conducted HVAC tune-up	Heating	Core
Installed heat pump	Heating and Cooling	Core
Installed solar thermal equipment	Domestic Hot Water	Core
Installed water heater	Domestic Hot Water	Core
Installed insulation in attic	Insulation – Attic	Core
Installed insulation in walls	Insulation – Wall	Core
Installed duct installation	Insulation – Other	Core
Installed insulation in floor and/or foundation	Insulation – Other	Core
Installed air sealing	Sealing	Core
Installed duct sealing	Sealing	Core
Installed weather stripping	Sealing	Core
Installed lighting	Lighting	Core
Installed solar photovoltaic equipment	Solar PV	Core
Installed clothes washer	Appliance	Noncore
Installed dishwasher	Appliance	Noncore
Installed freezer	Appliance	Noncore
Installed refrigerator	Appliance	Noncore
Installed doors	Other	Noncore
Installed domestic hot water insulation	Other	Noncore
Installed fireplace insert	Other	Noncore
Conducted furnace tune-up	Other	Noncore

Continued…

MEASURE	MEASURE CATEGORY	CORE OR NONCORE
Installed water conservation equipment	Other	Noncore
Installed windows	Other	Noncore
Installed radian barriers	Other	Noncore
Installed chimney liner	Other	Noncore
Installed smart strips	Other	Noncore

Residential Outlays

Total outlays are grant funds spent on marketing and outreach, labor and materials, and other program expenses incurred by the grantees. Grantees reported total outlays at the program level without disaggregating them by sector. Because analyses of program success occurred for the residential sector only, we disaggregated total outlays by sector.

To do this, we first estimated how much more it costs to achieve energy savings in the residential sector than in the nonresidential sector. Table B-6 shows the data sources and the method used in obtaining this estimate.

Table B-6: Methods for Estimating How Much More it Costs to Achieve Savings in the Residential Sector than the Nonresidential Sector

METHOD	DATA SOURCES	ESTIMATE
Obtained data on dollars spent per MMBtu saved in the residential and nonresidential sectors. Divided the residential $/MMBtu estimate by the nonresidential $/MMBtu estimate to calculate how much more it costs to achieve savings in the residential than the nonresidential sector. Averaged estimates from two data sources.	2011 natural gas and electricity savings and associated expenditures by sector from energy efficiency programs in the U.S. (CEE 2012).	It costs 1.4 times more to achieve residential savings compared with commercial savings
	2013 natural gas and electricity savings and associated expenditures by sector from energy efficiency programs in Oregon (Energy Trust 2013).	It costs 1.6 times more to achieve residential savings compared with commercial savings
	Average: 1.5	

Next, using the average estimate from Table B-6, we developed an equation to determine the proportion of grantees' total outlays used for the residential sector. The equation is as follows: Residential outlays = Total single-family site-level MMBtu savings*(Total Outlays/ [Total single-family site-level MMBtu savings] + [Total non-single-family site-level MMBtu savings/1.5]).

B.3. FACTOR AND RELIABILITY ANALYSES OF PREDICTOR VARIABLES

Our analyses of grantee success involve a relatively small number of records (grantees), which limits the number of predictor variables that a regression model can accommodate. Thus, we conducted factor analysis on the predictor and control variables as a means of data reduction. Factor analysis identifies clusters of variables that co-vary together and collectively constitute underlying constructs, which in turn informs the construction of representative index variables. Using both orthogonal (varimax) and oblique (direct oblimin) rotation techniques, we conducted principal axis factor analyses in an iterative fashion: we first included all continuous predictor and control variables in the model and removed variables until the factor analysis yielded a methodologically valid, interpretable, and theoretically sound rotated factor matrix.[22]

Ultimately, three factors emerged:

- Socioeconomic status: Higher factor scores indicate a higher proportion of the population with a bachelor's degree or more education and with a high school degree or more education, a lower proportion of the population that is unemployed, and a higher median income;[23]
- Constraints on energy use and savings opportunities: Higher factor scores indicate older housing stock, more heating degree days, and fewer cooling degree days;
- Timing of peak performance: Higher factor scores indicate longer lengths of time the program functioned at its best and shorter lengths of time between program launch and when the program began to function at its best.

Table B-7 exhibits the rotated factor matrix of the three factors mentioned above and the corresponding factor loadings. Since the factors did not significantly correlate with each other ($r < .24$) when employing an oblique rotation, we chose to use an orthogonal rotation as the final rotation method (and is represented in Table B-7).

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22 We removed variables from the factor analyses for various reasons, such as: failing to load on any factors, cross-loading on multiple factors, or loading on a factor that contained a set loading variables that were theoretically and fundamentally different. We relied on statistical literature for common interpretations of factor analysis methodological validity, namely: a minimum Kaiser-Meyer-Olkin Measure of Sampling Adequacy value of .5 and a significant ($p < .05$) value for Bartlett's Test of Sphericity.

