NATIONAL EVALUATION OF THE ENERGY EFFICIENCY AND CONSERVATION BLOCK GRANT PROGRAM

Volume I

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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 (CO_2) 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.

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[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.

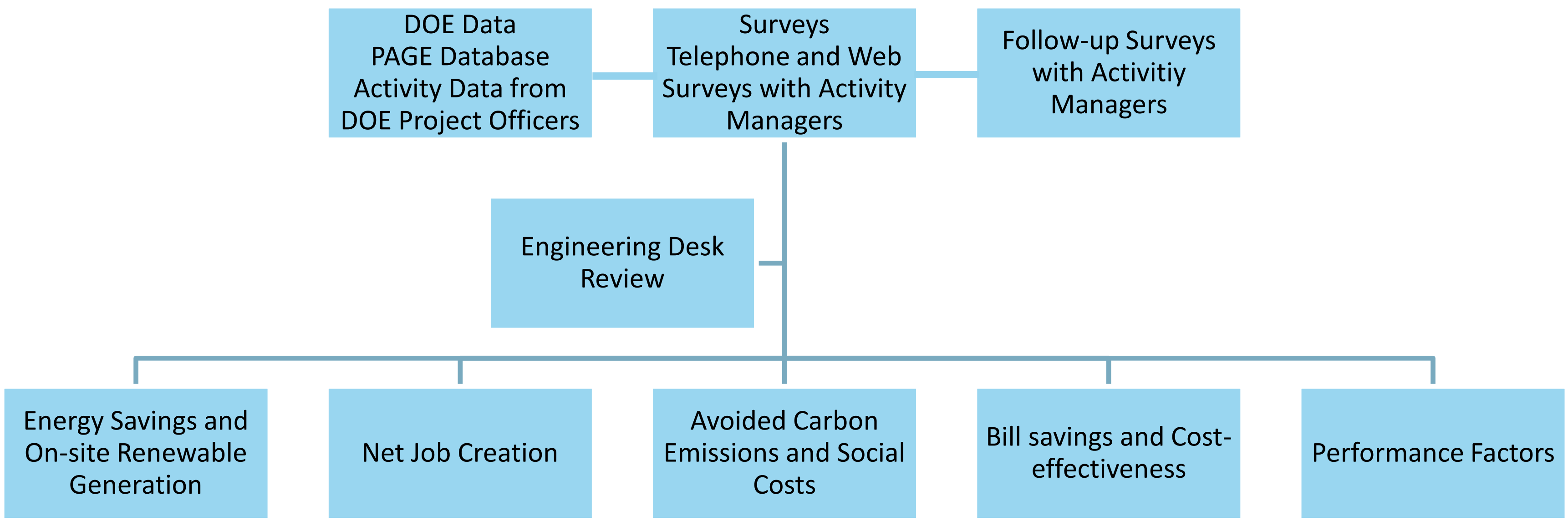

Figure ES-1: Summary of EECBG evaluation approach

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.

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[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.

1. INTRODUCTION

This report presents the findings, methodology, and results of an evaluation of the Energy Efficiency and Conservation Block Grant (EECBG) Program, a national program administered by the US Department of Energy (DOE). 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 covered the entire formal program period from 2009–2011, allowing for some grant extensions that stretched into 2013.[30]

The principal objective of the EECBG evaluation was to develop independent estimates of the following key program outcomes:[31]

- Reduction in energy use and production of energy from renewable sources,
- Generation of jobs through the funded activities,
- Reduction in carbon emissions associated with energy production and use, and
- Reduction in energy costs and program cost-effectiveness.

All impacts reported are EECBG-attributable impacts, meaning they are the impacts that occurred as a result of EECBG funding.

In addition, a performance analysis was performed to search for organizational and operational factors that could affect the energy savings achieved per grant dollar expended.

1.1. Program description

The EECBG program was created to help eligible state and local government entities and Indian tribes develop, promote, implement, and manage energy efficiency and conservation efforts.

EECBG was authorized by Title V, Subtitle E of the Energy Independence and Security Act (EISA), and signed into law December 19, 2007. EECBG was funded by the 2009 American Recovery and Reinvestment Act (ARRA), and ran for one program cycle under the direction of DOE. The Funding Opportunity Announcement (FOA) for formula grants was issued June 25, 2009 and closed June 25, 2010. The EECBG program was designed to enable grant recipients to create and implement projects to:

- Reduce fossil fuel emissions,
- Reduce total energy use, and
- Improve energy efficiency in the building and transportation sectors.

More than $2.7 billion was distributed through formula grants[32] to 2,187 cities, counties, states, territories, and Indian tribes across a range of 14 program categories referred to as broad program areas (BPAs). The grants funded slightly less than 7,500 individual programs, projects, or activities

[30] At the time of this report, there are still some programs in closeout and one grant that is still active.

[31] 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.

[32] Federal formula grants use a specific formula to calculate the distribution of funds to states.

(referred to herein as activities).[33] Grants could be used for a range of initiatives including energy efficiency building retrofits, financial incentives, building code support, renewable energy installations, distributed energy technologies, transportation activities, recycling and waste management efforts, and other activities approved by DOE.

Figure 1-1 summarizes how the funds were distributed across the scope of the program.

Figure 1-1: Scope of the EECBG program

Table 1-1 shows the final distribution of grant activities across the full range of BPAs. The table shows the number of activities and percent of program funding received for each BPA. The table also shows the cumulative funding total for the BPAs. The first six BPAs (highlighted in bold in the following table) represent 82% of the dollars spent under EECBG and 74% of the total number of activities. The EECBG evaluation focused on these six BPAs.

[33] 7,394 activities were listed in the PAGE database as of March 2011. This figure did not include activities funded through sub-grants of EECBG funds to states, so the total number of funded activities is higher.

Table 1-1: Distribution of EECBG grant activities by BPA

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**

[1]Activities in the EECBG program are classified into 14 BPAs. The energy efficiency and conservation strategy BPA has been split into direct and indirect grants because the indirect portion of this BPA is outside the target population for this evaluation. Indirect grants in this BPA are excluded due to the inability to obtain a respondent in this group for this evaluation.

1.2. Evaluation objectives and approach

1.2.1. Evaluation objectives

The work carried out in this study was guided by an evaluation plan provided in a competitive solicitation issued by ORNL, the agency responsible for overseeing independent evaluation of the program. The evaluation plan outlined two key objectives for the study:

- Objective 1: Accurately quantify the principal outcomes achieved by DOE’s $2.7 billion formula grant investment in energy efficiency.
- Objective 2: Determine the most effective types of activities supported by the program, and identify key organizational and operational characteristics related to successful performance.

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

1. What is the total lifetime magnitude of impacts achieved by the six studied BPAs, together, for each of the following outcomes? [34]
   - Energy savings and on-site renewable energy generation (expressed in source MMBtu)[35]
   - Labor impacts (expressed as the net number of jobs created)
   - Avoided carbon emissions (expressed as million metric tons of carbon equivalent (MMTCE) reduced) [36]
   - Bill savings and cost-effectiveness (expressed as both cost and energy saved per dollar spent)
2. What is the lifetime effect of the above-named outcomes achieved by each of the six studied BPAs, individually?
3. What are the key organizational and operational factors influencing the magnitude of EECBG outcomes? Performance was defined as the amount of energy saved per dollar spent, a figure that was then used as the dependent variable in a regression model that examined a range of possible variables.

The methodologies used to answer these questions are described in Section 2 of this report. Results associated with questions 1 and 2 are presented in Section 3, and results associated question 3 are presented in Section 4.

1.2.2. Summary of evaluation approach

The EECBG evaluation was based on an engineering analysis used to estimate 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, bill savings and cost-effectiveness, and performance factors. Figure 1-2 on the next page summarizes the evaluation approach.

The key components in the evaluation included:

Characterizing the full set of EECBG program activities in terms of BPAs and measures of size. The principal objectives of this step were to:

- Develop the sample frame from which the individual program activities to be evaluated were selected and analyzed
- Develop the information needed to expand the results from the sampled program activities to estimate total impacts for the BPA groups
- Gather information on the level and quality of available program documentation, which was used to make the final determination of engineering approaches that were used

Developing the sample of individual program activities for evaluation. The contractor team selected a primary sample of 562 program activities from the total pool of grants and sub-grants listed in PAGE.

[34] 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.
[35] Energy savings, such as reduced consumption of electricity or natural gas, is the primary objective of EECBG grants and thus the evaluation did not include an estimation of demand impacts.
[36] Carbon emissions use energy savings from energy efficiency and displaced energy as a result of renewable energy generation.

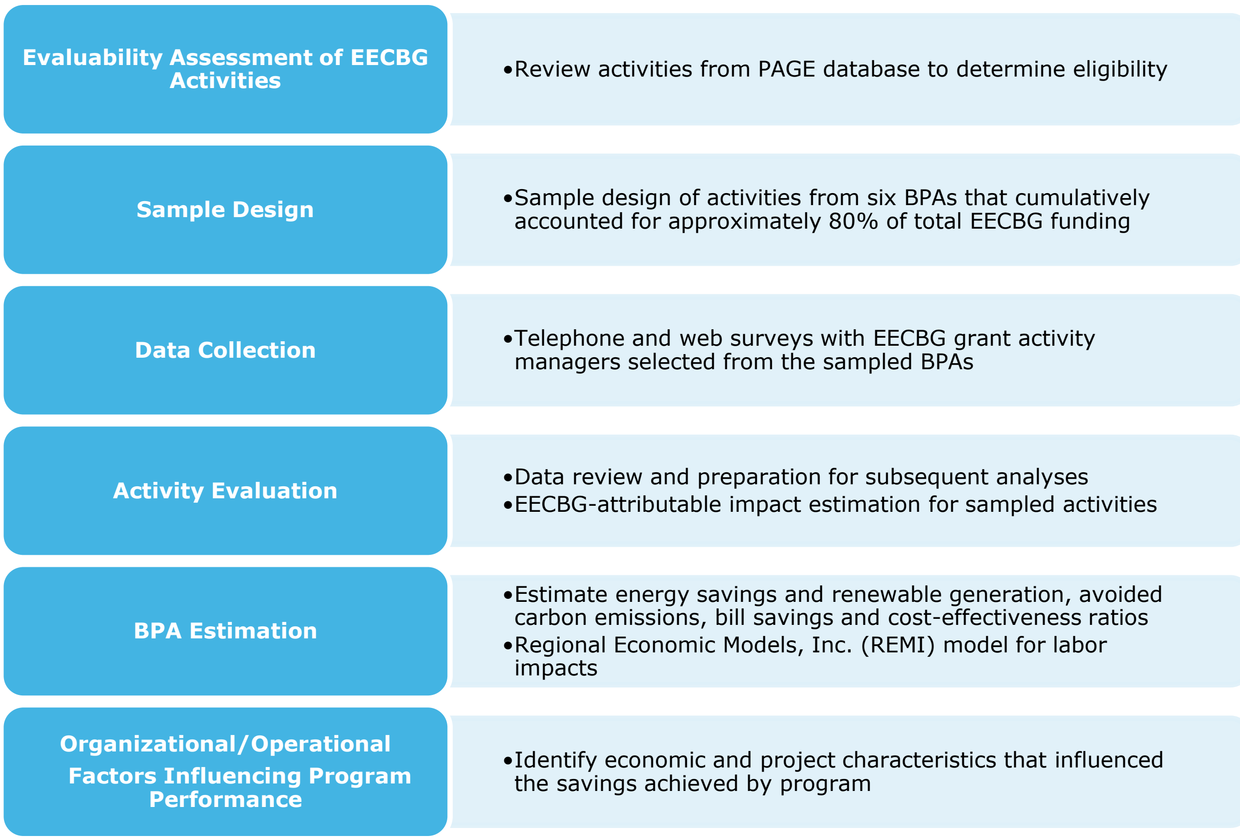

Figure 1-2: Overview of study Approach

Assessing the "evaluability" of the sampled individual program activities. The contractor team developed a set of criteria for determining whether a program activity that was selected for the sample had adequate information concerning the energy-saving actions taken to render a reasonable estimate of outcomes. The steps included the following:

1. Confirm progress in implementation.
2. Confirm the availability of program records and the completeness of those records.
3. Use the telephone survey to eliminate non-energy-producing activities, such as activities for administrative support.

Of the 562 sampled activities, 317 completed the evaluability stage representing a 56% response rate.

Conducting engineering analyses to estimate energy impacts of the selected activities. Each activity selected in the sample was assigned to a project engineer to review all available data, associated with the activity. A total of 169 of the 317 activities completed this stage in the process, which yielded a response rate of 53%. The total evaluation response rate for the telephone survey results and the impact evaluation combined was 30%.[37] All estimates and results presented in this report were derived from the 169 responding activities.

The contractor team quantified the energy savings for each of the 169 activities. The savings estimates were based upon data and information from the following sources:

- Activity data and documentation including grant applications and quarterly reports from PAGE
- Additional documentation for the activities provided by the DOE Program Officers
- Telephone and web surveys with the activity project managers
- Follow-up telephone interviews with the activity project managers who were directly involved and most knowledgeable of the activity to obtain additional information required for the analysis that was not available from either the various DOE databases or surveys

These data were combined with documented input assumptions and used in industry standard engineering formula to estimate savings for all or a sample of participants. These engineering formulae have been vetted and used throughout the energy efficiency evaluation industry. This included:[38]

- Attributing estimated energy impacts to EECBG and other sources for the individual program activities. For each selected activity, analysts determined what portion of estimated energy impacts was attributable to the EECBG program and what portion was due to other influences, such as general developments in the market or activities of other organizations offering similar kinds of programs or services. Attribution of effects was assessed separately for each selected activity studied, and was based on information collected from the activity managers. Impacts are assumed to end 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.
- Estimating energy cost savings. For each selected activity, analysts calculated the value of annual energy savings and bill savings over the effective useful life[39] of the activity.
- Estimating effects of individual activities on carbon emissions. Estimates of annual and lifetime energy savings attributable to the program were used as inputs for a carbon emissions reduction model based on the carbon content of fossil fuels and electricity consumption avoided.
- Estimating effects of individual activities on employment. The energy savings estimates were combined with other program information—such as matching funds, participant expenditures for labor and materials, and direct program expenditures—and were used as inputs into a regional economic model to estimate net employment impacts.

Once the individual activity evaluations were completed and reviewed for accuracy and completeness, the results were aggregated to the BPA level.

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[37] The final sample size in the BPAs of 169 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 produce results not representative of the population.

[38] This approach is commonly referred to as engineering-based assessment or statistically adjusted engineering assessment.

[39] 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.

1.3. Guidance on interpreting the findings in this report

This study was based on a complex sample design, and the data were analyzed using sample weights created from a multi-phase weighting process (summarized in Appendix C). [40] Proper interpretation of the results of such complex studies requires consideration of various caveats that are typical and expected for such an evaluation. When reviewing the findings presented in the remainder of this report, the following should be noted:

- Estimates are derived from a selected probable sample of activities, and therefore, like all sampling approaches, are subject to sampling error. Sampling error occurs due to variations inherent in the sample selection and data collection methodologies used. Estimates of sampling error associated with several statistics are presented in Appendix M in the form of a margin of error. The sampling error for some statistics can be large due to the small sample size and high degree of variability across the data used to derive an estimate.
- All tables in this report employ the following conventions:
  - "-" indicates that the estimate rounds to zero and is considered imprecise. Note that an estimate that equals zero, or rounds to zero, does not necessarily mean the corresponding population parameter is zero. Estimates are derived from a sample and, as noted above, are subject to sampling error. The relative sampling error associated with small estimates is generally large in this study due to the small sample size and high degree of variability in the data collected from the activities.
  - "*" indicates that the estimate exhibits low precision. Low precision estimates have a relative standard error greater than 75%, or a sample of four or fewer BPA activities.
- Estimates considered imprecise, or that exhibit low precision, should be interpreted cautiously. The estimates may differ greatly from the population parameters that they estimate. However, these estimates are useful as a measure of what was observed with the sample of activities selected for this study.
- Estimates presented in any table may not sum to the estimates reported in the "Total" row and “Total” column due to rounding, suppression of estimates that round to zero, or because the units associated with estimates changed in a row or column.
- The precision of estimates associated with energy savings, renewable generation, and bill savings is summarized in Appendix M.
- Estimates of precision are not presented for labor impacts, avoided carbon emissions, and several cost-effectiveness estimates presented in this report. These estimates, however, are subject to sampling error that is likely of the same magnitude as that reported for the energy impact and bill savings estimates. This is discussed in Appendix M.

