NATIONAL EVALUATION OF THE ENERGY EFFICIENCY AND CONSERVATION BLOCK GRANT PROGRAM

Executive Summary

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Table of contents

List of Figures

List of Tables

Report Terms and Definitions

Activity	A project, group of projects or a program that represents one portion of the grant funding. Activities are the basic building blocks of the Program and refer to the specific actions taken by individual grant recipients. These could be a single action or project, such as installation of a high efficiency lighting system in a government facility, or development of a renewable energy generation facility. An activity may also refer to a complex retrofit of a range of measures in one or more buildings implemented under one portion of grant funding. Or finally, particularly in the case of Indirect Grants, an activity could consist of multiple actions funded by a single grant and performed under a common administrative framework, such as an energy-efficiency loan program. For the purposes of this study, the "activity" is the basic unit sampled and evaluated, regardless of whether it consisted of one or more actions, projects, buildings or ultimate end users or beneficiaries.
ARRA	American Recovery and Reinvestment Act of 2009; in this report, ARRA refers specifically to the Department of Energy's Energy Efficiency and Conservation Block Grants' ARRA funding
Broad Program Area (BPA)	Or "program area" refers to a related set of activities performed by multiple grant recipients in different states and locals that have basic similarities in terms of the actions performed and services provided. One of 14 eligible types of activities eligible for funding under the EECBG formula grants. Six of the fourteen BPAs representing 80% of the total EECBG funding for grants are the focus of this evaluation.
CATI	Computer-Assisted Telephone Interviews
CGE	Computable General Equilibrium
Direct Grant	Grants provided to entities that directly implemented activities.
DOE	US Department of Energy
EECBG	Energy Efficiency and Conservation Block Grants
EERE	Energy Efficiency and Renewable Energy
EPAct	Energy Policy Act of 2005
FOA	Funding Opportunity Announcement
Grant/Formula Grant	An amount of funding provided to an eligible recipient for carrying out qualified activity(ies) under the EECBG program.
Grantee/grant recipient	The cities, counties, states, territories and Indian tribes that received EECBG funds for carrying out qualified activities.
GREET	Greenhouse Gases, Regulated Emissions, and Energy use in Transportation
ICP	Institutional Conservation Program
IDI	In-Depth Interview

Impact Evaluation	Subset of an outcome evaluation that assesses the net effect of a program (defined by Government Accountability Office)
Indirect Grant	Grants provided to States that in turn issued funding to various other eligible grantees through sub-grants
I-O	Input-output (model)
MMBtu	Million British thermal units
MMTCE	Million metric tons of carbon equivalent
NASEO	National Association of State Energy Officials
OMB	Office of Management and Budget
ORNL	Oak Ridge National Laboratory
Outcome evaluation	Evaluation that assesses the extent to which a program achieves its outcome-oriented objectives (defined by Government Accountability Office)
OWIP	Office of Weatherization and Intergovernmental Programs
PAGE information system	Performance and Accountability for Grants in Energy reporting information system that is the primary source of descriptions of activities performed by EECBG grant recipients.
Program	Refers to the entire EECBG program, which consists of all funded activities carried out by grant recipients nationwide.
PV	Present value or photovoltaic
PY	Program year
RAC	Recovery Act Cost
REMI	Regional Economic Models, Inc.
SCT	Standard Calculation Tool
SEO	State Energy Office
SEP	State Energy Program
SOW	Statement of work
Subarea	A group of common activities within a BPA. *Subareas refer to identifiable sets of activities within a BPA that have common characteristics that distinguish them from others types of activities within their program area.*
Sub-grant	An amount of funds provided to an eligible entity from a statewide EECBG funding allocation. Sometimes also referred to as sub-award.

EXECUTIVE SUMMARY

This document presents findings from an evaluation of the Energy Efficiency and Conservation Block Grant (EECBG) Program, a national program operated by the U.S. Department of Energy (DOE) from 2009 to 2015 that provided grants and technical assistance to local governments, states and territories to support a wide variety of energy efficiency and renewable energy activities.[1] It was funded by the American Reinvestment and Recovery Act (ARRA or Recovery Act) and was a one-time program. The evaluation was commissioned by DOE's Weatherization and Intergovernmental Programs Office (WIPO), which managed the EECBG Program. The study was carried out by an independent evaluation team led by DNV GL, with oversight from Oak Ridge National Laboratory (ORNL) and its advisors. The evaluation was carried out between 2011 and 2015 and culminated in this report.

ES.1. Key Findings

Table ES-1 lists the principal metrics or outcomes of this evaluation along with their definitions.[2] All impacts reported are EECBG-attributable impacts, meaning they are the impacts that occurred as a result of EECBG funding.

Table ES-1: Key evaluation outcomes and metrics

Outcome	Metric Description
Energy Savings	• Annual and cumulative energy savings by fuel, sector and total source Million British Thermal Units (MMBtu)
Renewable Generation	• Annual and cumulative renewable generation by fuel, sector and total source MMBtu
Job Creation	• Direct, indirect, and induced jobs created or retained • Job impacts over the estimated life of program energy impacts
Avoided Carbon Emissions	• Annual and cumulative avoided carbon emissions by sector and program mechanism • Annual and cumulative avoided social costs of carbon emissions, by sector and program mechanism[3]
Bill Savings and Cost-Effectiveness	• Annual and cumulative dollar savings on energy bills by sector • Recovery Act Cost (RAC) test ratio of annual energy savings and renewable generation per thousand dollars of program expenditures • Lifetime present value (PV) ratio of dollar savings to program costs

The evaluation shows that the cumulative impacts of EECBG that are attributable to the program are as follows:

- Energy savings /renewable generation –
    - EECBG produced a combined attributable energy savings from all EECBG activities of 409 million source MMBtu for the 2009 to 2050 period

[1] This evaluation period included projects from 2009 through 2011 because that is when the sample was selected.

[2] According to the Government Accountability Office, this evaluation is an impact evaluation, which is a subset of an outcome evaluation that assesses the net effect of a program. This report will refer to the evaluation's net impacts as its outcomes.

[3] According to the US Environment Protection Agency, the social cost of carbon is "an estimate of the economic damages associated with a small increase in carbon dioxide (CO2) emissions, conventionally one metric ton, in a given year… The SCC is meant to be a comprehensive estimate of climate change damages and includes, but is not limited to, changes in net agricultural productivity, human health, and property damages from increased flood risk."