23 We generated factor scores using SPSS's regression-based factor score option. SPSS calculated three factor scores for each grantee (one factor score per grantee for each respective factor extracted) which demonstrates their multivariate relationship with each underlying construct. However, we did not use factor scores in subsequent regression models; rather, we used indexes from the variables loading on each respective factor.

Table B-7: Rotated Factor Matrix

FACTOR LOADING	SOCIOECONOMIC STATUS FACTOR	CONSTRAINTS ON ENERGY USE AND SAVINGS OPPORTUNITIES FACTOR	TIMING OF PEAK PERFORMANCE FACTOR
Proportion of grantee's target population with a bachelor's degree or more education	0.926		
Proportion of grantee's target population with a with a high school degree or more education	0.531		
Proportion of grantee's target population that is unemployed	-0.508		
Average median income in grantee's target area	0.431		
Average cooling degree days in grantee's target area		-0.909	
Average heating degree days in grantee's target area		0.698	
Average age of housing stock in grantee's target area		0.406	
Length of time program functioned at its best (years)			0.839
Time between program launch and best functioning period (years)			-0.740

The factor analysis presented in Table B-7 informed the subsequent construction of composite indicator variables (or, indexes) for each factor extracted. We employed the following computation methods to create the three resulting index variables. First, we computed Z-scores to standardize each of the nine input variables from our factor analysis. Then, we inverted the standardized versions of all variables with negative factor loadings in the Rotated Factor Matrix (Table B-7).[24, 25] We then computed three indexes by summing the respective standardized versions of variables identified in each factor. We used these three indexes as independent variables in subsequent regression models.

24 Inverting standardized versions of variables with negative factor loading values ensures that all variables in a given index go in the same direction as their corresponding factor concept. For example: while higher values on *Length of time program functioned at its best (years)* are "good," higher values on *Time between program launch and best functioning period (years)* are "bad." Thus, inverting the standardized *Time between program launch and best functioning period (years)* values enables construction of an index that measures how "good" a grantee did on the Peak Program Performance Factor. Inversion = standardized variable * -1.

25 Instead of inverting the standardized version of *Proportion of grantee's target population that is unemployed*, we inverted the original [unstandardized] variable by subtracting each grantee's value on this variable from 1 (resulting in *Proportion of grantee's target population that is employed*) and subsequently standardized the resulting employment rate variable.

APPENDIX C. STATISTICAL DETAIL

C.1. MARGINALLY SIGNIFICANT BIVARIATE PREDICTORS OF CLUSTER MEMBERSHIP

When exploring what program characteristics predicted membership in the least or most successful cluster, respectively, we first conducted individual bivariate logistic regressions using each proposed predictor variable. Some variables were found to be marginally significant predictors of cluster membership at the bivariate level (.05 < *p* < .10), and we included them in subsequent multivariate models to examine whether they became significant predictors when other predictors also were included the model. The tables in this section provide the results of step-wise regression models using variables that were marginally significant at the bivariate level and did not achieve statistical significance (*p* < .05) when included in subsequent multivariate models.

Table C-1: Proportion of Upgrade Contractors with High Skills – Marginal Bivariate Predictor of Membership in the Least Successful Cluster (n = 54)

	MODEL 1	MODEL 2	MODEL 3
Any contractor training offered	0.04 [d]		0.05 [b]
Proportion of upgrade contractors with high skills		0.39 [a]	0.40
Wald test	9.56 [c]	2.93 [a]	9.14 [b]
Tjur's R^2	0.32	0.08	0.40

[a] *p* < .1; [b] *p* < .05; [c] *p* < .01; [d] *p* < .001

Table C-2: State-level Average Electricity Cost (Cents per kWh) – Marginal Bivariate Predictor of Membership in the Least Successful Cluster (n = 54)

	MODEL 1	MODEL 2	MODEL 3
Any contractor training offered	0.04 [d]		0.05 [c]
State-level average electricity cost (cents per kWh)		0.64 [a]	0.63
Wald test	9.56 [c]	2.58	8.98 [b]
Tjur's R^2	0.32	0.07	0.38

[a] *p* < .1; [b] *p* < .05; [c] *p* < .01; [d] *p* < .001

Table C-3: Comprehensive Audits Offered – Marginal Bivariate Predictor of Membership in the Least Successful Cluster (n = 54)

	MODEL 1	MODEL 2	MODEL 3
Any contractor training offered	0.04 [d]		0.06 [c]
Comprehensive assessments offered		0.24 [a]	0.46
Wald test	9.56 [c]	2.89 [a]	9.16 [b]
Tjur's R^2	0.32	0.06	0.34

[a] $p < .1$; [b] $p < .05$; [c] $p < .01$; [d] $p < .001$

Table C-4: State-level Energy Efficiency Funding Per Capita – Marginal Bivariate Predictor of Membership in the Most Successful Cluster (n = 54)