[40] Each responding activity was assigned a sample weight, or expansion factor, that was used during the final analysis and estimation process to form appropriate estimates for the entire target population from the respondent data. The activity-level weights that allowed the activity-level results to expand back to the BPA target population consisted of several components. These included the inverse of the probability of selecting the activity, adjustments to account for nonresponse at the CATI and evaluation phases of data collection, and several components that were applied to calibrate the weighted funding estimates to the best estimate of total target population funding for each BPA that was available at that stage in the weighting process.

1.4. Limitations of the Study

This evaluation was supported by a healthy budget and timeline and was based upon sound evaluation practice and methodology. Even so, a few factors contributed to potential limitations of the study and are acknowledged here:

1. Lack of direct contact with project managers and end users – The study design, which was crafted to maximize the number of activities studied, did not allow primary data collection from end users and direct project managers. Rather, surveys were conducted with program managers that administered the grants.
2. The Organizational Factors analysis produced interesting but limited outcomes that would benefit from a larger set of questions and separate analysis by BPA, two features that were not possible under the scope of this study, but that might prove fruitful in future investigations.
3. One time nature of the EECBG Program – Although not a limitation of the evaluation, it should be noted that the EECBG program's one-time nature may have contributed to difficulties in getting detailed surveys completed after program operations had ceased.

1.5. Structure of the report

The remainder of this report is organized as follows:

- Section 2 - Methodology: This section presents an overview of study methods, sampling, research and data collection activities, outcome estimation approaches, and weighting methods. Much of the detailed description of methodologies is presented in the appendices.
- Section 3 - EECBG findings by outcome: For each outcome, the total impacts are presented, followed by BPA-specific estimates.
- Section 4 - References: This section lists all references cited in the study.

The appendices are located in additional volumes. The appendices cover all detailed methodologies, research activities, data collection dispositions, survey instruments, and summary tables of detailed energy impacts and customer bill savings by fuel type.

Table 1-2 lists the appendices included in the study.

Table 1-2: EECBG report appendices

Appendix	Appendix Title
Appendix A.	Summary of Research Planning Activities
Appendix B.	Final Data Collection Disposition
Appendix C.	Detailed Sampling and Weighting Methodology
Appendix D.	Final Evaluability Assessment Methodology
Appendix E.	Final BPA Population Data
Appendix F.	Detailed Activity-level Energy Impact Estimation Methodology
Appendix G.	EECBG-Attributable Impact Methodology
Appendix H.	Detailed BPA Expansion Methodology
Appendix I.	Detailed Labor Impact Methodology
Appendix J.	Detailed Carbon Impact Methodology
Appendix K.	Detailed Bill Savings and Cost-effectiveness Methodology
Appendix L.	Organizational/Operational Factors Methodology
Appendix M.	Summary Tables of Detailed Energy Impacts and Customer Bill Savings
Appendix N.	Data Collection Instruments

2. METHODOLOGY

2.1. Overview of study methods

The basic flow of the study approach, from determining eligible activities to identifying factors that influenced program savings, is shown in Figure 2-1.

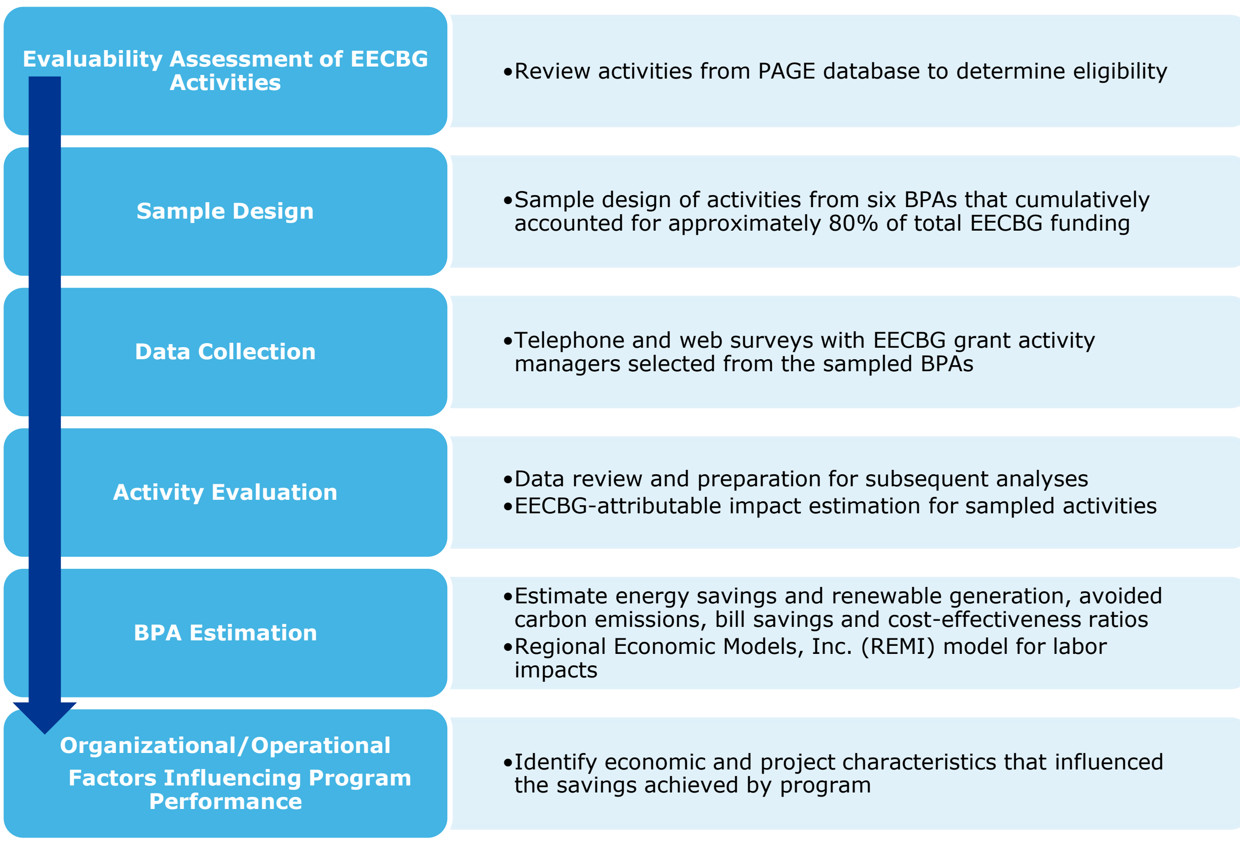

Figure 2-1: Overview of study approach

The first step in the study was to review the available program data and to assess the evaluability of the program activities, starting with the acquisition of program tracking data from DOE's PAGE information system. The database includes information such as funding amounts, contact information, activity descriptions, and completion status for nearly 7,500 EECBG activities.

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. The target population is formally defined in Section 2.3. This section also contains a summary of how the sample of activities was selected for this evaluation.

During the activity evaluation phase, the contractor team collected activity-specific data and evaluated energy savings and renewable generation impacts over the effective useful life[41] of all efficiency measures and renewable technologies for the selected activities. Data were collected using both a computer assisted telephone interview (CATI) and a web-based data collection instrument. Additional detail on the data collection methodology is provided in Section 2.4.

Key data parameters from the final set of responding activities, including estimates of energy savings and renewable generation impacts, were then extrapolated to the BPA level through a sample weighting process. While energy savings and renewable generation estimates at the BPA level were derived directly from this process, outcomes (such as avoided carbon emissions, cost effectiveness, and labor impacts) required additional calculation steps. Additional detail on the BPA estimation process is provided in Section 2.5.

The final step in the evaluation was to examine the organizational and operational factors of the activities that explained the relative level of savings per EECBG dollar, and to quantify the relationship between those characteristics and activity performance. Section 2.5.6 describes this process further.

The discussions below summarize the various methodologies used to select activities, collect data, and create the final estimates from this evaluation. These tasks are provided in greater detail in Volume II of this study report.

2.2. BPA components researched

This study was guided by a scope of work and summary plan developed by ORNL and independent contractor TecMarket Works in 2011. In February 2012, the contractor team developed a detailed evaluation plan to serve as a road map for conducting the evaluation of the EECBG program.[42] The plan outlined two key objectives for the EECBG evaluation. First and foremost, the goal was to accurately quantify the principal outcomes achieved for the six most heavily funded BPAs separately and for all six together. The second goal was to identify key organizational and operational characteristics related to successful performance.

This evaluation focuses on three key research questions:

1. What is the total lifetime magnitude achieved by all the studied BPAs, together, for each of the following outcomes?
   - Energy savings and on-site renewable energy generation (expressed in source MMBtu)[43]
   - Labor impacts (expressed as the net number of jobs created)
   - Avoided carbon emissions (expressed as million metric tons of carbon equivalent reduced)
   - Bill savings and cost-effectiveness (expressed as both cost and energy saved per dollar spent)
2. What is the lifetime magnitude of the above-named outcomes achieved by each of the six studied BPAs individually?

[41] 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.

[42] Evaluation Work Plan – Energy Efficiency Conservation and Block Grant Program, February 9, 2012.

[43] Energy savings, such as reduced consumption of electricity or natural gas, is the primary objective of EECBG grants and thus the evaluation did not include an estimation of demand impacts.

3. What are the key organizational and operational factors influencing the magnitude of EECBG outcomes? Performance was defined as the amount of energy saved per dollar spent, a figure that was then used as the dependent variable in a regression model that examined a range of possible variables. The methodology and results of the performance factors analysis are described in Sections 2.5.6 and 4.

2.3. Sampling selection methodology

Given the breadth and variety of activities that received funding, the evaluation of EECBG began with a randomly selected sample of activities within groups defined by BPA and grant type (indirect or direct grants[44]). Some of the largest activities were selected *purposely* for this evaluation—these were the activities that received the largest amount of funding from the EECBG program. However, most of the activities were *randomly* selected with probability proportionate to their funding. This is important for several reasons:

- Selecting activities randomly means the estimates resulting from the evaluation will not have any bias in the sample design.
- Random selection means the precision of estimates can be estimated.
- Selecting activities proportional to funding means those activities that received a larger amount of EECBG funding received a proportionally higher chance of being selected for this evaluation. However, all activities that received some funding have a chance of being selected, so there in no coverage bias in estimates resulting from this evaluation.[45]
- Selecting activities proportional to funding will also yield more precise estimates because most of the key outcome measures of interest will be highly correlated with funding within a BPA. For example, the total amount of electricity energy savings from a program will likely be highly correlated with the amount of funding it received within any particular BPA.

Figure 2-2 provides more detail of the study approach presented in Figure 2-1, which summarizes the sampling selection methodology, data collection process, and analysis steps associated with this evaluation. Section 2.3.1 presents some additional detail on the sampling approach; Section 2.3.2 presents a discussion of the frame, sample, and respondent distributions; Section 2.3.3 summarizes the weighting methodology; and Section 2.3.4 presents a discussion of the estimated precision associated with estimates from this evaluation. Additional detail on the sampling methodology can be found in Appendix C. Additional discussion on the data collection methodology and estimation process can be found in Sections 2.4 and 2.5.

[44] Direct grants are those that are awarded directly to a recipient. Indirect grants are awarded to state/territorial agencies that then disburse funds to subrecipients.

[45] Coverage bias is when the estimated value deviates from the population due to excluding certain groups or individuals from the sample frame.

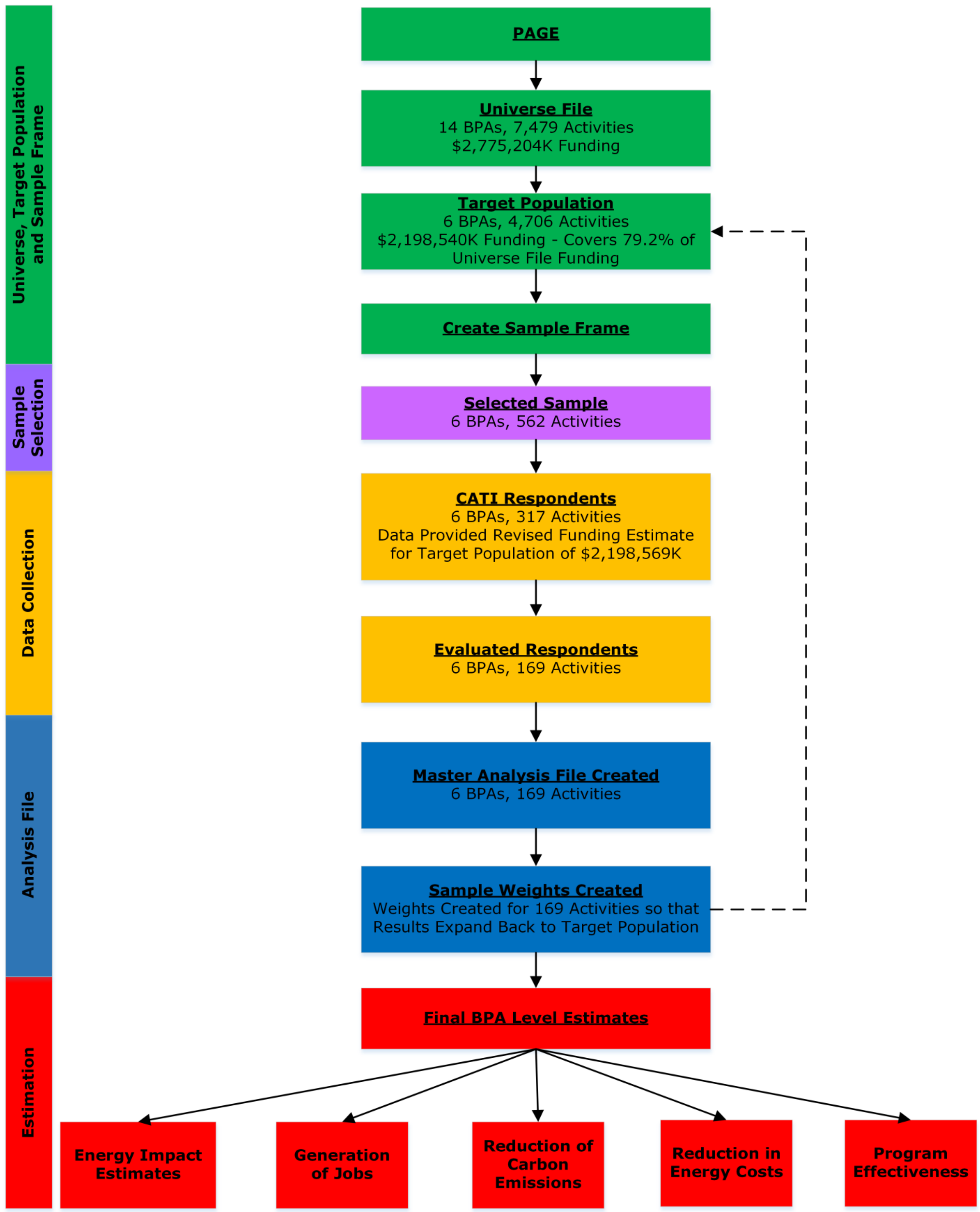

Figure 2-2: Summary of the EECBG sample selection, data collection, and estimation processes

2.3.1. Overview of sampling approach

The sample for this evaluation was selected randomly to yield statistically defensible, reliable, design-unbiased estimates that can be confidently used in subsequent studies. A stratified random sample of activities was selected from a list of all activities in the target population with probability proportionate to each activity's funding. This means those activities that received a greater amount of funding from the EECBG program had a proportionally higher chance of being selected for this evaluation. However, all activities within BPAs of interest had some chance of being selected. Sampling was performed in the following steps:

1. The target population was defined. The target population refers to the set of activities in the population that estimates of this study would apply to.
2. A suitable sample frame was constructed. The sample frame is a list of all activities in the target population.
3. A random sample of activities was selected from the frame within major groups of interest. The major groups of interest in this evaluation were BPA and grant type (direct and indirect grants). These groups define the stratification that was used when selecting the sample.