- EECBG generated 4.2 MMBtu from on-site renewable energy projects

- Labor impacts –
  - EECBG produced a net total job gain of 62,902 job years for the BPAs studied.
  - EECBG's job gains represent approximately $36,260 per job created based on $2.280 billion in funding for the evaluated BPAs.

- Avoided carbon emissions –
  - EECBG avoided 25.7 million metric tons of carbon equivalent due to energy savings and renewable generation
  - EECBG saved $1.7 billion in social costs of carbon due to energy savings alone and an additional $62 million in social costs avoided from displaced energy as a result of renewable generation.

- Bill Savings and cost-effectiveness –
  - EECBG produced $5.2 billion of total cumulative savings on energy bills, 70% of which were realized by residential consumers, 29% in the public institutional sector, and 1% the commercial and industrial sectors.
  - The Recovery Act Cost (RAC) Test, which quantifies the EECBG-attributable savings (measured in source MMBtu saved per year) per $1,000 of program expenditures, showed the overall program met the DOE-specified cost effectiveness baseline of 10.0. RAC test results are presented from a building perspective, which evaluates cost effectiveness of energy savings and renewable energy generation, and from a system perspective, which evaluates cost effectiveness of energy savings and conventional energy displaced by renewable generation.[4]
  - The PV ratio compares the present value of participant bill savings attributed to EECBG against the present value of EECBG program funding using a 2.7% discount rate. The PV ratio was 1.76, which indicates participant bill savings exceeded EECBG program expenditures.

ES.2. Program Description

The Energy Independence and Security Act created the EECBG Program to help eligible state and local government entities and Indian tribes develop, promote, implement, and manage energy efficiency and conservation efforts. Funded efforts were designed to reduce fossil fuel emissions and total energy use of eligible entities, improve energy efficiency in transportation, building, and other sectors, and create and retain jobs. Given that the program was of a limited duration and a single funding cycle, an emphasis was placed on projects already in the pipeline for execution that could be launched and break ground within 18 months.

More than $2.7 billion was distributed through formula grants to 2,187 cities, counties, states, territories, and Indian tribes across a range of 14 categories or Broad Program Areas (BPAs). The

[4] The substantive distinction between the RAC test from the building and system perspectives is the treatment of on-site renewable generation. From the building (consumer facility) perspective, on-site generation is considered supplemental electricity that does not incur transmission or production losses. From the system (electric grid) perspective, on-site generation replaces a need for conventional electricity generation such that the total displaced electricity is used in the RAC test numerator. In contrast, utility scale renewable generation is always assumed to displace conventional electricity.

grants funded over 7,400 individual programs, projects, or activities (referred to herein as activities). Grants could be used for a range of initiatives, including energy efficiency building retrofits, financial incentives for energy efficiency, building code support, renewable energy installations, distributed energy technologies, transportation activities, recycling and waste management efforts, and other activities approved by the U.S. DOE. Grants were provided directly to local government entities, state agencies and Indian tribes. Seventy percent of the grants funding went directly to local governments with nearly all of the remainder (28%) going to the States. States receiving EECBG funds were obligated to disperse a minimum of 60% of those funds to local entities in indirect grants.

Table ES-2 lists the distribution of grant activities across the full range of categories or BPAs for which EECBG funding was provided. The table shows the number of activities and percent of program funding received. The first six BPAs, highlighted in bold below, represent the top 80% of the dollars spent under EECBG and 74% of the total number of activities.

Table ES-2. Distribution of Funding and Activities across 14 EECBG BPAs

BPA	Percent of Funding	Cumulative Percent of Funding	Number of Activities
Energy Efficiency Retrofits	38.8%	38.8%	2,525
Financial Incentive Program	17.9%	56.8%	361
Buildings and Facilities	9.7%	66.5%	784
Lighting	7.1%	73.6%	637
On-site Renewable Technology	6.0%	79.6%	456
Energy Efficiency and Conservation Strategy (Direct Grants)[1]	2.6%	82.2%	735
Transportation	4.3%	86.4%	533
Other	2.8%	89.2%	79
Technical Consultant Services	2.4%	91.6%	518
Residential and Commercial Buildings and Audits	2.3%	93.9%	443
Energy Efficiency and Conservation Strategy (Indirect Grants)[1]	2.1%	96.0%	24
Material Conservation Program	1.2%	97.2%	164
Energy Distribution	1.1%	98.3%	68
Reduction/Capture of Methane/Greenhouse Gases	1.1%	99.3%	42
Codes and Inspections	0.7%	100.0%	110
Total	**100.0%**		**7,479**

ES.3. Scope of the Evaluation

The EECBG evaluation effort was organized and implemented along three dimensions: the grant funding categories of BPAs; whether the grants were direct grants to local government entities or indirect, that is sub-grants to such entities via state governments; and the target sectors defined as residential, non-residential and public. The study reports findings at the BPA level for direct and indirect grant activities combined, and presents results by sector where appropriate.

The EECBG evaluation focused on the six BPAs that cumulatively account for slightly more than 80% of total formula grant expenditures as directed by WIPO. The nature of the activities performed in each of those BPAs is described in Table ES-3.

Table ES-3: Six BPAs in this EECBG evaluation

BPAs	Definitions
Energy Efficiency Retrofits	The Energy Efficiency Retrofits BPA encompasses activities that provide financial support for building retrofit and equipment replacement projects in existing residential, commercial, and industrial facilities.
Financial Incentives	The Financial Incentives BPA encompasses activities that focus on financial incentives for energy efficiency, including rebates, financing, loans, third party loans and local bank-guarantee loans.
Buildings and Facilities	The Buildings and Facilities BPA encompasses activities that focus on architecture, design and engineering activities; energy management systems, and energy efficiency rating and labeling.
On-site Renewables	The On-site Renewables BPA encompasses activities that focus on renewable energy systems and retrofits, training and capacity building associated with these systems.
Lighting	The Lighting BPA encompasses activities that focus on the replacement of traffic lighting and street lighting with energy efficient lighting technologies.
Energy Efficiency and Conservation Strategy	The Energy Efficiency and Conservation Strategy BPA encompasses activities that cover a wide range of policies and programs designed to facilitate adoption of energy efficiency and renewable energy technologies in multiple sectors

ES.4. Evaluation Objectives

This evaluation is focused on the quantification of EECBG program impacts. As such, the study did not include an assessment of program processes, participant satisfaction, or policy objectives. The original evaluation plan outlined two key objectives for the EECBG evaluation: (1): to accurately quantify the principal outcomes achieved by DOE's $2.7 billion formula grant investment in energy, and (2) to investigate potential key grantee organizational and operational characteristics related to successful grant performance.