VARIABLE	MODEL 1	MODEL 2	MODEL 3
State-level energy efficiency funding per capita		1.03 [a]	1.02
Direct install options offered	24.82 [d]		18.91 [d]
Number of audit types offered	3.89 [b]		3.76 [b]
Number of eligible upgrade contractor firms	1.02 [c]		1.02 [c]
Wald test	11.81 [c]	2.69	12.58 [b]
Tjur's R^2	0.55	0.06	0.57

[a] $p < .1$; [b] $p < .05$; [c] $p < .01$; [d] $p < .001$

Table C-5: All Team Members Had Five Years or Less of Relevant Previous Experience – Marginal Bivariate Predictor of Membership in the Most Successful Cluster (n = 54)

VARIABLE	MODEL 1	MODEL 2	MODEL 3
All team members had five years or less of relevant previous experience		0.14 [a]	0.38
Direct install options offered	24.82 [d]		18.79 [d]
Number of audit types offered	3.89 [b]		4.00 [b]
Number of eligible upgrade contractor firms	1.02 [c]		1.02 [c]
Wald test	11.81 [c]	1.57	12.08 [b]
Tjur's R^2	0.55	0.06	0.56

[a] $p < .1$; [b] $p < .05$; [c] $p < .01$; [d] $p < .001$

Table C-6: Program Administered by a Governmental Organization – Marginal Bivariate Predictor of Membership in the Most Successful Cluster (n = 54)

VARIABLE	MODEL 1	MODEL 2	MODEL 3
Program administered by a governmental organization		0.33 [a]	0.21 [a]
Direct install options offered	24.82 [d]		19.33 [d]
Number of audit types offered	3.89 [b]		3.51 [b]
Number of eligible upgrade contractor firms	1.02 [c]		1.02 [c]
Wald test	11.81 [c]	2.71 [a]	13.49 [c]
Tjur's R^2	0.55	0.06	0.64

[a] $p < .1$; [b] $p < .05$; [c] $p < .01$; [d] $p < .001$

C.2. CLUSTER MEANS AND PROPORTIONS FOR BIVARIATE PREDICTORS OF CLUSTER MEMBERSHIP

Not all variables that were found to be significant or marginally significant predictors of cluster membership at the bivariate level retained significance when included in subsequent multivariate models with other predictors. This section displays means (for continuous variables) and proportions (for categorical variables) across the three success clusters (most successful, average, least successful) for variables that were significant or marginally significant in bivariate regression models but not in multivariate regression models.[26]

Table C-7: Cluster Means and Proportions for Bivariate Predictors of Membership in the Least Successful Cluster (n = 54)

INDEPENDENT VARIABLE	MOST SUCCESSFUL CLUSTER	AVERAGE CLUSTER	LEAST SUCCESSFUL CLUSTER
Count of training types offered (mean)	4.08	3.91	1.29
State's EE budget per capita* (mean)	28.0	17.4	21.0
Any auditor training (proportion offered)	92%	83%	29%
Any business training (proportion offered)	67%	54%	14%
Any program training (proportion offered)	100%	89%	43%

Continued…

26 In the case of training variables predicting membership in the least successful cluster, we present the cluster means and proportions as they were not tested in multivariate models (since we used *any contractor training offered* as the training variable for multivariate modeling).

INDEPENDENT VARIABLE	MOST SUCCESSFUL CLUSTER	AVERAGE CLUSTER	LEAST SUCCESSFUL CLUSTER
Any sales training (proportion offered)	83%	74%	29%
Any upgrade contractor training (proportion offered)	83%	89%	29%
Auditor program training (proportion offered)	92%	80%	29%
Auditor sales training (proportion offered)	75%	66%	14%
Upgrade contractor program training (proportion offered)	83%	83%	29%
Upgrade contractor sales training (proportion offered)	58%	69%	29%

* Marginally significant predictor at the bivariate level

Table C-8: Cluster Means and Proportions for Bivariate Predictors of Membership in the Most Successful Cluster (n = 54)

INDEPENDENT VARIABLE	MOST SUCCESSFUL CLUSTER	AVERAGE CLUSTER	LEAST SUCCESSFUL CLUSTER
Constraints on energy use and savings opportunities index (mean)	1.28	-0.35	-0.43
Ramp-up time (mean)	1.51	2.09	1.91
Timing of peak performance index (mean)	1.14	-0.42	0.13
Population of grantee's service area (mean)	1038490.33	364808.80	476531.29
Proportion of upgrade contractors with high skill level* (mean proportion)			
Most	33%	29%	71%
Some	42%	29%	14%
Few to none	25%	43%	14%
State-level average electricity cost (cents per kWh; mean)	14.00	12.22	10.70
Savings threshold required for qualified projects (proportion required)	33%	83%	71%
Comprehensive audits offered* (proportion offered)	92%	83%	57%
At least one team member had 15 years or more of relevant previous experience	83%	51%	29%
All team members had five years or less of relevant previous experience*	0%	23%	14%
Program administered by a governmental organization*	33%	57%	86%

* Marginally significant predictor at the bivariate level