Some additional detail on these steps is provided next. A complete summary of the sample design and selection process is provided in Appendix C.

2.3.1.1. Target population

The target population is defined as the set of activities that the evaluation is designed to draw conclusions about. In other words, the target population is the inferential population of interest.

In order to obtain results from this evaluation in a cost-effective manner, DOE decided to restrict the target population of this evaluation so that it covered approximately (but no less than) 80% of the total amount of EECBG funding awarded. This was achieved by restricting the initial set of EECBG activities as follows:

- This evaluation was designed to make inferences about activities associated with the six most heavily funded BPAs, which are the first six shaded in orange in Table 2-1.
- Only those activities in these largest BPAs that received more than $10,000 in funding would be considered for this evaluation.
- Activities that had not started and had not spent any funding dollars at the time the sample was being drawn were excluded from the evaluation.

Activities that received funding from the EECBG program were partitioned into the 14 BPAs noted in Table 2-1. These same activities were also divided into two grant types: direct and indirect. Direct grants are those that are awarded directly to a recipient. Indirect grants are awarded to state and territorial agencies that then disburse the funds to sub-recipients. The distinction is important because different data collection approaches were needed for the two types of funding mechanisms, and it was expected that energy impact estimates would be considerably different between them for each BPA.

Because of its importance, grant type (direct and indirect or sub-grant) was considered an important stratification variable in the sample selection process, and the sample was designed and selected to ensure an appropriate representation of both direct and indirect grants in target BPAs. The stratification used in the sample selection process is discussed in Section 2.3.1.3.

Table 2-1: Distribution of EECBG activities and funding by BPA

Broad Program Area (BPA)	Activities	Percent of Activities	Cumulative Percent of Activities	Funding (in thousands of US$)	Percent of Funding	Cumulative Percent of Funding
Energy Efficiency Retrofits	2,525	33.8%	33.8%	$1,077,760	38.8%	38.8%
Financial Incentive Program	361	4.8%	38.6%	$497,494	17.9%	56.8%
Buildings and Facilities	784	10.5%	49.1%	$270,503	9.7%	66.5%
Lighting	637	8.5%	57.6%	$197,059	7.1%	73.6%
On-site Renewable Technology	456	6.1%	63.7%	$165,974	6.0%	79.6%
Energy Efficiency and Conservation Strategy (Direct Grants)	735	9.8%	73.5%	$72,057	2.6%	82.2%
Transportation	533	7.1%	80.6%	$118,013	4.3%	86.4%
Other	79	1.1%	81.7%	$77,236	2.8%	89.2%
Technical Consultant Services	518	6.9%	88.6%	$66,363	2.4%	91.6%
Residential and Commercial Buildings and Audits	443	5.9%	94.5%	$63,712	2.3%	93.9%
Energy Efficiency and Conservation Strategy (Indirect Grants)	24	0.3%	94.9%	$57,355	2.1%	96.0%
Material Conservation Program	164	2.2%	97.1%	$33,130	1.2%	97.2%
Energy Distribution	68	0.9%	98.0%	$30,245	1.1%	98.3%
Reduction/Capture of Methane/Greenhouse Gases	42	0.6%	98.5%	$30,122	1.1%	99.3%
Codes and Inspections	110	1.5%	100.0%	$18,180	0.7%	100.0%
Total	**7,479**	**100.0%**		**$2,775,204**	**100.0%**	

Note: Activities in the EECBG program are classified into 14 BPAs. The energy efficiency and conservation strategy has been split in this table into direct and indirect grants because the indirect portion of this BPA is outside the target population for this evaluation. Indirect grants in this BPA are excluded due to the inability to obtain a respondent in this group for this evaluation. Funding may not sum to the total displayed in this table due to rounding.

One of the six BPAs with the greatest funding was energy efficiency and conservation strategy. Both direct and indirect grants associated with this BPA were initially included in the target population. However, none of the representatives of any of the sampled indirect grants in this BPA responded during data collection. Consequently, the indirect grant portion of the BPA was excluded from the final target population for this study, and is referred to in this report as energy efficiency and conservation strategy (direct grants).

Table 2-2 presents a summary of the final target population for this evaluation. The target population covers 79% of the funding of the original EECBG population (noted in Table 2-1), which is just under the initial target of 80%. The target population covers 63% of the total activities. Note that coverage within the six BPAs is not 100% because those activities that received less than $10,000 in funding and those that did not start at the time the sample was being drawn were omitted from the target population.

Table 2-2: Summary of EECBG evaluation target population

Broad Program Area (BPA)	EECBG Universe		Target Population			
			Funding (in thousands of US$)		Activities	
	Funding (in thousands of US$)	Activities	Total	Percent of Original BPA Covered	Total	Percent of Original BPA Covered
Energy Efficiency Retrofits	$1,077,760	2,525	$1,042,878	97%	2,187	87%
Financial Incentive Program	$497,494	361	$491,138	99%	320	89%
Buildings and Facilities	$270,503	784	$252,939	94%	667	85%
Lighting	$197,059	637	$185,066	94%	572	90%
On-site Renewable Technology	$165,974	456	$161,825	98%	400	88%
Energy Efficiency and Conservation Strategy (Direct Grants)	$72,057	735	$64,694	90%	560	76%
Total BPAs Evaluated	**$2,280,847**	**5,498**	**$2,198,540**	**96%**	**4,706**	**86%**
Total EECBG Universe	**$2,775,204**	**7,479**	**$2,198,540**	**79%**[1]	**4,706**	**63%**[1]

[1]Coverage compared with the EECBG universe file that contains 7,479 activities and $2,775,204K in EECBG funding. Funding may not sum to the totals displayed in this table due to rounding.

As discussed earlier, this evaluation originally intended to target both direct and indirect grants in the energy efficiency and conservation strategy BPA. If responses could have been obtained from the sample indirect grants in this BPA, the total funding associated with grants in the target population of this study would have accounted for 83% of the entire EECBG universe file instead of 79%. The 83% is slightly more than the 80% target.

2.3.1.2. Sample frame

The next step in the sample selection process was to develop an appropriate sample frame of activities. In this evaluation, the **sample frame** was simply a data file where each record in the file represented an activity in the target population.

The sample frame was constructed beginning with the creation of a **universe file** from PAGE that accounted for all funding distributed from the EECBG program. Program activity-level data were extracted from the PAGE system March 30, 2012. The data provided a wealth of information for the construction of the sample frame. This included proposed and spent funding for each activity, BPA classification for each activity, activity outcomes, state, and grant number. After the universe file was constructed, those activities not in the target population were removed and the resulting file was the sample frame for this study. Consequently, the sample frame and target population were equivalent.

2.3.1.3. Sample selection methodology

A total of 562 activities were selected for the evaluation, including 452 direct grants and 110 indirect grants. Initially, the sample was designed to achieve 350 evaluated activities distributed across the six BPAs of interest in proportion to funding amounts. This target was modified and the original sample was supplemented to account for higher than anticipated nonresponses in some BPAs. The 562 activities selected in the sample reflect the changes made during data collection and represent the final selected sample size.

The final sample of activities was selected from the frame with probability proportionate to funding using a stratified, systematic sampling approach attributed to Chromy (1979).[46]

In the EECBG program, individual sets of program outcomes that allowed DOE to monitor progress on an activity's scope of work were referred to as **process metrics**. EECBG recipients were required to report on one primary process metric per project activity on a quarterly basis. In general, recipients chose metrics based on which set most accurately described their project activity, regardless of the BPA category the activity fell under.

Using Chromy's procedure, activities were selected within groups, or strata, defined by BPA and grant type (direct or indirect). Sample selection was done independently between these strata, so BPA and grant type were the **explicit stratification variables** in the design. For sample selection purposes, within each explicit stratum the frame was ordered by primary process metric (outcomes) and funding prior to the systematic selection. So, the primary process metric was the **implicit stratification variable** in the sample selection process.

Since activities were selected with probability proportionate to their funding, those activities that received a larger amount of funding were given a proportionally higher chance of being selected into the sample. Within each explicit stratum on the sample frame, some activities received a comparatively large portion of funding. Those activities with the largest amount of funding were selected with certainty. In this context, **selecting a sample with certainty** means the activity was purposely chosen for the evaluation outside the random selection process, so its probability of being in the sample was 1.00. Selecting the activities with the largest amount of funding with certainty is beneficial because it increases the precision of the final estimates by including a larger proportion of the frame funding in the sample. The random, systematic sampling process was conducted to select the noncertainty sample of activities.

2.3.2. Summary of frame, sample, and respondents

Once a sample was selected, the team conducted evaluability assessments of each activity to determine the likelihood of obtaining sufficient information to evaluate the activity. Activities that were deemed evaluable were then moved to the next data collection phase. As part of the evaluability assessment, grant activity managers for each activity were contacted by telephone for an interview to confirm data about the grant and selected activity as indicated in PAGE, and to identify the person most knowledgeable about the activity in question for a subsequent web-based survey. Each contact was asked a series of questions including a set of verification questions to check the BPA assignment

[46] Chromy, J. R. (1979). Sequential sample selection methods. In Proceedings of the 1979 American Statistical Association, Survey Research Methods Section pp. 401-406.

associated with the activity and funding received from the program. Responses to the verification questions revealed some changes in BPA assignment and funding, which were incorporated during the analysis and estimation phase of the study. Therefore, the BPA assignment and funding assigned to each activity during estimation were the corrected values of these variables resulting from the CATI interview.

For each sampled activity, contacts who completed the CATI were subsequently asked to send 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. As noted in the previous section, 562 activities were selected for this evaluation; of those, 317 contacts were interviewed. Of these, 169 were considered evaluable, meaning they submitted adequate amounts of information necessary to estimate energy impacts, and represent the set of final respondents for this evaluation.

Table 2-3 provides a summary of the sample frame (column A), the selected sample (column B), the CATI respondent sample (column C), and the sample of respondents with the reassigned BPA category and new funding data applied (column D). Column E reflects the final sample generated from this evaluation (e.g., the evaluable sample). The weighting funding estimates equal column D by design. Column E reflects Column D data but represents the final weighted sample that was evaluated in the study. The estimated total amount of funding in these six BPAs changed slightly from $2,198,540,000 to $2,198,569,000 as a result of the corrected data collected during the CATI interviews.

Table 2-3: Summary of sample frame, selected sample, CATI sample, and final evaluated sample by BPA

BPA	A. Frame		B. Selected Sample		C. CATI Respondents (Using Frame BPA and Funding Data)		D. CATI Respondents (Using New BPA and Funding Data)		E. Evaluated (Final Respondents and Final Weight)	
	Funding	Activities	Funding[1]	Activities	Funding[1]	Activities	Funding[1]	Activities	Funding[1]	Activities
Energy Efficiency Retrofits	$1,042,878	2,187	$1,042,878	277	$1,042,878	160	$1,070,071	167	$1,070,071	86
Financial Incentive Program	$491,138	320	$491,138	83	$491,138	49	$500,830	50	$500,830	14
Buildings and Facilities	$252,939	667	$252,939	70	$252,939	40	$210,853	29	$210,853	18
Lighting	$185,066	572	$185,066	58	$185,066	33	$193,286	36	$193,286	27
On-site Renewable Technology	$161,825	400	$161,825	52	$161,825	27	$157,801	27	$157,801	19
Energy Efficiency and Conservation Strategy (Direct Grants)	$64,694	560	$64,694	22	$64,694	8	$65,728	8	$65,728	5
Total	**$2,198,540**	**4,706**	**$2,198,540**	**562**	**$2,198,540**	**317**	**$2,198,569**	**317**	**$2,198,569**	**169**

All funding data in thousand US$. All funding data in thousands and represents the total funding for the BPA and may not sum to totals due to rounding.
Column C shows the activities categorized by BPA and funding level as originally indicated in PAGE. The CATI survey verified the BPA for each activity and reassigned the activity to BPA and revised funding level accordingly.

[1]This is funding estimated from weighted data. Funding may not sum to the totals displayed in this table due to rounding.

A summary of response rates of the samples by BPA are shown in Table 2-4. The final evaluated sample size will differ in this table compared with the one before (Table 2-3) because it reflects the original frame BPA classification.

The sample response rate was 56.4% for CATI respondents and 53.3% for the respondents who subsequently provided requested data including funding amounts. The final total response rate is the product of these two response rates, which is 30.1%.

Table 2-4: Study sample response rates by BPA

Sample Frame BPA	Frame Activities	Selected Sample	CATI Respondents	CATI Response Rate	Evaluable Respondents	Evaluable Response Rate	Final Response Rate
Energy Efficiency Retrofits	2,187	277	160	57.8%	82	51.3%	29.6%
Financial Incentive Program	320	83	49	59.0%	14	28.6%	16.9%
Buildings and Facilities	667	70	40	57.1%	25	62.5%	35.7%
Lighting	572	58	33	56.9%	24	72.7%	41.4%
On-site Renewable Technology	400	52	27	51.9%	19	70.4%	36.5%
Energy Efficiency and Conservation Strategy (Direct Grants)	560	22	8	36.4%	5	62.5%	22.7%
Total	**4,706**	**562**	**317**	**56.4%**	**169**	**53.3%**	**30.1%**

Note: The CATI response rate is the total number of CATI respondents divided by the selected sample. The evaluation response rate is the total number of evaluated respondents divided by the number of CATI respondents. The final response rate is the product of the two.

2.3.3. Sample weighting

A nonresponse adjusted and calibrated sample weight was created for each of the 169 final evaluated activities. The sample weight included a calibration adjustment so that weighted funding estimates from the 169 activities would equal the correct program funding estimates provided by CATI respondents. This sample weight was used to expand the activity-level data back to the BPA target population during the final estimation phase. All estimates were created using final sample weights so that estimates would reflect the original target population and not apply only to the 169 respondents. Weighting methodology details are provided in Appendix C.

2.3.4. Estimation and precision of estimates

Random sampling makes it possible to estimate the precision of all direct savings estimates generated from the weighted respondent data. The estimated precision, also known as the sampling error, was computed for many descriptive statistics in this report.

Appendix M lists most of the weighted impact estimates generated from the 169 evaluated respondents. For each estimate presented, its margin of error is provided in parenthesis beneath it. The 90% confidence interval for an estimate is the estimate +/- its margin of error, and the standard error of each estimate is roughly its margin of error divided by 1.66.

2.4. Data collection

The evaluation of the EECBG program is based upon information obtained from three key data sources:

- **Program Records** – PAGE and activity documentation and records reported by the EECBG activity managers were part of the data collected.
- **Primary Data Collection** – Telephone and web-based surveys were conducted with EECBG activity project managers closest to the activities sampled. This included a telephone survey to verify basic activities and program funding budgets, and to identify the correct contact to provide additional grant detail. The identified contact was given a self-administered web-based survey to provide detailed information regarding specific measures and energy efficiency projects.
- **Clarification Interviews** – Follow-up interviews with activity contacts were conducted to obtain additional activity-specific information required for the evaluation that was not provided by the program databases or the telephone surveys.