To meet the objectives of the study, the evaluation focused on three critical research questions:

1. What is the total lifetime magnitude of energy and cost savings and other key outcomes achieved in those BPAs that cumulatively account for approximately 80% of total Formula Grant expenditures in the 2009-2011 program years?[5]
2. What is the lifetime magnitude of outcomes achieved by each of the most heavily funded BPAs within the EECBG portfolio?
3. What are the primary performance factors influencing the magnitude of EECBG outcomes?

The principal outcomes of the evaluation were estimated through various impact evaluation analyses and were defined as:

- Energy savings and on-site renewable energy generation - expressed in million source BTUs or MMBTUs[6]
- Labor impacts - expressed as the net number of jobs created
- Avoided carbon emissions - expressed as million metric tons of carbon equivalent [MMTCE) reduced[7]
- Bill savings and cost-effectiveness - expressed as both cost and energy saved per dollar spent

The secondary objective of the evaluation related to identifying organizational factors that contribute to grant performance, which was defined as the amount of energy saved per dollar of EECBG program spending. The grant performance indicator was then used as the dependent variable in a statistical regression model to identify and rank operational and organizational factors as to their likely level of influence on program performance.

ES.5. Summary Tables

There are several ways in which the outcomes of the EECBG evaluation process are expressed in summary tables below and in the body of the report. First, the energy impact outcomes and metrics are expressed in MMBtu for each of three program mechanisms: energy savings, renewable energy generation, and alternative fuels.

The avoided carbon emissions outcome is then calculated by applying carbon emission rates to the verified EECBG-attributable energy impacts. Reductions in carbon emissions in turn avoid societal damages that are directly or indirectly caused by such emissions, such as flood damage or health effects: these are reflected in a second carbon emissions indicator called the avoided social costs of carbon and is expressed in dollars.

Finally, two cost effectiveness indicators are listed in the table, the RAC test and a present value indicator.

[5] As directed by DOE, effects were studied through 2050. For some revolving loan programs, it is possible that program effects would continue after 2050, but those future effects were not included in this analysis.
[6] Energy savings, such as reduced consumption of electricity or natural gas, are the primary objective of EECBG grants, and thus the evaluation did not include an estimation of demand impacts.
[7] Carbon emissions are determined from the type and magnitude of energy saved through energy efficiency and displaced energy as a result of renewable energy generation

All of the impact methodologies used to create the values shown below are described in more detail in subsequent sections of the full report.

ES.5.1. Energy impacts

Tables ES-4a and ES-4b present cumulative energy savings and renewable generation in source MMBtu for all six BPAs studied. Table ES-4a shows the combined EECBG-attributable energy savings from all EECBG activities as 409 million source MMBtu for the 2009 to 2050 period.[8] The majority of energy savings (over 57%) were associated with grants in the financial incentives BPA. That BPA is followed by energy efficiency retrofits and lighting BPAs, at 17% each. All three of these BPAs are characterized by a high proportion of projects with direct installation of energy efficiency measures.

Table ES-4a: Lifetime EECBG-attributable energy savings

	Estimated total energy savings (source MMBtu)	Estimated energy savings as percent of total savings in all BPAs (%)
Energy Efficiency Retrofits	70,887,192	17.3%
Financial Incentives	235,891,401	57.6%
Buildings and Facilities	29,982,236	7.3%
Lighting	70,590,085	17.2%
On-site Renewable Technology	68,223	0.0%
Energy Efficiency and Conservation Strategy	1,859,179*	0.5%
Total	**409,278,316**	**100.0%**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
"*" indicates estimate exhibits low precision.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

On-site renewable projects produce electricity, thereby offsetting the need to consume grid-delivered electricity that uses other energy sources. Table ES-4b shows the amount of energy generated from the EECBG-funded renewable energy projects in all BPAs where that applied. The combined EECBG-attributable renewable generation impact from all EECBG activities is four million source MMBtu for the 2009 to 2050 period. While the on-site renewable technology BPA accounted for the majority of that generation (78% of all generated MMBtu), the financial incentives BPA also contributed significantly to producing renewable energy impacts (18%).

Table ES-4b: Lifetime EECBG-attributable renewable generation

	Estimated total renewable generation (source MMBtu)	Estimated renewable generation as percent of total generation in all BPAs (%)
Energy Efficiency Retrofits	156,594	3.7%
Financial Incentives	770,852*	18.2%
Buildings and Facilities	-	-
Lighting	-	-
On-site Renewable Technology	3,316,077	78.1%
Energy Efficiency and Conservation Strategy	2,352*	0.1%
Total	**4,245,875**	**100.0%**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
"*" indicates estimate exhibits low precision. Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

[8] The term "source Btu" refers to the total energy required to produce a British thermal unit of energy used on-site by the ultimate consumer. Site to source Btu conversions are based on: http://www.energystar.gov/ia/business/evaluate_performance/site_source.pdf.

Tables ES-5a and ES-5b display energy savings and renewable generation by sector. The majority of the energy savings occur in the residential sector with 263 million source MMBtu, followed by the public institutional sector with 145 million source MMBtu of energy savings. The large majority of renewable generation occurs in the public institutional sector.

Table ES-5a: EECBG-attributable energy savings for all BPAs studied by sector (source MMBtu)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional
Energy efficiency retrofits	4,657,245	929,323	31,934*	65,268,690	-
Financial incentives	216,265,347	257,372*	-	19,368,682	-
Buildings and facilities	52,084*	336,002*	-	29,594,150	-
Lighting	39,760,583*	-	-	30,829,502	-
On-site renewable technology	49,921	-	-	18,302*	-
EE and conservation strategy	1,756,020*	-	-	103,159*	-
Total	**262,541,200**	**1,522,697**	**31,934**	**145,182,485**	**-**

"-" indicates estimate rounds to zero and is considered imprecise.
"*" indicates estimate exhibits low precision.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

Table ES-5b: EECBG-attributable on-site renewable generation for all BPAs studied by sector (source MMBtu)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional
Energy efficiency retrofits	9,558*	-	-	147,036	-
Financial incentives	117,255*	-	-	653,597*	-
Buildings and facilities	-	-	-	-	-
Lighting	-	-	-	-	-
On-site renewable technology	-	-	-	3,316,077	-
EE and conservation strategy	2,352*	-	-	-	-
Total	**129,165**	**-**	**-**	**4,116,710**	**-**

"-" indicates estimate rounds to zero and is considered imprecise.
"*" indicates estimate exhibits low precision.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

ES.5.2. Labor impacts

Labor impacts by BPA are presented in terms of jobs created or retained. The Regional Economic Models, Inc. (REMI) economic forecasting model used for this study is a dynamic computable general equilibrium (CGE) model with an input-output transaction model at its core.[9] The REMI model was designated for this evaluation because it can capture lasting net energy reduction impacts for the commercial and industrial customer sectors that participated in these programs. The model is also appropriate for depicting changes in household and public agency budgets. When energy efficiency or renewable generation programs reduce costs to energy consumers, they can support positive job growth through the added money available to spend in more job-intensive economic streams compared to energy related economic streams.

Table ES-6a shows a net total job gain of 62,902 job years for the BPAs studied. This indicates that one job was created or retained for each $36,260 of program expenditures, based on $2.280 billion in funding for the evaluated BPAs. It should be noted that the employment impacts from the various

[9] See Appendix I for a high-level description of key REMI model features.

BPAs do not have the same lifetime. For example, lighting effects last until 2030, energy efficiency retrofits until 2036, energy efficiency and conservation strategy until 2036, on-site renewable technology until 2036, financial incentives until 2050, and buildings and facilities until 2031.

Table ES-6a: Direct, indirect, and induced jobs created in the U.S. from the studied EECBG activities

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
EE & Conservation Strategy	180	508	564	501	33	88	36	-4	0	1,906
Financial Incentives	1,474	1,925	2,056	2,183	756	-408	1,635	1,705	-1,860	9,467
Energy Efficiency Retrofits	2,152	8,067	9,028	5,296	1,058	3,938	1,845	-233	0	31,151
Buildings & Facilities	484	1,464	1,812	950	472	2,236	938	16	0	8,372
Lighting	-30	1,054	1,025	1,330	1,460	1,765	1,486	0	0	8,090
On-site Renewable Technology	162	1,122	515	121	-10	690	1,093	224	0	3,916
Total US	**4,422**	**14,140**	**14,999**	**10,382**	**3,769**	**8,309**	**7,033**	**1,708**	**-1,860**	**62,902**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

Table ES-6b presents the direct job effects occurring as a result of the program funding for EECBG activities. The values reported are cumulative in the interval within which projects are installed and the program funds were to be disbursed. The cumulative direct job effects are 21,206 job years in the US for the short-term interval related to EECBG program administration and project deployment (through 2013). However, the financial incentives BPA, due to its revolving loan structure, has installation or technical services contracts, on-going loan administration support, and some prolonged equipment purchases that extend beyond 2013 (to 2033). Those direct jobs are also shown in Table ES-6b. Cumulative direct job years are 25,567 through 2033.

Table ES-6b: EECBG-attributable cumulative direct job years for all BPAs studied 2009–2033

	2009	2010	2011	2012	2013	2014-2033	Total
EE & Conservation Strategy	6	83	94	79	2	-	264
Financial Incentives	620	1,403	1,465	1,303	665	4,361	9,816
Energy Efficiency Retrofits	797	3,289	3,592	1,776	177	-	9,631
Buildings & Facilities	321	911	709	481	226	-	2,648
Lighting	352	680	716	194	273	-	2,215
On-site Renewable Technology	65	510	305	107	8	-	994
Total US	**2,160**	**6,875**	**6,881**	**3,939**	**1,350**	**4,361**	**25,567**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

ES.5.3. Avoided carbon emissions and avoided social cost estimates

Avoided carbon emissions from the EECBG activities are derived from energy savings, renewable generation and some direct carbon reductions from alternative fuels (Tables ES-6a and ES-6b). Avoided carbon emissions shown in TableES-7a total 25.7 million metric tons of carbon equivalent (MMTCE) and are derived mostly from energy savings at 24.9 MMTCE. There are 0.9 MMTCE of avoided carbon emissions from renewable generation.

Table ES-7a: Avoided lifetime carbon emissions from EECBG by BPA and program mechanism (MMTCE)

	Avoided Carbon From Energy Savings 2009-2050	Avoided Carbon From Renewable Generation 2009-2050
Energy Efficiency Retrofits	4.54	0.04
Financial Incentives	13.94	0.16
Buildings and Facilities	1.87	-
Lighting	4.42	-
On-site Renewable Technology	<0.01	0.68
Energy Efficiency and Conservation Strategy	0.11	<0.01
Total	**24.87**	**0.88**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

Avoided carbon emissions resulting from the six BPAs, range from 0.11 MMTCE for energy efficiency and conservation strategy to 14.09 MMTCE for financial incentives (Table ES-7b). The majority of avoided carbon emissions occur in the residential sector (16.03 MMTCE), followed by the public institutional sector (9.65 MMTCE).

Table ES-7b: Avoided lifetime carbon emissions from EECBG activities, by sector and BPA (MMTCE)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional
Energy efficiency retrofits	0.272	0.045	0.002	4.257	-
Financial incentives	12.813	0.009	-	1.267	-
Buildings and facilities	0.003	0.02	-	1.847	-
Lighting	0.004	-	-	0.684	-
On-site renewable technology	2.823	-	-	1.593	-
EE and conservation strategy	0.1	-	-	0.006	-
Total	**16.015**	**0.074**	**0.002**	**9.654**	**-**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

Avoided social costs of carbon from EECBG activities total $1,788 million. As shown in Table ES-8a, energy savings account for the majority of the avoided social costs at $1.7 billion. Renewable generation accounts for just under $62 million in social costs avoided.

Table ES-8a: Avoided lifetime social costs of carbon from EECBG activities, by BPA and program mechanism (thousands of 2009$)

	Avoided Social Costs From Energy Savings 2009-2050	Avoided Social Costs From Renewable Generation 2009-2050
Energy Efficiency Retrofits	$294,270	$2,341
Financial Incentives	$1,014,927	$11,494
Buildings and Facilities	$119,419	-
Lighting	$290,162	-
On-site Renewable Technology	$317	$47,998
Energy Efficiency and Conservation Strategy	$6,824	$30
Total	**$1,725,920**	**$61,864**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

The avoided lifetime social costs of carbon from EECBG activities, by BPA and sector, are shown in Table ES-8b. The greatest avoided social costs occurred in the Residential sector ($1.16 billion) followed by the Public Institutional sector ($0.62 billion).