Figure 2-3 shows the relationship between these three primary data sources and key analytical components of the evaluation.

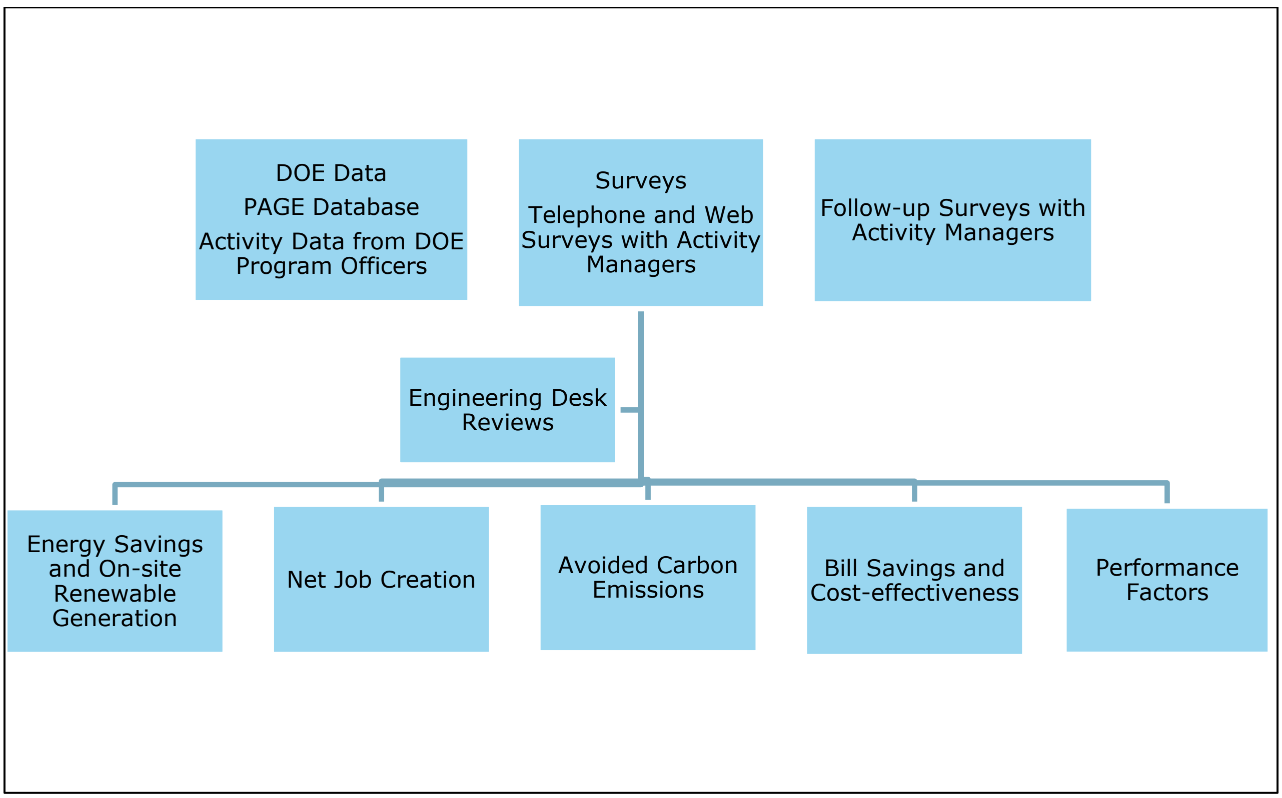

Figure 2-3: EECBG data collection processing flow

2.4.1. Reporting data and activity documentation

DOE's PAGE was the initial source for compiling activity-level data. The contractor team reviewed several key reports from PAGE and other sources. Below we list the reports used in the analysis and the information collected from each report.

Quarterly reporting to OMB – Required of grantees; may be delegated to sub-grantees

- Total amount of ARRA funds received from DOE
- Amount of ARRA funds expended on or obligated to projects or activities
- Detailed list of all projects or activities
- Information on subcontracts or sub-grants awarded by the prime recipient

Quarterly reporting to DOE (PAGE) – Required of all grantees

- All prime recipients are required to report quarterly through PAGE
- Two additional reports
    - Federal financial report (SF-425)
    - Performance report (at the level of activity):
        - Activity status
        - Activity milestones
        - Financial metrics
        - Process metrics
- Two categories of process metrics:
    - Jobs/hours worked
    - Standard program metrics – outlay and obligation of funds, amount of activity completed

2.4.2. Grant activity manager survey (GAMS) instruments

The GAMS instrument was the keystone of the evaluation. The survey collected data on the specific energy efficiency measures and projects associated with the activities sampled to be used for the energy savings calculations. Survey instruments are provided in Appendix N.

The survey instrument was tailored to collect information for residential and non-residential buildings. It addressed the following topics:

- Introduction and screening for correct respondent
- Confirmation of BPA activity categorization
- Respondent's role in the activity
- Building and firmographic characteristics
- Verification of measure-specific information
- Attribution
- Performance factors

A two-step approach was used for collecting information on specific grant activities selected for the sample.

First, CATI surveys were conducted with program activity managers for the purpose of confirming data about the grant and selected activity as indicated in PAGE, and for identifying the person most knowledgeable about the activity in question for participating in the web-based survey. If the activity manager was not the appropriate contact, the interviewer asked for contact information for the correct person. The phone survey also collected basic information such as confirmation of the BPA designation, grant activity description (the basis of sample selection), status of the implementation of the activity's measures, grant amount, and contact information for the individual being interviewed. Upon completion of the telephone survey, respondents were sent an email with a link to the online survey.

Second, the designated contacts provided additional detailed information through the self-administered online GAMS, which contained different sections used to elicit specific information. The survey was pre-populated with information collected during the telephone interview and designed to collect activity measure-level details for a comprehensive array of residential and non-residential energy efficiency equipment and projects. The survey was comprised of a series of modules; each module addressed a specific end use, such as residential lighting or non-residential heating. Respondents selected the modules that were relevant to their specific activity.

Attribution questions

Following the customized questions on program activities, all respondents were guided to a series of questions related to attribution. These questions were based upon industry-standard methods of probing for the extent to which a specific intervention—in this case the funding from the EECBG grant—influenced the actions taken. For example, how did the presence of EECBG funds affect the timing of the activity or the size of the project? The results of these questions were used to determine the level of savings attributable to the EECBG program.

Performance factors questions

The last section of the survey collected data related to program performance to help determine what factors influence the magnitude of the outcomes achieved. Section 4 of this report describes the data analysis in detail. Selected survey questions were designed to elicit information on some factors that may influence program performance, such as number of staff devoted to the project and number of times a grantee took advantage of available technical assistance. Data on external factors were also collected from secondary sources to enhance the analysis. Examples include heating- and cooling-degree days or a state efficiency score (see Section 4 for a more detailed discussion).

Follow-up interviews with grantee and sub-grantee activity project managers

After the web surveys were completed, the information collected for each activity was reviewed to determine if there were any remaining gaps in the data for calculating energy savings and if any of the responses needed clarification. While the surveys were carefully designed to elicit the information necessary to conduct the savings analysis, sometimes information required was unique to the specific activity and could not be collected using the survey. In those instances, engineers made follow-up calls to the activity project manager to ask for the limited amount of information that was still needed.

2.5. Impact methodologies

2.5.1. Activity-level energy savings and renewable generation estimation

The estimation of activity-level energy savings from energy efficiency measures 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 due to the EECBG contribution that would not have occurred without it.

2.5.1.1. Overall energy savings and renewable generation

This section describes the methods used to estimate energy savings and renewable generation impacts for each of the activities evaluated. The energy impacts referred to in this section correspond with "gross savings," a commonly used term in evaluations of utility energy efficiency programs. As noted earlier, this refers to *all* savings achieved by activities and not just that portion attributable to EECBG.

Table 2-5 shows the major data collection and impact estimation methods used for the various BPAs studied.

Table 2-5: Impact method groups

Impact Calculation Method	**Applicable BPAs**	**Number of Activities in Group**	
		Direct	Indirect
Standard Calculation Tool (Section F.4)	Energy Efficiency Retrofits	77	9
	Financial Incentive 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.[47]

Standard Renewable Protocol: Calculation methods were standardized for each of the following renewable technologies, using publicly available tools and methods: biomass combustion systems,[48,49,50,51] photovoltaic systems,[52] solar water heating,[53] and wind systems[54].

Each of the impact calculation methods shown in Table 2-5 are explained in more detail Appendix F. Section F.4 details the standard calculation tool used to calculate energy savings impacts from energy efficient equipment in all BPAs except on-site renewable technology and energy efficiency and conservation strategy. Section F.5 outlines the renewable standard protocol used for calculating energy savings and generation from renewable energy technologies. Section F.6 outlines the method used to calculate revolving loan impacts, which occurred for activities across several of the applicable BPAs.

For each of these methods, there were quality assurance and control (QA/QC) procedures in place to check the output for reasonableness. This included the data being reviewed by the lead analyst prior to analysis of the energy impacts. The analysts would check similar measure types against each other to look for outliers. In these cases, the analysts would go back to the SCT engineers to verify the inputs and outputs from the model. Other checks included checking the measures' fuel types, units and fuel values, checking measure types and fuel outputs against the project description. For example, they would make sure that a lighting program had a kWh savings output. Additional checks for reasonableness were done by the carbon, cost-effectiveness, and labor analysis leads before they began their work. Again, any flags raised by one of these leads would prompt a review by the engineering teams.

2.5.1.2. EECBG attributable savings

EECBG-attributable energy savings were estimated from project-level data using a standard methodology across all 169 activities. This section presents the standard evaluation approach used to assess the extent to which estimated impacts were the result of the program.

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47 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).

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

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

50 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.

51 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.

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

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

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

Program activities provided individual market actors with information, tools, and incentives to accelerate the adoption of targeted energy efficiency and renewable energy measures in specific projects. Assessment of program attribution relied on program manager reports that provided insight into how key decision makers made choices.

The standard attribution methodology is designed to answer the following two fundamental research questions for each evaluated activity:

1. Program effects on market actors

What would 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?

This question provides the framework for determining the portion of overall outcomes that are due to the program. Market actors include energy users and firms and individuals in the supply chain of energy using equipment, renewable energy generating equipment, and design, installation, and maintenance services. For EECBG, program effects were estimated based on online survey responses provided by program managers for the direct and indirect grants.

Program managers were asked a set of attribution questions directed at answering the question of how EECBG influenced participant behavior. The attribution battery sought to determine the answer to this question through three parameters: timing of participant behavior, quality of technology or service used by participant, and quantity of technology or service used by participant. These three factors, where appropriate, were the foundation for estimating a program's influence on a participant or other market actor's behavior.

For indirect grants, the same basic attribution battery was used, but for each parameter the program manager was asked to estimate the portion of the projects in the activity to which each response option applied.

2. Influence of EECBG activities on other program sponsors

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?

Here a conservative approach was taken based on the evidence. In many states, ratepayer funded programs targeted some of the same outcomes as EECBG activities. While some EECBG participants indicated that other programs had an effect on their decision-making to take efficiency actions, there was not clear evidence that EECBG had enough of an impact on other programs to claim additional indirect savings generated by those programs. Therefore, EECBG claimed no additional attributable savings beyond its own programs.

2.5.2. BPA-level energy 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) were 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 encountered during data collection. In summary, BPA-level estimates of energy savings presented in this report were computed by weighting the sample activity-level data with an expansion factor so that the estimates represents the entire EECBG population of activities within each BPA. Additional information on the direct survey estimation process, including information on how the precision of the estimates were computed, is provided in Appendix H.

Estimates for labor impacts, avoided carbon emissions, bill savings, cost-effectiveness, and performance factors were generated using various models and algorithms that employed direct survey estimates as inputs. The following notes about these estimates and the inputs used in these models are important to consider:

- Estimates of precision are not presented for the labor impacts, avoided carbon emissions, performance factors, and several cost-effectiveness estimates presented in this report primarily because of the complex system of models used to estimate key parameters. These estimates, however, are subject to sampling error that is likely of the same magnitude as that reported for the energy impact and bill savings estimates. Additional information on the sampling error is provided in Appendix H.
- Several models and algorithms used to generate estimates required location-specific inputs in order to account for geographic variation in model parameters and algorithm assumptions. Some of the models and algorithms required state-specific estimates, while others only required estimates of regions defined by the US Bureau of Economic Analysis (BEA). This evaluation did not have the sample size to support obtaining direct survey and state- and region-specific estimates within evaluated BPAs. Therefore, to account for geographic variation, state-level estimates were created as follows:
    - If a state had one or more evaluated activity in a specific BPA, then the state-level estimate was created using data associated with the state.
    - Otherwise, direct survey estimation was used to estimate national totals for each BPA and activity type (direct or indirect grant) such as the total EECBG-attributable energy savings associated with electricity or gas. These estimates of totals were proportioned to the states with no sampled activities proportional to the funding that the state received within a BPA and activity type group.
    - Total estimates by BPA and state were summed to the required geographic level necessary for the model or algorithm under consideration. This process of deriving state-level estimates within each BPA and type adds additional sampling error and potentially some bias to the estimates generated from the models and algorithms.

The models and algorithms used to estimate labor impacts, avoided carbon emissions, bill savings, cost-effectiveness, and organizational factors influencing program performance are discussed in the next few sections of this report.

2.5.3. Labor impacts

The REMI economic forecasting model used for this study is a dynamic general equilibrium model with an input-output transaction model at its core.[55] The model was used for this evaluation because it can capture 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. When a

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

specific industry (designated with a NAICS[56] code) experiences energy (and associated bill) savings, it becomes a reduction in the cost of doing business. The model includes dynamic region-specific and industry-specific outputs to respond to these cost changes. This is the basis for assessing market share growth based on the assumption of being more competitive once adopting some efficient device or system, which supports job growth. Therefore, part of the impacts by BPA includes these dynamic responses that can work both ways—either in terms of job creation or losses—depending on whether the BPA evaluated outcomes are negative or positive.

Job impacts occur in response to initial program-related spending within any BPA, which means they occur in response to spending by state agencies 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 US-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, provided the investment was cost-effective and delivered energy savings over the life of the equipment.

Over time, there are additional transactions that emerge and multiply from each program's direct job effects. Direct job effects are associated with the initial event of injecting more funds into state programs. The induced multiplier effects account for job changes when households experience a change in disposable income and they either consume more or less than they would have prior to the program. The indirect multiplier effects account for situations such as when a US 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.

Another mechanism at work is a set of adjustments that bring the macro-economy back to equilibrium. The adjustments occur among organizations in an industry, among industries in an economy, between employers and the labor market, between capital goods markets and labor markets, between consumers (firms or individuals) and the good/services providers, and between one regional economy and another (through trade and commuter flows).

One adjustment is that persistent future bill savings, through energy efficiency or on-site renewable generation for customers, implies less demand for electric and gas utilities, as well as for the supply chain that delivers propane and heating oil.[57]

Note that the job impacts to be shown in specific sections of this report are presented at the nationwide level and do not include the territories. The REMI model uses a multi-regional impact forecasting system[58] of the eight major BEA[59] regions. BPA-related information was provided for each region (when a region showed participation in a specific EECBG-funded activity) and the REMI analysis provided outputs at the sub-national level with all regions interacting simultaneously. Before any modeled region is stimulated by a program's initial spending effects, each regional economy is

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[56] NAICS stands for the North American Industry Classification System. It is a standard code developed by USOMB and is used to classify business establishments.