Table ES-8b: Avoided lifetime social costs of carbon from EECBG activities, by sector and BPA (thousands of 2009$)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional
Energy Efficiency retrofits	$18,018	$2,856	$120	$275,618	-
Financial incentives	$943,092	$597	-	$82,733	-
Buildings and facilities	$200	$1,134	-	$118,086	-
Lighting	$269	-	-	$48,047	-
On-site renewable technology	$190,036	-	-	$100,126	-
EE and conservation strategy	$6,490	-	-	$365	-
Total	**$1,158,105**	**$4,587**	**$120**	**$624,975**	**-**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

ES.5.4. Bill savings and cost-effectiveness

This section presents findings on bill savings and cost-effectiveness indicators for the studied activities funded by EECBG. Bill savings are presented in 2009 dollars and include utility or energy bill savings to customers from the reduced use of energy due to increases in energy efficiency and on-site renewable generation.

The Recovery Act Cost (RAC) test quantifies the annual EECBG-attributable savings (measured in MMBtu of source energy saved per year) per $1,000 of program expenditures. RAC test results are presented from a building perspective, which evaluates cost effectiveness of energy savings and renewable energy generation, and from a system perspective, which evaluates cost effectiveness of energy savings and conventional energy displaced by renewable generation.[10]

The single year EECBG RAC test results for all studied BPAs at the building and system levels are 9.83 and 10.67, respectively, when including the loan dollars extended to participants in financing programs. Three of the BPAs passed the RAC test threshold of 10 (lighting, buildings and facilities, and financial incentives).[11]

For the six BPAs studied, cumulative bill savings total $5.2 billion through the year 2050, as shown in Table ES-9, with the majority of bill savings being produced by the financial incentives and lighting BPAs followed by energy efficiency retrofits.

[10] The substantive distinction between the RAC test from the building and system perspectives is the treatment of on-site renewable generation. From the building (consumer facility) perspective, on-site generation is considered supplemental electricity that does not incur transmission or production losses. From the system (electric grid) perspective, on-site generation replaces a need for conventional electricity generation such that the total displaced electricity is used in the RAC test numerator. In contrast, utility scale renewable generation is always assumed to displace conventional electricity.

[11] A benchmark score of 10 was established by DOE, meaning that any ratio of MMBtu of source energy saved per $1,000 of program expenditures that exceeds 10 can be considered cost-effective.

Table ES-9: RAC test result and lifetime bill savings for BPAs studied

Metrics	RAC Test Result (Building)	RAC Test Result (System)	Bill Savings ($Thousands)
Energy Efficiency Retrofits	5.18	5.20	$748,188
Financial Incentives (with loan principal)	9.76	9.92	$2,742,413
Financial Incentives (without loan principal)	14.97	15.20	$2,742,413
Buildings and Facilities	13.70	13.70	$260,377
Lighting	39.17	39.17	$1,312,710
On-site Renewable Technology	0.90	2.92	$123,550
Energy Efficiency and Conservation Strategy	2.86	2.87	$21,192
Total (with loan principal)	9.64	10.47	$5,208,429
Total (without loan principal)	9.83	10.67	$5,208,429

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
"*" indicates estimate exhibits low precision.
Estimates may not sum to the estimates reported in the "Total" row due to rounding or suppression of estimates that round to zero.

The PV ratio compares the present value of participant bill savings attributed to EECBG against the present value of EECBG program funding. A ratio greater than 1.0 means the lifetime discounted-value of EECBG-attributable bill savings is greater than total EECBG funding. For this analysis, a discount rate of 2.7% was applied. This rate is the "risk-free" real interest rate on US 30-year Treasury bonds in 2009 and reported in OMB circular A-94.[12] Results are presented in a range from 0.7% to 4.7% to assess the sensitivity of the findings.

Three BPAs – financial incentives, lighting, and buildings and facilities – had ratios greater than one. As a whole all six BPAs had a PV ratio of 1.76, indicating EECBG-attributable bill savings is greater than total EECBG funding.

Table ES-10: PV ratio for BPAs studied

Discount Rate	0.70%	2.70%	4.70%
Energy Efficiency Retrofits	0.66	0.56	0.49
Financial Incentives (with loan principal)	4.95	3.77	2.95
Financial Incentives (without loan principal)	7.61	5.79	4.51
Buildings and Facilities	1.18	1.05	0.94
Lighting	6.37	5.38	4.6
On-site Renewable Technology	0.72	0.57	0.47
Energy Efficiency and Conservation Strategy	0.31	0.27	0.23
Total (with loan principal)	2.18	1.76	1.44
Total (without loan principal)	2.37	1.91	1.57

ES.6. Organizational Performance

The objective of the performance analysis was to determine if there were organizational or operational aspects of the EECBG program that could be identified as having a statistical relationship to the energy savings achieved per grant dollar spent. An understanding of such factors related to successful performance could be helpful to public policy makers, program managers, and other parties interested in allocating funding for the adoption and effective utilization of energy efficiency and renewable energy technologies. Using available program data and secondary sources, the contractor

[12] OMB. Circular A-94, Revised, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, "OMB Budget Assumption," December 26, 2013. http://www.whitehouse.gov/sites/default/files/omb/assets/a94/dischist-2014.pdf.

team used a regression framework to attempt to identify key organizational and operational characteristics that explain the relative level of savings achieved per grant dollar expended.

Various iterations of the statistical models were performed in order to assess whether grant activity performance could be explained by the operational variables of interest. We conducted both univariate (one at a time) and multivariate (all at once) regression analyses in an attempt to extract any insights of value[13]. Since the point of the study was to isolate the impact of operational and organizational factors on performance (rather than equipment or energy saving measures), we eliminated other variables that were directly related to – and included in –the development of the dependent variable (i.e., the energy savings impacts). For example, we did not include in the model variables related to what kinds of measures or equipment were installed through the grant program because they were already taken into account in calculating the energy savings. We wanted to determine: ***What else*** might be having an impact on the energy savings per grant dollar achieved?

The findings from the statistical regression modeling effort indicate some significant relationships between program performance, defined as EECBG-attributable energy savings per dollar spent, and selected performance factors. The regression analysis with the best result showed that 13 variables explained 68% of the result (R-square = 0.68) for 148 grant activity records that were included in the model, with the BPA categories of financial incentives and lighting having the highest explanatory value for grant performance. Finally, a univariate regression analysis was run on each of the independent variables and while no single variable explained more than 15% (R-sq=.15) of the variability of the dependent variable, the top three variables with any explanatory value at all were BPA categories. Detailed results from the performance factors analysis can be found in Chapter 4 of the report and Appendix L.

ES.7. Evaluation Approach

The basic steps of the study approach are presented in Figure ES-1.

[13] Regression analysis is defined as a statistical procedure to determine the relationship between the dependent variable, in this case the savings per $1,000 of EECBG funding, and independent variables such as whether or not a project included an energy audit.

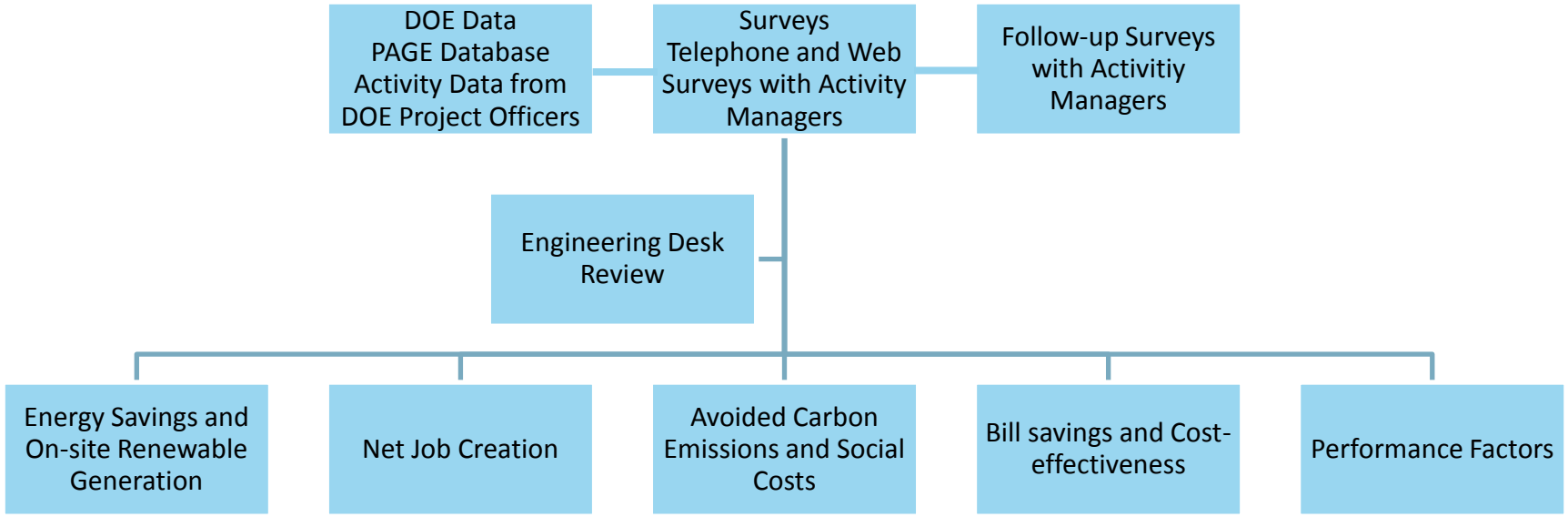

Figure ES-1: Summary of EECBG evaluation approach

The first step in the study was to review the available program data and assess the evaluability of the program activities, starting with the acquisition of program tracking data from DOE's PAGE information system. The next step was to identify the most heavily funded BPAs that, in combination, accounted for approximately (but no less than) 80% of total EECBG program funding. The resultant BPAs constituted the target population for this evaluation.

For each sampled activity, activity contacts who completed the survey were subsequently asked to provide various data files and provide additional information via a web-based data collection system. These additional data items were used to estimate the energy impacts of their grant. Of the 562 activities selected for this evaluation, 317 contacts were interviewed. Of these, 169 were considered evaluable, meaning they submitted information necessary to estimate energy impacts, and they represent the set of final respondents for this evaluation. Table ES-11 shows the number of activities sampled and evaluated by BPA.

Table ES-11: Study sample by BPA

Sample Frame BPA[14]	Frame Activities	Selected Sample	CATI Respondents	Evaluable Respondents
Energy Efficiency Retrofits	2,187	277	160	82
Financial Incentive Program	320	83	49	14
Buildings and Facilities	667	70	40	25
Lighting	572	58	33	24
On-site Renewable Technology	400	52	27	19
Energy Efficiency and Conservation Strategy (Direct Grants)	560	22	8	5
Total	**4,706**	**562**	**317**	**169**

After activities were determined to be evaluable, the activity evaluation phase began. During this period the contractor team collected activity-specific data and evaluated energy savings and renewable generation impacts over the effective useful life[15] of all efficiency measures and renewable technologies for the selected activities. The EECBG Evaluation employed an engineering analysis based on technology installation and use conditions as the method for estimating EECBG-attributable savings for each of the six selected BPAs. The BPA-level savings were then used to estimate impacts for the other program outcomes: net job creation, avoided carbon emissions and social costs, bill savings and cost effectiveness, and performance factors. The evaluation of the EECBG program utilized information obtained from three key data sources:

- **Program Records** - DOE's Performance and Accountability for Grants in Energy (PAGE) information system and activity documentation and records reported by EECBG activity managers

[14] The sample frame BPA may differ from a final activity's BPA designation, if during the evaluation an activity was reassigned from one BPA to another. For example, if an activity was in the Energy Efficiency Retrofits BPA in the original sample, but when evaluated it had been mostly renewables, it would be re-classified as an activity in the On-Site Renewable Technology BPA. However in this table, that activity would appear in the Energy Efficiency Retrofits BPA.

[15] The effective useful life is defined as the number of years over which the new (efficient) equipment is expected to be maintained at the efficient condition for which it was intended. Energy savings from efficient equipment is zero after the end of the EUL.

- **Primary Data Collection** - Telephone and web-based surveys with EECBG activity project managers who are closest to the activities sampled. This included a telephone survey to verify basic activity information and budgets and identify the correct respondent to provide additional grant detail, followed by a self-administered web-based survey where detailed information regarding specific measures and energy efficiency projects are provided.
- **Clarification Interviews** - Follow-up interviews with activity project managers to obtain additional activity-specific information required for the evaluation that is not provided by the program databases or the telephone surveys.