[57] The value of the utility sector demand offset is assumed to be equal (but opposite in sign) to the dollar value of the bill savings achieved through energy efficiency and on-site customer renewable systems. Load reductions in one region will not necessarily translate dollar for dollar into reduced generation for that region. Some utility sector jobs will be forfeited however, and this should be interpreted as a worst-case result.

[58] REMI is a *dynamic* forecast, producing year-by-year predictions in the presence of a proposed *change.*

[59] Multistate aggregate regions defined by BEA.

characterized by relative costs (e.g., labor, housing, capital, energy, taxation, and general cost-of-living), and relative profitability of each NAICS sector, which play a role in the resulting impacts once the programs' effects are introduced.

For example, if a region is expected to see an increase in bill savings or a large investment of up-front project deployment, and that region already exhibited relatively higher cost characteristics than a neighboring region, the program's shocks will exacerbate labor and capital demand conditions. This includes driving up costs higher than the neighboring region, resulting in feedbacks in the model that curtail that region's ability to sell into neighboring regions, thereby reducing jobs. The presentation of national impacts implicitly captures all of these macro adjustments affecting job impacts at the regional level. These adjustments are secondary, however, to characteristics of specific BPA effects. Examples include the time profile of the various project costs, loan costs, bill savings persistence, which customer sectors participate, and the cost-effectiveness of their money used to make improvements.

2.5.4. 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[60] were applied to electricity savings and conventional electricity displacement from renewable sources, since the mix of fuels used to generate electricity varies regionally.[61] Because emission rates from fuels (e.g., natural gas, oil, and propane) do not vary much by region, only one emission rate was needed for each such fuel type.[62] 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 renewable generation were then aggregated to determine the total carbon impact for each BPA.

This evaluation also considered the monetary impact associated with carbon emissions. The team monetized the carbon impacts associated with EECBG-funded programs using the social cost of carbon (SCC) from the following sources:

- 2009: R. Ruegg, A. O'Connor and R. Loomis. Evaluating Realized Impacts of DOE/EERE R&D Programs: Standard Impact Evaluation Method (August 2014).
- 2010-2050: Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.[63]

EPA defines the social cost of carbon as the economic damages associated with a small increase in carbon dioxide (CO_2) emissions in a year.[64] The avoided social cost is the monetary value of avoided damages for that carbon not having been emitted.

[60] 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.

[61] 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.

[62] 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.

[63] United States Government. *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866*. Interagency Working Group on Social Cost of Carbon, May 2013. https://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

The team used the SCC values associated with a 2.5% social discount rate, as that was the value closest to the discount rate used in other areas of this study. These SCC values were applied to the annual carbon impacts for each BPA to estimate the monetary impact of the avoided carbon emissions.

2.5.5. Bill savings and cost-effectiveness

Bill savings are presented in 2009 US dollars, and include bill savings from energy efficiency and on-site renewable generation. For bill savings estimates and cost-effectiveness analyses, the dollar savings are based on average state-level retail rates and include US territories.

For cost-effectiveness, two indicators are presented in this report and detailed definitions for them are provided in Appendix K. These indicators are the RAC test and the ratio of the present value (PV) of participant bill savings to the PV of program dollars spent.

The RAC test result is expressed in EECBG-attributable MMBtu of source energy saved or generated per year, per $1,000 of program funding. A program can be considered cost-effective for any ratio above the benchmark of 10 set by DOE. The RAC test, developed for ARRA-SEP programs, is also used here for EECBG. It should be noted that while the RAC test captures only the energy savings cost benefits, there are other metrics, such as the avoided carbon per dollar spent that can be examined that capture different EECBG program benefits and objectives. This is especially true for renewable generation goals, where the primary objective was avoided generation of fossil fuels and the associated reduction in carbon emissions, rather than on-site electricity savings.

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.

For EECBG, one BPA included a revolving financing mechanism. Loans are considered an asset by the lender and this has implications for RAC. RAC requires program funding in the denominator. This is to measure the efficiency of the BPA's spending and in most cases the two are equal. When loans are included, however, program spending is less than program funding because the loans are paid back and these paid-back funds can be applied to other activities. As a result, in addition to Building and System perspectives resulting from on-site generation, RAC for the financial incentive BPA category is shown at the portfolio level with full program funding (initial loan principal included) and net program spending (initial loan principal excluded).

[64] United States Environmental Protection Agency. *The Social Cost of Carbon*. November, 2013. http://www.epa.gov/climatechange/EPAactivities/economics/scc.html

The PV ratio compares the present value of participant bill savings attributed to EECBG against the present value of EECBG program funding. When the ratio is equal to 1.0, the present value of bill savings attributable to EECBG is equal to the program's expenditures. A ratio greater than 1.0 means the lifetime discounted-value of EECBG-attributable bill savings is greater than total EECBG funding. A ratio of less than one means that EECBG funding is greater than any EECBG-attributable energy bill savings resulting from EECBG program activity.

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.[65] Results are presented in a range from 0.7% to 4.7% to assess the sensitivity of the findings.

Finally, program spending is reported in PV from 2009 when the funding was first disbursed for two reasons. First, even though funds were disbursed by ARRA in a single year (2009), funds were not disbursed or necessarily committed to projects in that same year. Project proposals in future periods included price inflation from 2009, and, as a result, ARRA dollars spent in the years after 2009 did not fund as much activity as they could have in 2009. The PV approach affects only dollars spent after 2009. For project dollars spent in 2009, the funding amount and the PV amount are identical numbers. The second reason for using PV dollars is consistency with the other tests. The PV ratio test requires PVs for program spending and bill savings. By using the same program spending value in both tests, the tests can be compared without caveats.

2.5.6. Operational/organizational factors influencing program performance

The objective of the performance analysis is to determine if there are organizational or operational aspects of the EECBG program that could be found to have a statistical relationship to the energy savings achieved per grant dollar spent. An understanding of the 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 team uses a regression framework to attempt to identify key organizational and operational characteristics that explain the relative level of savings per grant dollar.

The dependent variable used in this regression model is the ratio of energy impact (source MMBtu) to funding (in thousands of dollars). Energy impact estimates and funding data are available for 169 activities. However, of the 169 activities only 148 activities had survey data for the organizational/operational variables. The distribution of the ratio of net savings to funding is right skewed as shown in Table 2-6. While 17% of activities have a ratio of zero and 60% of all 169 activity respondents have ratios less than 50, the remaining 40% of activity respondents have ratios that range from above 50 to as high as 6020.

Table 2-6 summarizes the distribution of the ratio of program impact in MMBtu to funding in thousands of dollars. As can be seen, the distribution has several extremely high values. It should be

[65] 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.

noted that the skewed distribution could limit the ability of the model to identify relationships between EECBG-attributable savings and operational factors for the activities with smaller savings.

Table 2-6: Distribution of ratio of program impact to funding in thousands of dollars

Program Impact/Funding in Thousands	Frequency	Percent
0	29	17%
.01 < 15	35	21%
15 to < 50	37	22%
50 to < 100	28	17%
100 < 150	15	9%
150 < 300	13	8%
300 < 700	9	5%
700 < 1000	0	0%
1000 to < 1500	1	1%
1500 < 2000	1	1%
2000 < 3000	1	1%
3000 < 6000	0	0%
6000 < 7000	1	1%

Note: Total of estimates may exceed 100% due to rounding.

The analysis attempted to explain the observed variation in the dependent variable using a combination of endogenous and exogenous independent variables. Endogenous variables are factors that are specific to the activity and may include the following:

- mix of measures implemented,
- mix of market segments in the project,
- square footage treated through the project,
- primary heating fuel,
- bill payment responsibilities by owner and renter, and
- perceived importance of the EECBG program in encouraging implementation of the energy efficiency project.

Exogenous variables are factors that are external to the program and that could potentially have an impact on program performance such as:

- the environment in which the program was implemented as indicated by the territory's/state's score per the 2014 American Council for Energy Efficient Economy (ACEEE) Energy Efficiency Scorecard,[66]
- annual heating and cooling degree days as measured by the National Oceanic and Atmospheric Administration (NOAA)[67] – this metric measures the variation in mean temperatures from the baseline temperature (generally 65 degrees for heating and cooling),[68]
- indicators related to energy costs such as average cost per kWh and/or cost per therm of natural gas, and
- the ability of the target audience to participate as indicated by the territory's/state's unemployment rates as reported by the US Census Bureau.

A total of 75 independent variables were considered for the model. The final model specification included 22 potential explanatory variables. Detailed findings for this analysis are presented in Section 4 and Appendix L.

66 ACEEE conducts an annual study to rank state's based upon their policies and programs that save energy, benefit the environment, and promote economic growth. Source: http://aceee.org/research-report/u1408

67 http://www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/

68 A day in the summer with a temperature of 70 degrees would equal 5 cooling degree days. Similarly, a day in the winter at 60 degrees would be 5 heating degree days.

3. EECBG FINDINGS BY OUTCOME

The following section presents the cumulative impacts and BPA-specific impacts by key outcome for the BPAs studied in this evaluation: energy efficiency retrofits, financial incentives, buildings and facilities, on-site renewables, lighting, and direct-grant-funded energy efficiency and conservation strategy. These impacts represent the results that are attributable to the EECBG program. The four outcomes presented are as follows:

- Energy savings/renewable generation
- Labor impacts
- Avoided carbon emissions
- Bill savings and cost-effectiveness

All impacts presented in this chapter and elsewhere in the body of the report are attributable to support received from the EECBG program. These EECBG-attributable impacts are analogous to net impacts discussed in other evaluations. Overall energy savings and renewable generation associated with the totality of support provided by EECBG are presented in Appendix M. Overall impacts are analogous to gross impacts discussed in other studies.

3.1. Summary of impacts

This section presents summary impacts of the EECBG program by outcome. Note that the findings presented below do not represent the entire EECBG program; rather they represent the 80% of funding that this evaluation covered.

3.1.1. Energy savings and on-site renewable generation

This section addresses EECBG-attributable energy savings and renewable generation impacts for all six of the BPAs studied in this evaluation. As many impacts last into the future, the study provides estimated impacts from the initial program year, 2009 through 2050. Most impacts will have ended by 2050.

The impacts are originally calculated in site energy, but are reported in source MMBtu. Site energy, is the amount of heat and electricity consumed by a building at that site, while source energy is the amount of raw fuel consumed at the generation source required to supply that building. Due to plant generation inefficiencies and transmission and distribution line losses of energy during transportation to its final destination, more power must be generated at the plant than is consumed at the building. To account for this loss of energy we apply an EPA source-site ratio adjustment.[69] These ratio adjustments are provided in Appendix K.

A total of 169 separate activities were studied and the findings were expanded to the target population, which consists of 4,706 activities totaling $2.2 billion in EECBG funding.

[69] ENERGY STAR© PortfolioManager® Technical Reference http://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf

3.1.1.1. Energy impacts for all fuel types and sectors combined (source MMBtu)

This study estimates that the six studied BPAs result in an estimated 409 million source MMBtu of EECBG-attributable energy savings from 2009 to 2050. The overall attribution level for all six BPAs combined was 92%, meaning that 92% of the energy savings achieved by the studied activities was attributable to EECBG support. This finding indicates that an additional 8% or 14.7 million source MMBtu of energy savings was due to funding from other sources. The attribution level varies across the BPAs ranging from 27% for On-site Renewable Technology to over 99% for Energy Efficiency and Conservation Strategy. Figure 3-1 shows the impacts over time. Energy savings peak 2012 through 2014, followed by a steady decline through 2050.

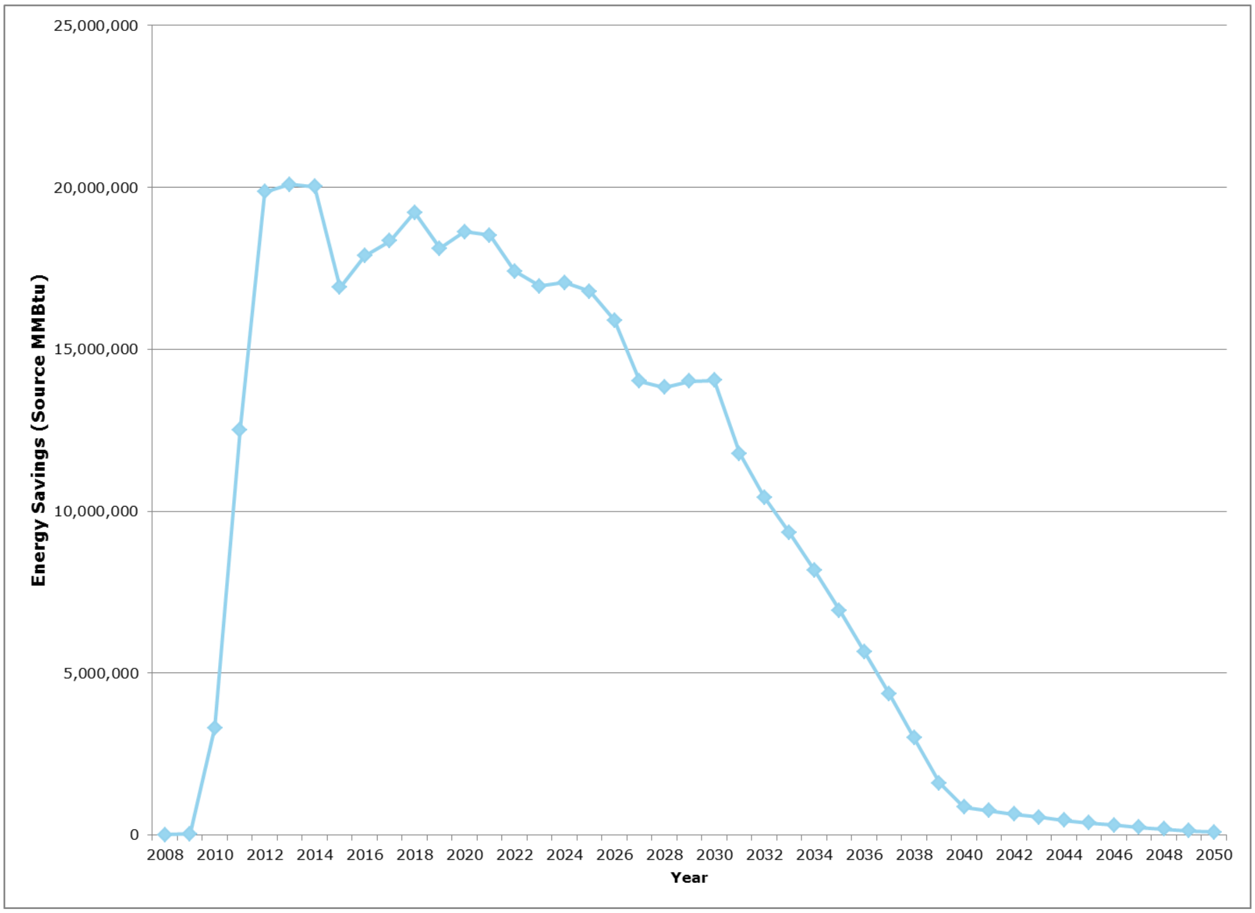

Figure 3-1: EECBG-attributable energy savings over time for all BPAs studied (source MMBtu)

EECBG BPAs result in 4 million source MMBtu of on-site renewable generation from 2009 to 2050. Figure 3-2 shows the impacts over time. The renewable generation peaks in 2012. The steep declines in 2035 occur as the effective useful lifetimes[70] of the associated renewable energy technologies expire.