The contractor team collected grant and activity level data from the above sources for use in calculation of evaluated outcomes. Details regarding the specific methods used for impact evaluation are described in Section ES7.1.

The final stage of the evaluation was the BPA expansion, wherein key data parameters for the 169 sampled activities were extrapolated through a sample weighting process to the BPA s they represent.[16] Energy savings and renewable generation estimates at the BPA level were derived directly from expansion of the verified activity level findings. Other evaluated outcomes, including avoided carbon emissions, cost effectiveness, and labor impacts, required additional calculation steps at the BPA level to generate final impacts.

ES.7.1. Overall impact estimation methods

The estimation of activity-level energy savings from energy efficiency and on-site renewable generation was conducted in two steps. The first step estimated the overall energy savings and renewable generation achieved by the activity in response to all resources provided, regardless of source. The second step estimated EECBG-attributable impacts, which is the portion of overall impacts that is due to the EECBG contribution and would not have occurred without it. Impacts were calculated by year and assumed to end for a particular measure when the measure life ends and the measure is effectively replaced with similar technologies in kind; however, the replacement technology stock is not counted as contributing to EECBG-attributable impacts. The impact calculation methods used to estimate overall impacts for each studied BPA are shown in Table ES-12. Each of the impact calculation methods are explained in more detail Appendix F.

[16] The final combined sample size of 169 varied substantially by BPA. The number for each BPA ranged from 5 activities (energy efficiency and conservation strategy – direct grants BPA) to 86 activities (energy efficiency retrofits BPA). To ensure the sample adequately represented the population of activities, we controlled for sampling error in two ways. First, the sample was stratified by funding levels and sampled within each stratum to minimize the margin of error of the results. Second, rigorous follow-up data collection attempts were made with each respondent to minimize the exclusion of sample respondents and thus avoid producing results that are not representative of the population.

Table ES-12: Overall impact calculation methods used by BPA

Impact Calculation Method	Applicable BPAs	Number of Activities in Group	
		Direct	Indirect
Standard Calculation Tool (Section F.4)	Energy Efficiency Retrofits	77	9
	Financial Incentives Programs	8	6
	Building and Facilities	13	5
	Lighting	25	2
Standard Renewable Protocol (Section F.5)	On-site Renewable Technology	18	1
Standard Calculation Tool (Section F.4) or Secondary Research	Energy Efficiency and Conservation Strategy	5	0
TOTAL		146	23

The following provides a brief summary of each impact estimation method:

Standard Calculation Tool (SCT): This tool is a collection of engineering-based calculations that allows the user to estimate energy savings for 19 residential and 11 nonresidential energy efficient measures. The SCT operates much like an automated evaluation results-based Technical Reference Manual for energy efficiency actions. The contractor team assembled the measures into a software application that prompts the user for the inputs necessary to complete calculations based on existing technical reference manuals. The user can then estimate energy savings for measures located anywhere in the country using input data that can vary greatly in terms of content and quality.[17]

Standard Renewable Protocol: Calculation methods were standardized for each of the following renewable technologies, using publicly available tools and methods: biomass combustion systems,[18,19,20,21] photovoltaic systems,[22] solar water heating,[23] and wind systems[24].

[17] The SCT is based on engineering algorithms and assumptions from previously-vetted TRMs, where available, and standard industry engineering best practices. Site-specific operating and equipment information was used as the primary calculation input. Where necessary, consistently-determined assumptions were used based on TRMs, secondary-source studies, and DNV GL professional judgment. We reviewed 22 national, regional, and state-level technical reference manuals (TRMs) to identify the best ones as judged on transparency and national applicability of source information, nationally relevant or modifiable algorithms, and range of measures per sector. Based on these selection criteria, nine TRMs were designated as preferred sources, including: ENERGY STAR, Regional Technical Forum (RTF) in the Pacific Northwest, Mid-Atlantic, Pennsylvania, Ohio, Wisconsin (nonresidential), New York, TVA, and Texas (residential).

[18] "An Analysis of Energy Production Costs from Anaerobic Digestion Systems on U.S. Livestock Production Facilities," Technical Note No. 1, USDA, NRCS, October 2007.

[19] Burke, Dennis A., P.E. "Dairy Waste Anaerobic Digestion Handbook." Page 38. Environmental Energy Company, 6007 Hill Street, Olympia, WA 98516. June 2001.

[20] American Society of Agriculture and Biological Engineers, ASAE D384.2: Manure production and characteristics, The Society for Engineering in Agriculture, Food and Biological System, St. Joseph, MI, 2005.

[21] John H. Martin, *A Protocol for Quantifying and Reporting the Performance of Anaerobic Digestion Systems for Livestock Manures*, ASERTI, USDA – Rural Development and EPA AgStar, (www.epa.gov/agstar/pdf/protocol.pdf), January 2007.

[22] *PVWatts version 1. A Performance Calculator for Grid-Connected PV Systems.* NREL. http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/ (accessed June 17, 2013).

[23] RETScreen International. Natural Resources Canada. www.retScreen.net (Accessed October 7, 2013)

[24] Wind Energy Payback Period Worksheet version 1.0. NREL http://www.nrel.gov/wind/docs/spread_sheet_Final.xls (Accessed October 9, 2013)

ES.7.2. EECBG-attributable impact estimation methods

Once overall energy impacts were calculated for each sampled activity, the next step was to estimate the extent to which those impacts could be attributed to EECBG support rather than some other influence. EECBG-attributable savings were estimated from using a standard methodology across all 169 activities that addressed the extent to which a sampled activity's estimated energy impacts were due to the influence of EECBG.

The EECBG activities focused on providing individual market actors with the information, tools, and incentives needed to induce or accelerate the adoption of targeted energy efficiency and renewable energy measures in specific projects. Assessment of attribution for these programs relied on program manager reports, which provided insight into how key decision makers made choices. The methodology applied for assessing attribution addressed two questions:

What would the market actors targeted by the sample activity have done in regard to adopting the activity-supported technology or service in the absence of the program?

In instances when two or more programs, including the EECBG activity, target the same outcomes in the same domain, to what extent are observed outcomes attributable to one program or another?

The attribution methodology used in this evaluation is explained in more detail in Section 2.5 and Appendix G.

ES.7.3. BPA level savings estimation

All energy savings estimates presented in this report were computed using a direct survey estimation technique. With this technique, estimates of totals such as EECBG-attributed energy savings by source are computed by weighting the data from each sampled activity with a calibrated sample weight that accounts for both the random sample selection process and the activity-level nonresponse that was encountered during data collection. The BPA-level estimates of energy savings presented in this report were, therefore, computed by weighting the sample activity-level data with an expansion factor so that the resulting estimates represent the entire EECBG population of activities within each BPA.

Estimates for labor impacts, avoided carbon emissions, bill savings, and cost effectiveness were generated using various regional BPA-level estimates to allow for the appropriate cost factors to be applied. The performance factors were generated using various models and algorithms that employed direct survey estimates as inputs. Additional information regarding the BPA-level impact methodologies can be found in Section 2.5.2 and Appendix H.

ES.7.4. Labor impacts

Job impacts from EECBG occur in response to initial program-related spending within a BPA (i.e. direct spending by cities, counties, state agencies or Indian tribes to run programs or spending by an energy customer). In the short-term, these expenditures create new orders or contracts for installation labor, and use some portion of U.S.-manufactured equipment. In the long-term, positive job impacts also emanate from newly installed systems when the cost savings from the new equipment are used to purchase other goods and services. Over time, there are additional transactions that emerge and multiply from each program's direct job effect (called multiplier effects). The indirect multiplier effects account for situations such as when a U.S. manufacturer receives an order for a more efficient heat

pump, and the manufacturer must transact with suppliers in order for the pump to be made, assembled, and sold to the customer.

The EECBG evaluation employed the Regional Economic Models, Inc. (REMI) economic forecasting model for this study because it captures lasting EECBG-attributable energy-reduction impacts and, in particular, energy bill savings. The model is also appropriate for depicting changes in household and public agency budgets. A detailed description of the model is provided in Section 2.5.3 and Appendix I.

ES.7.5. Avoided carbon emissions

Carbon impacts at the BPA level were calculated by applying the appropriate emission rates to the verified EECBG-attributable energy impacts from each BPA. State-level non-baseload emission rates from EPA's eGrid model[25] were applied to electricity savings and conventional electricity displacement from renewable sources since the mix of fuels used to generate electricity varies regionally; nationwide emissions rates from EPA's Climate Leaders Greenhouse Gas Inventory Protocol[26] were used for other fuels.[27] The appropriate emission rates were applied to the EECBG-attributable energy savings from energy efficiency or renewable generation and aggregated to the BPA level. Emissions from energy efficiency and displaced energy from renewable generation were then aggregated to determine the total carbon impact for each BPA.

Additional detail regarding the avoided carbon emissions methodology can be found in Section 2.5.4 and Appendix J.

ES.7.6. Bill savings and Cost Effectiveness

The EECBG evaluation applied the RAC test, established by DOE to measure the cost-effectiveness of ARRA period program investments. A benchmark score of 10 was established by DOE, meaning that any ratio of MMBtu of source energy saved per year per $1,000 of program expenditures that exceeds 10 can be considered cost-effective.[28] RAC test results are presented from a building perspective, which evaluates cost effectiveness of energy savings and renewable energy generation, and from a system perspective, which evaluates cost effectiveness of energy savings and conventional energy displaced by renewable generation. The substantive distinction between the RAC test from the building and system perspectives is the treatment of on-site renewable generation. From the building (consumer facility) perspective, on-site generation is considered supplemental electricity that does not incur transmission or production losses. From the system (electric grid) perspective, on-site generation replaces a need for conventional electricity generation such that the total displaced electricity is used in the RAC test numerator. In contrast, utility-scale renewable generation is always assumed to displace conventional electricity.

[25] H. Pechan & Associates, Inc., "The Emissions & Generation Resource Integrated Database for 2010 (eGRID2010) Technical Support Document," Prepared for the U.S. Environmental Protection Agency, Office of Atmospheric Programs, Clean Air Markets Division, Washington, D.C., December 2010.

[26] U.S. Environmental Protection Agency, OAR, Climate Protection Partnerships Division. Climate Leaders Greenhouse Gas Inventory Protocol, June 2014. http://www.epa.gov/climateleadership/documents/resources/stationarycombustionguidance.pdf.

[27] Note that the source energy displaced from renewable sources is different than the source renewable energy generated. Tables with the source energy displaced from renewable sources by BPA can be found in Appendix M.

[28] "SEP Recovery Act Financial Assistance Funding Opportunity Announcement," Section 5.7, pg 28. March 12, 2009. http://energy.gov/sites/prod/files/edg/media/ARPA-E_FOA.pdf (accessed November 15, 2014).

It should be noted that while the RAC test captures only the energy savings cost benefits, there are other cost-effectiveness metrics that could be examined that address different EECBG benefits and objectives. This is especially true for renewable generation where the primary objective was avoided generation of fossil fuels and the associated reduction in carbon emissions, rather than on-site electricity savings.

A present value ratio was also computed to compare the present value of EECBG-attributable participant energy bill savings to the present value of program expenditures. For this cost-effectiveness test, a ratio greater than 1.0 means the lifetime value of the bill savings is greater than total program spending, and a ratio below 1.0 means that program spending exceeds the lifetime value of the energy bill savings. For this analysis, a discount rate of 2.7% is applied.[29]

Additional information concerning the bill savings and cost effectiveness methodologies used in this evaluation can be found in Section 2.5.4 and Appendix K.

ES.7.7. Organizational and operational performance factors

The evaluation of the EECBG program included an investigation into the potential relationship between various program organization and operational features and performance, defined as the amount of EECBG-attributable energy saved per grant dollar expended. This was done through a statistical regression analysis using energy savings per dollar spent as the dependent variable, with a set of independent variables representing factors relevant to the operation of the grant activity, the context of the state in which the activity was conducted and selected other factors. The specific factors of interest were identified by the evaluation team and its advisors and relevant data were collected through questions placed in the survey of grant managers. Data on other variables of interest were obtained from secondary sources and included heating and cooling degree days, unemployment rate, and retail rate of electricity averaged over the grant period (2009-2011).

More information regarding the methodology used in conducted the performance assessment can be found in Section 2.5.6 and Appendix L.

[29] For this analysis, a discount rate of 2.7 percent is applied. This rate is the "risk-free" real interest rate on the U.S. 30-year Treasury bond as of 2009, as reported in OMB circular A-94.[29] We also provide results using a range of discount rates from 0.7 percent to 4.7 percent to assess the sensitivity of these results.

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