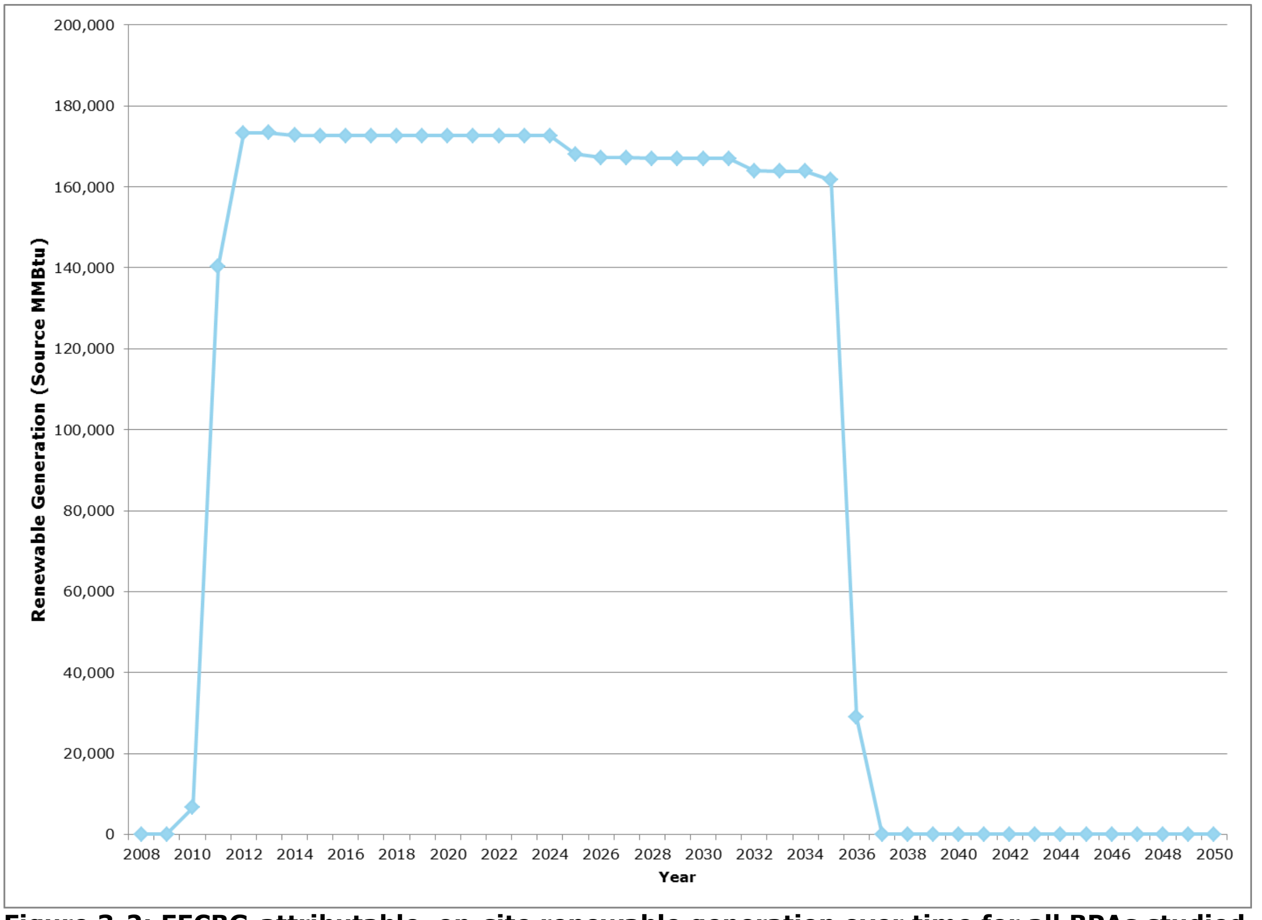

Figure 3-2: EECBG-attributable, on-site renewable generation over time for all BPAs studied (source MMBtu)

3.1.1.2. Energy impacts by fuel type

Table 3-1 presents energy savings over time by fuel type. The majority of energy savings, 326 million source MMBtu, result from electricity savings. Gasoline savings amount to about 40 million source MMBtu. Natural gas savings are about 33 million source MMBtu. There are energy savings from diesel, wood, and oil as well, but these are substantially less than savings from electricity and gas.

Table 3-2 shows on-site renewable generation over time by fuel type. All of the renewable energy produced is in the form of electricity.

[70] 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.

Table 3-1: EECBG-attributable energy savings (source MMBtu) for all BPAs studied by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	28,393	3,093,713	8,927,115	15,887,363	16,178,206	16,131,279	85,235,278	122,572,695	56,601,538*	1,815,434	326,471,012
Natural Gas	886*	219,529	1,075,863	1,470,217	1,404,511	1,395,624	8,853,108	11,192,653	5,524,916	1,892,157*	33,029,463
Oil	-	1,378*	18,182*	18,182*	18,182*	18,182*	109,090*	30,581	5,511*	-	219,286*
Propane	-	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	20,357*	20,357*	20,357*	20,357*	122,144*	101,787*	-	-	305,360*
Diesel	-	-	473,062*	473,062*	473,062*	473,062*	2,838,374*	4,730,623*	-	-	9,461,247*
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	1,990,881*	1,990,881*	1,990,881*	1,990,881*	11,945,284*	19,883,143*	-	-	39,791,949*
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**29,280**	**3,314,619**	**12,505,459**	**19,860,062**	**20,085,198**	**20,029,385**	**109,103,277**	**158,511,481**	**62,131,964***	**3,707,591***	**409,278,316**

"-" 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 and column due to rounding or suppression of estimates that round to zero.

Table 3-2: EECBG-attributable renewable generation (source MMBtu) for all BPAs studied by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Renewable Electricity Generated	-	6,707	140,362	173,345	173,399	172,799	1,035,870	1,694,041	849,352	-	4,245,875
Methane Produced	-	-	-	-	-	-	-	-	-	-	-
Landfill Gas (50% CH_4/50% CO_2) Produced	-	-	-	-	-	-	-	-	-	-	-
Digester Gas (Sewage or Biogas) Produced	-	-	-	-	-	-	-	-	-	-	-
Biodiesel Production	-	-	-	-	-	-	-	-	-	-	-
Ethanol Production	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**6,707**	**140,362**	**.73,345**	**173,399**	**172,799**	**1,035,870**	**1,694,041**	**849,352**	**-**	**4,245,875**

"-" 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 and column due to rounding or suppression of estimates that round to zero.

3.1.1.3. Energy impacts by sector

Figure 3-3 displays energy savings by sector over time. 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.

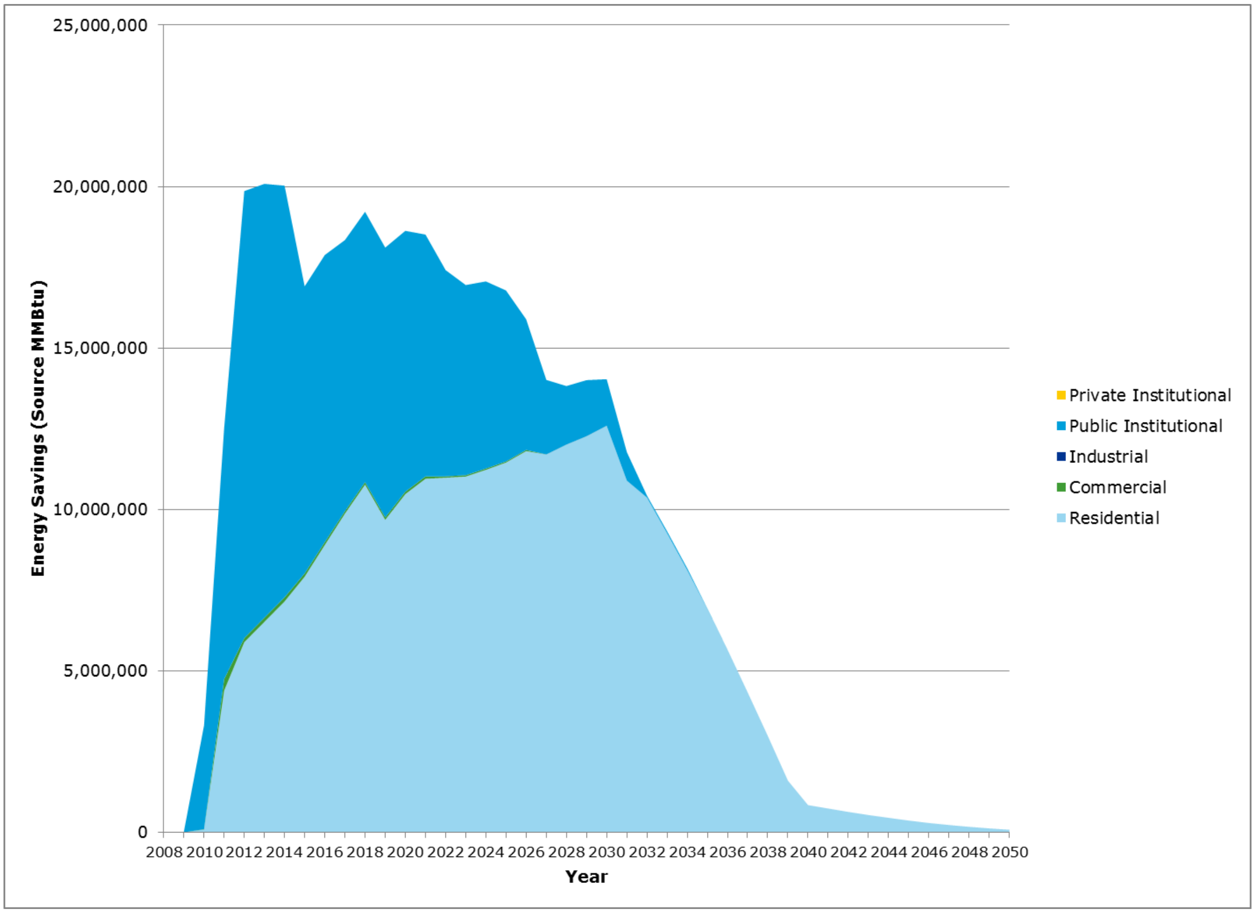

Figure 3-3: EECBG-attributable energy savings for all BPAs studied by sector by year (source MMBtu)

Table 3-3 shows total energy savings by sector for all years combined.

Table 3-3: EECBG-attributable energy savings for all BPAs studied by sector (source MMBtu)

	Attributable Savings
Residential	262,541,200
Commercial	1,522,697
Industrial	31,934*
Public Institutional	145,182,485
Private Institutional	-
Total	**409,278,316**

"-" 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.

Figure 3-4 displays on-site renewable generation by sector over time. The large majority of renewable generation occurs in the public institutional sector.

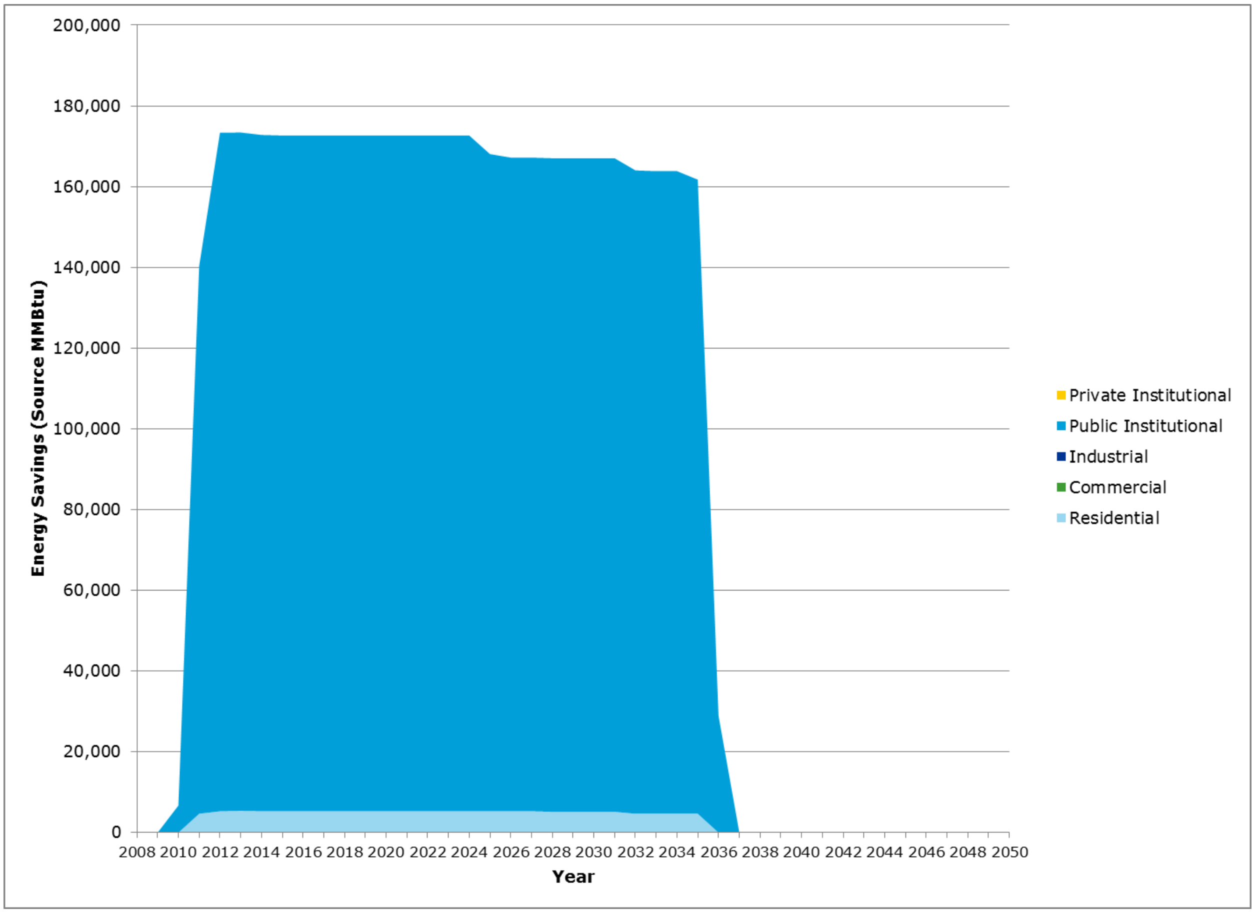

Figure 3-4: EECBG-attributable on-site renewable generation for all BPAs studied by sector by year (source MMBtu)

Table 3-4 shows total renewable generation by sector for the total period of 2009 to 2050.

Table 3-4: EECBG-attributable on-site renewable generation for all BPAs studied by sector (source MMBtu)

	Attributable Savings
Residential	129,165*
Commercial	-
Industrial	-
Public Institutional	4,116,710
Private Institutional	-
Total	**4,245,875**

"-" 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.

3.1.2. Labor impacts

The labor impacts resulting from individual BPA activities are comprised of three components:

- A short-term effect on job generation related to program administration and project installations;
- A longer-term effect on job generation derived from the life-cycle of project energy-savings potential to energy customers in all segments; and
- An indirect or multiplier effect when customers are able to deploy the cost-savings stemming from the EECBG-attributable savings to the purchase of other goods and services.

3.1.2.1. Employment impacts (national roll-up)

This section presents combined national job impacts from EECBG activities for the six BPAs studied. Two different impact concepts— direct and total—are reported depending on the analysis time period. The direct jobs are those required to administer the programs, install projects, and manufacture project components. The total jobs include direct jobs as well as indirect (jobs created down the supply chain as a result of the projects) and induced jobs (jobs resulting from the economic impact of customer bill savings).

For all six studied BPAs combined, cumulative total job changes – inclusive of the REMI model's dynamic adjustments and economic multiplier effects – total more than 62,900 job years. These results are shown in Table 3-5. It should be noted that the employment impacts from the various 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,[71] and buildings and facilities until 2031.

Table 3-5: EECBG-attributable cumulative direct, indirect, and induced jobs created in the US for all BPAs studied

	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**

[71] Impacts past 2050 were not studied as part of this evaluation, so any impacts from future revolving loans past 2050 are not included here.

3.1.2.2. Employment (job-years) tied to direct spending

This section presents the direct job effects occurring in the short-term as a result of the EECBG 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. These direct jobs are estimated from the REMI model and assumptions provided by the contractor team as presented in Appendix I, labor methodology.

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 shown in Table 3-6. Cumulative direct job years are 25,567 through 2033.

Table 3-6: 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 and column due to rounding or suppression of estimates that round to zero.

3.1.2.3. Total employment impact over life of EE equipment

This section presents the longer-term job generation effects of the EECBG activities and job impacts inclusive of the multiplier effects (indirect and induced effects). The values are job years as this section is reporting on the cumulative span of the assumed life cycle of the portfolio of project installations. Figure 3-5 shows the direct, indirect, and induced job years created from the EECBG activities over time.

Over time, the job impacts are greatest within the project deployment period (2011 experiences the maximum job impact). Subsequently, modest positive job impacts persist until 2030 when several BPAs have exhausted (or are nearing the end of) their derived energy benefits, as shown in the figure. The pulse of small jobs impacts from 2033 through 2038 is explained by the pattern of assumed future revolving loan recipients in the financial incentives BPA.

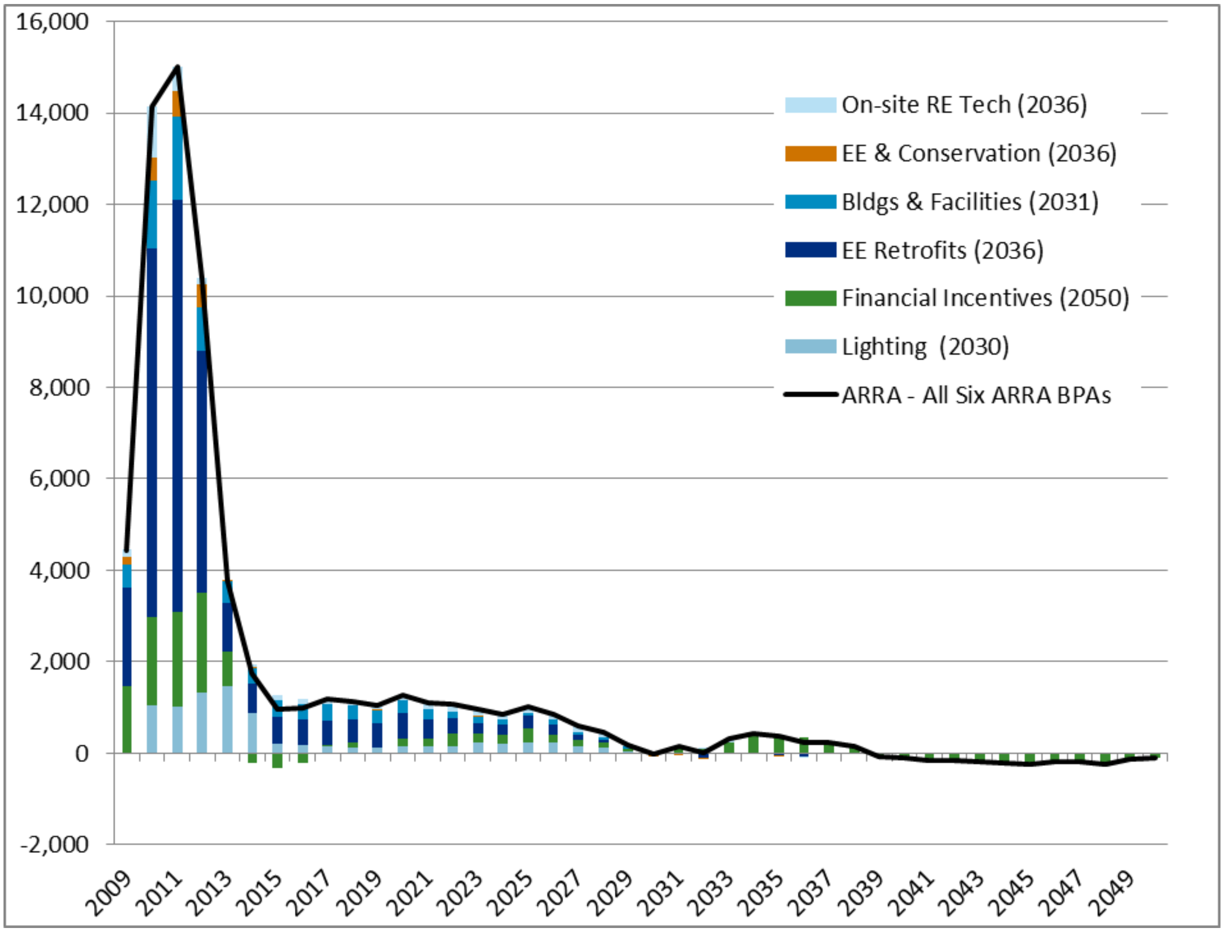

Figure 3-5: EECBG-attributable cumulative direct, indirect, and induced job changes created in the US for all BPAs studied

A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.

As shown in Figure 3-6, the comparison of job impacts occurring in 2009 and 2022 generally shows net positive job impacts across all sectors except for energy-related sectors such as utilities and mining, which experience job losses related to decreased demand for energy. The job distribution for 2009 indicates the types of businesses that are involved in project deployment or program administration. The 2022 distribution of jobs points more toward the effect of bill savings working through the recipient customer segments, multiplier effects and the reduced demand for energy that now faces the utility sector. The reduction in retail jobs is due to a BPA that includes improvements in traffic idling (due to lighting improvements) and results in a reduction in retail gasoline purchases and a net reduction in retail jobs.

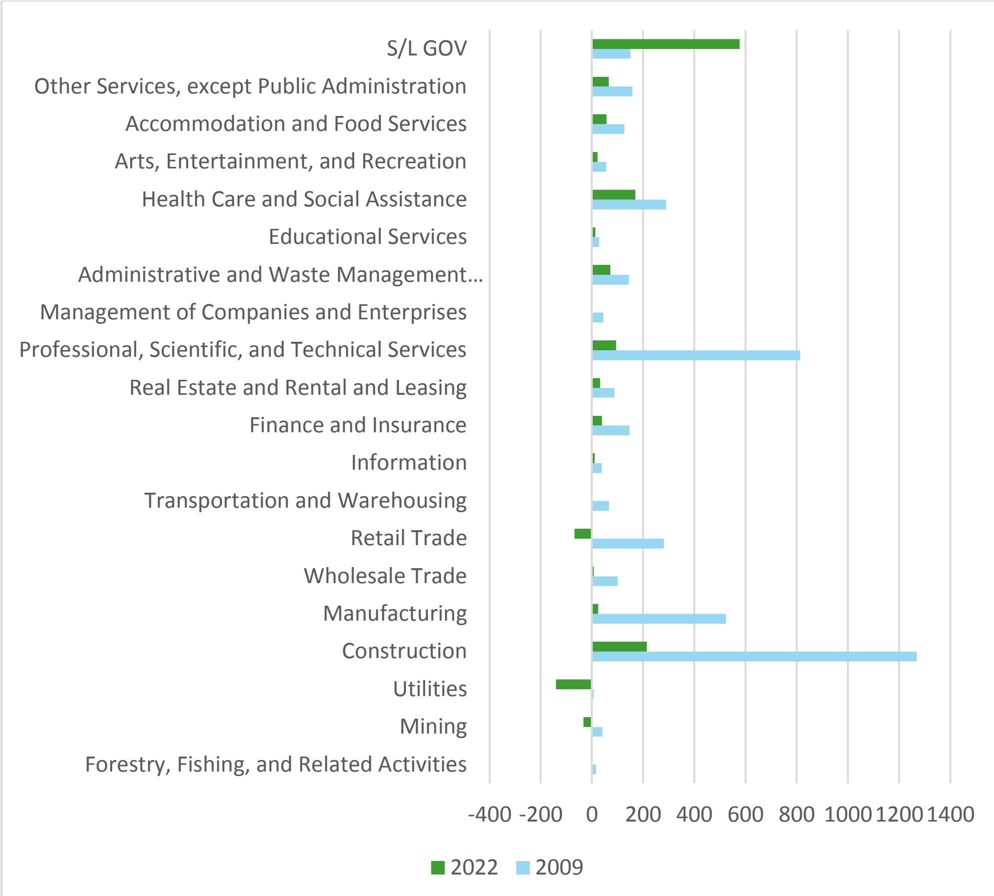

Figure 3-6: EECBG-attributable cumulative job impact for all BPAs studied, by NAICS sector

3.1.3. Avoided carbon emissions and associated social costs

This section presents avoided carbon emissions and the avoided social costs of carbon for the six BPAs studied in this evaluation. The avoided emissions impacts are all reported in MMTCE. The avoided social costs are reported in 2009 US dollars.

EPA defines the social cost of carbon as the economic damages associated with a small increase in carbon dioxide (CO_2) emissions in a year.[72] The avoided social cost is the monetary value of avoided damages for that carbon not having been emitted.

[72] United States Environmental Protection Agency. The Social Cost of Carbon. November, 2013. http://www.epa.gov/climatechange/EPAactivities/economics/scc.html

3.1.3.1. Avoided carbon emissions

Figure 3-7 shows annual carbon emissions avoided due to the program activities studied in this evaluation. Total carbon emissions avoided during the lifetime of the EECBG activities studied was 25.75 MMTCE.

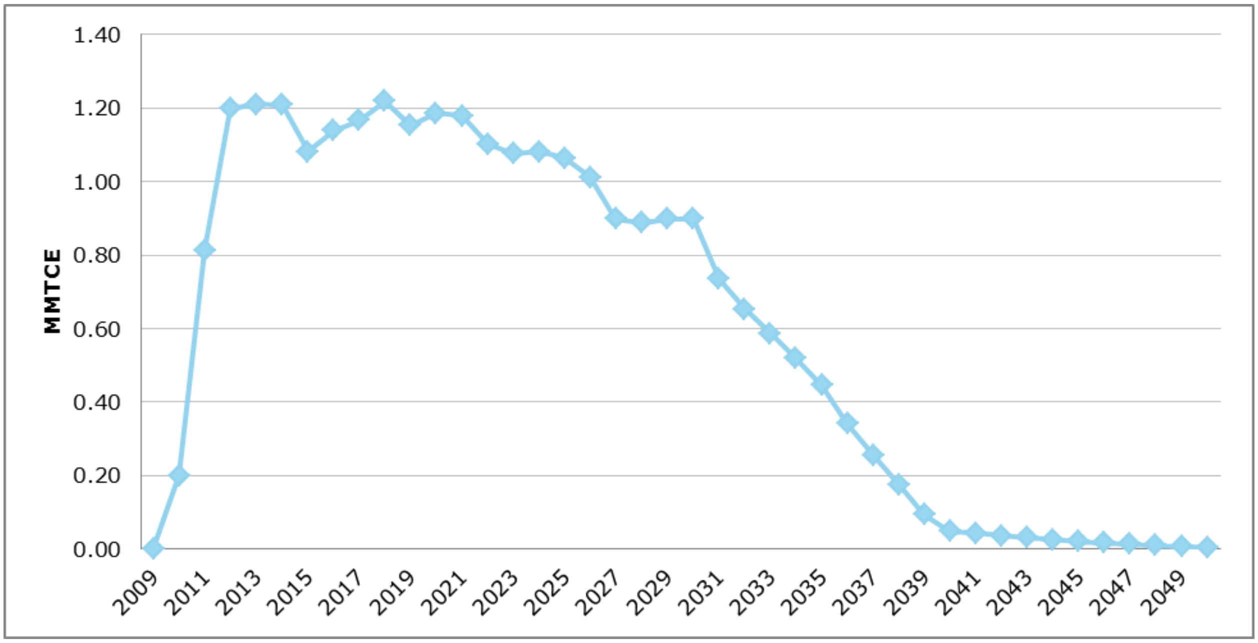

Figure 3-7: EECBG-attributable annual carbon emissions avoided for all BPAs studied, by year (MMTCE)

Figure 3-8 shows lifetime avoided carbon emissions by sector, with residential accounting for the majority at 16 MMTCE and public institutional accounting for nearly 10 MMTCE. The commercial, industrial, and private institutional sectors had less avoided carbon emissions as a result of fewer program activities occurring in those sectors.

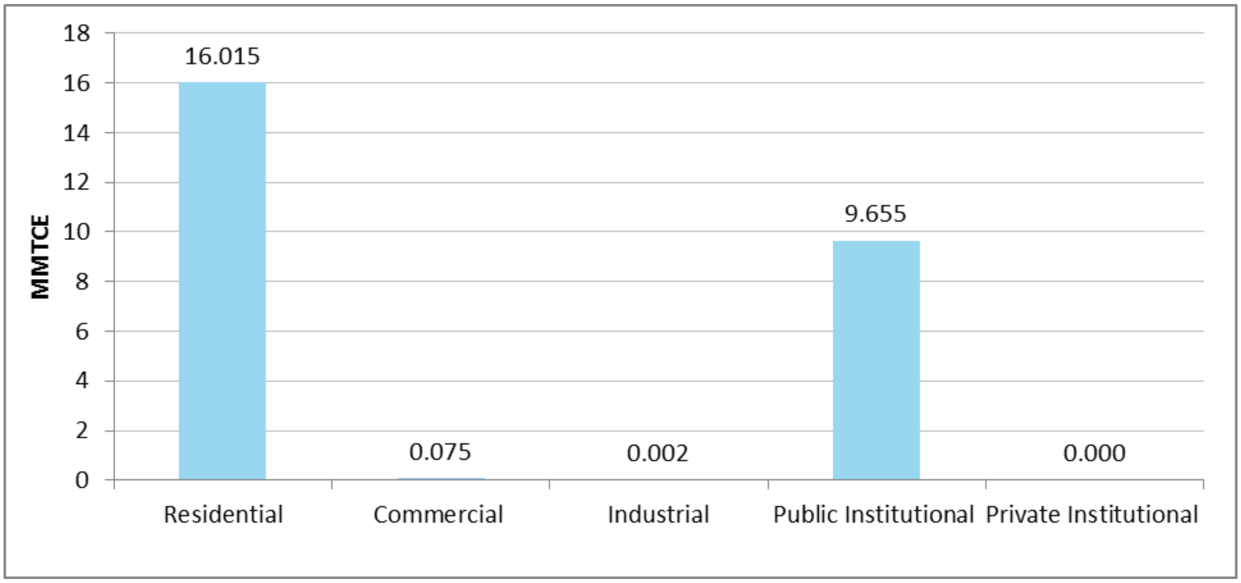

Figure 3-8: EECBG-attributable Lifetime avoided carbon emissions for all BPAs studied by sector (MMTCE)

Lifetime avoided carbon emissions from program activities are mostly due to energy savings rather than renewable generation (Figure 3-9).

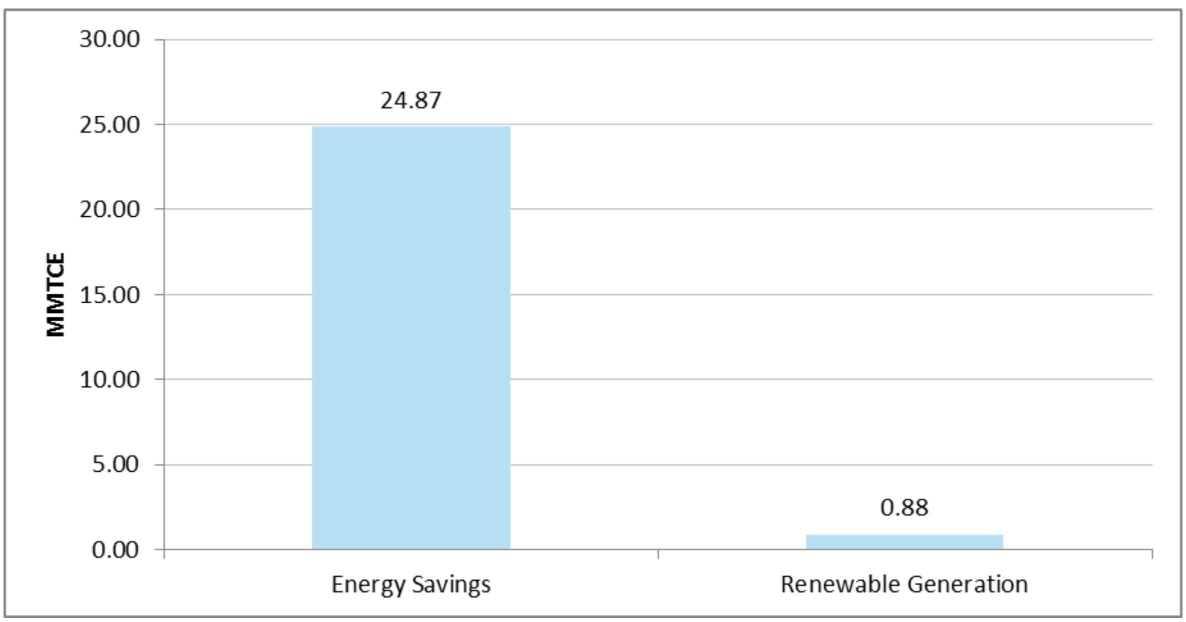

Figure 3-9: EECBG-attributable lifetime avoided carbon emissions for all BPAs studied by mode of savings (MMTCE)

3.1.3.2. Social costs of carbon impacts

In terms of carbon's social costs, the EECBG BPAs studied avoided $1.79 billion using the methodology described in Section 2.5.4. Figure 3-10 illustrates those avoided social costs over time.

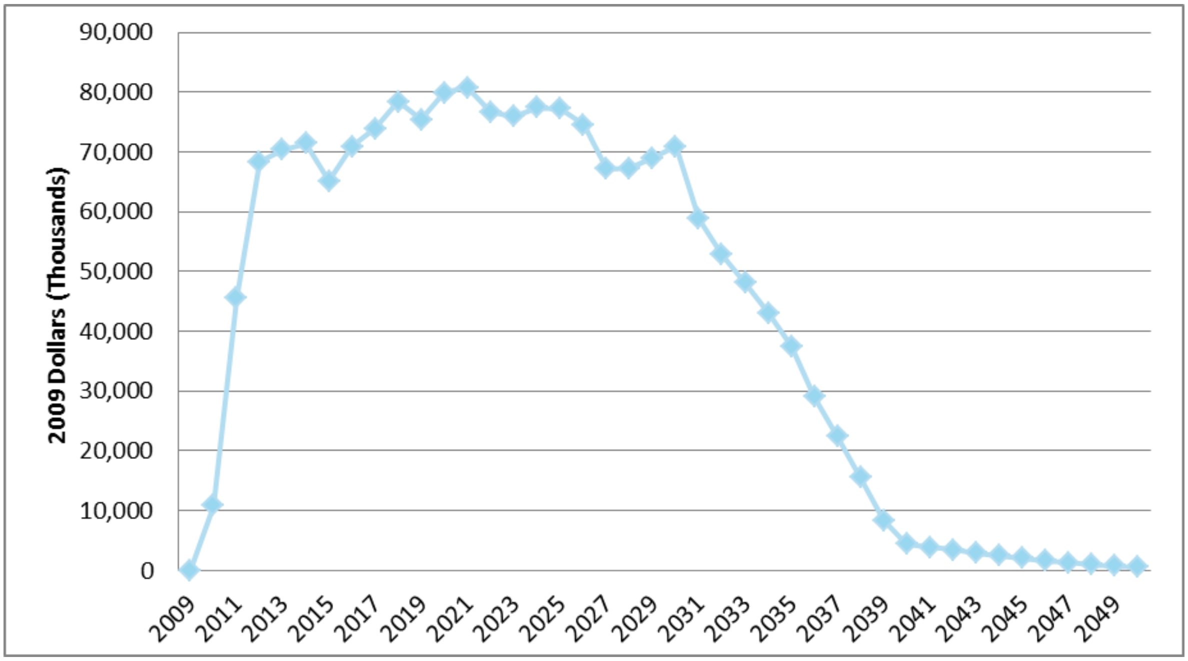

Figure 3-10: EECBG-attributable social costs not incurred due to avoided carbon emissions for all BPAs studied by year (thousands of 2009 US$)

Figure 3-11 shows the social costs not incurred due to avoided carbon emissions from program activities by sector. Residential had the greatest avoided social costs, followed by public institutional.

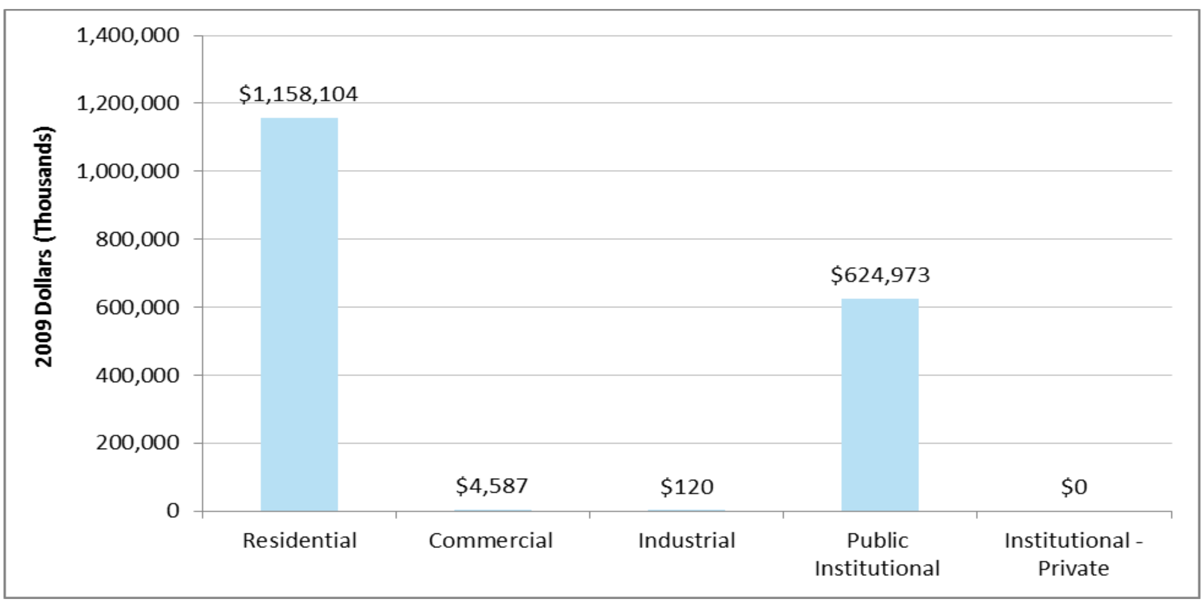

Figure 3-11: EECBG-attributable social costs not incurred due to avoided carbon emissions for all BPAs studied by sector (thousands of 2009 US$)

Figure 3-12 shows how avoided social costs from program activities are distributed across mode of impact; most come from energy savings and a small portion from renewable generation.

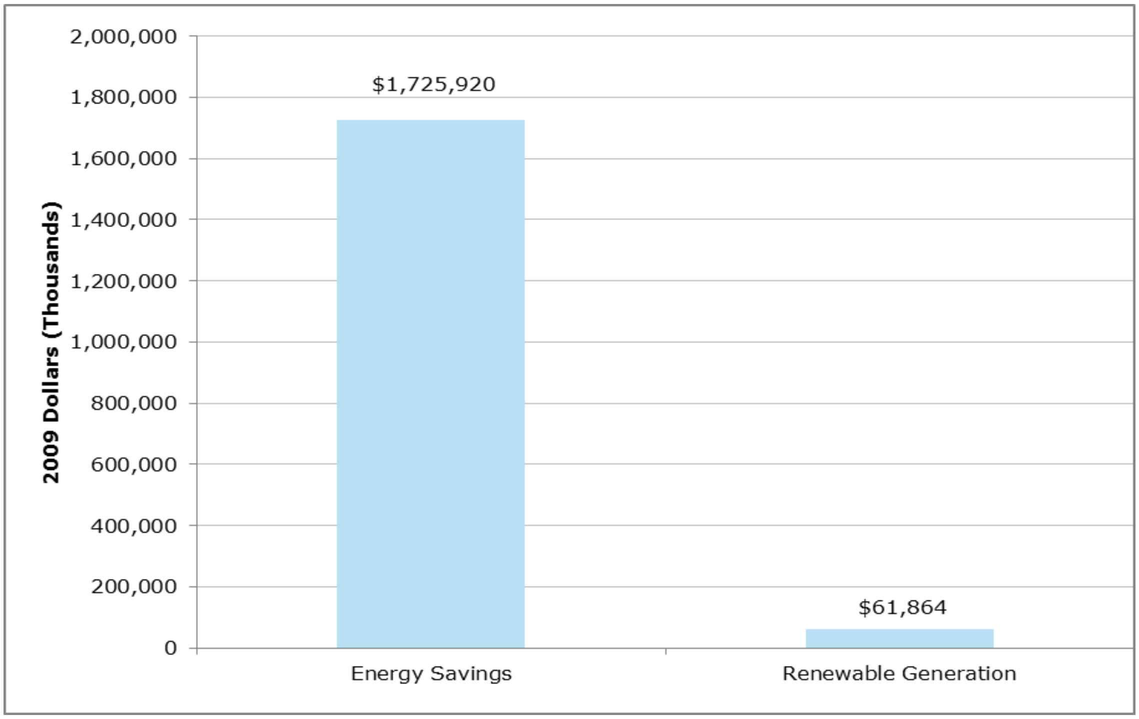

Figure 3-12: EECBG-attributable social costs not incurred due to avoided carbon emissions for all BPAs studied by mode of savings (thousands of 2009 US$)

3.1.4. Bill savings and cost effectiveness

This section examines bill savings and the overall cost-effectiveness of the programs by sector.

3.1.4.1. Customer bill savings

Overall, the total bill savings during the evaluation period was $5.2 billion. Figure 3-13 displays the energy bill savings by sector over time. Each value is an annual savings value in 2009 dollars. Overall bill savings in the residential sector accounted for 70% of the total bill savings generated by EECBG. Public-institutional accounted for 29%. The commercial and industrial sectors shared the remaining portion.

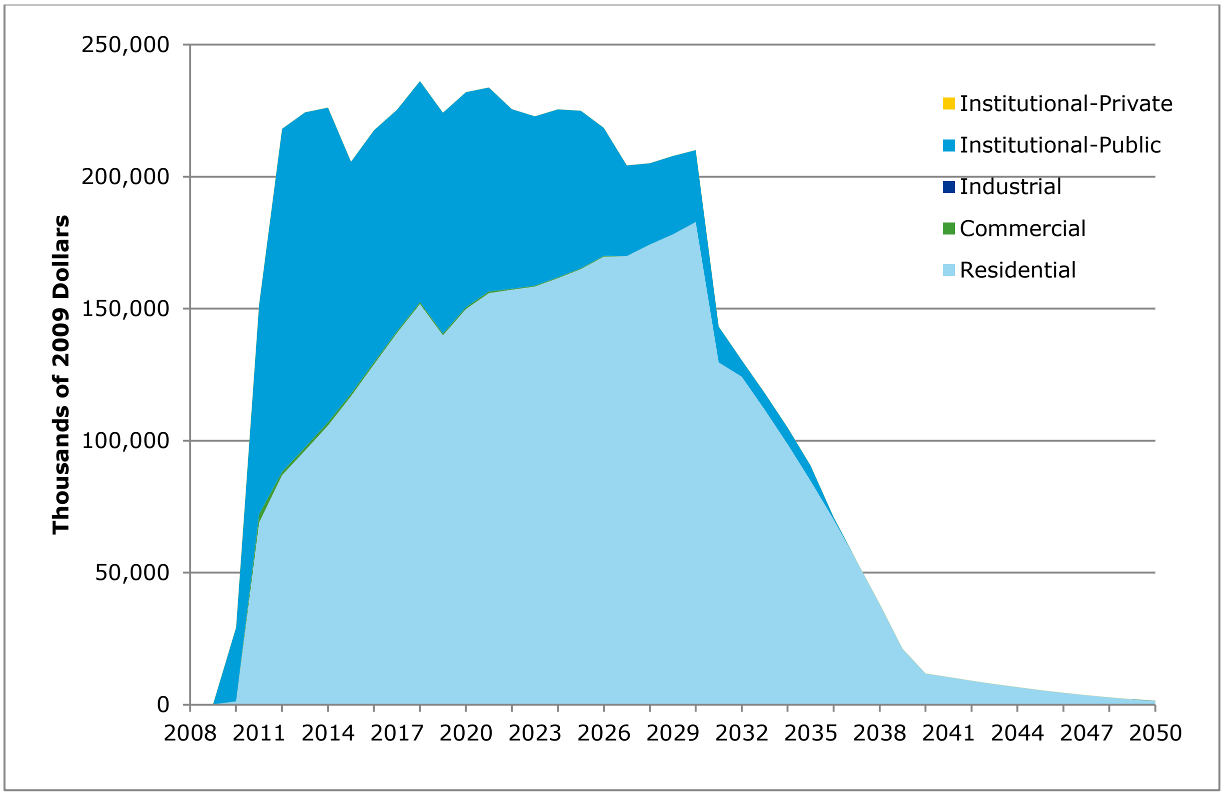

Figure 3-13: EECBG-attributable bill savings for all BPAs studied by sector by year (thousands of 2009 US$)

Table 3-7 shows the bill savings from Figure 3-13 by sector and fuel type. As noted above, 70% of the bill savings accrued to the residential sector. A little more than two-thirds (68%) of all bill savings was due to reduced electricity consumption and 20% from gasoline. Natural gas (7%) and diesel (4%) accounted for the remainder.

Table 3-7: EECBG-attributable bill savings for for all BPAs studied by fuel type and sector (thousands of 2009 US$)

	Residential	Commercial	Industrial	Institutional-Public	Institutional-Private
Electricity	$2,378,674*	$11,010	$169*	$1,170,169	-
Natural Gas	$236,086	$2,655	-	$130,399	-
Oil	$744*	-	-	$2,988*	-
Propane	-	-	-	-	-
Kerosene	-	-	-	-	-
Wood	$5,559*	-	-	-	-
Diesel	-	-	-	$230,124*	-
Ethanol	-	-	-	-	-
Gasoline	$1,039,082*	-	-	$769*	-
Other	-	-	-	-	-
Total	**$3,660,146**	**13,665**	**$169***	**1,534,449**	**-**

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.

3.1.4.2. Cost-effectiveness

This section presents cost-effectiveness indicators for EECBG funded activities. The two major indicators of cost-effectiveness used in this study are (1) the RAC Test, which compares energy savings per year to EECBG expenditures, and (2) the ratio of the PV of lifetime customer bill savings to EECBG expenditures. Each one is described in greater detail in Appendix K.

Table 3-8 shows the RAC test result for all six of the BPAs studied, in combination. 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.[73]

Regardless of how they are calculated, the portfolio-level RAC values hover around the benchmark of 10.0, with the result exceeding that value slightly when the System perspective is used and falling just below the benchmark value when employing the Building perspective.

[73] 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.

Table 3-8: EECBG-attributable single-year RAC test ratio for all BPAs studied

Perspective	Benchmark	RAC
Building	10.0	9.64 (loan principal included)
System	10.0	10.47 (loan principal included)

Perspective	Benchmark	RAC
Building	10.0	9.83 (loan principal excluded)
System	10.0	10.67 (loan principal excluded)

Table 3-9 shows the ratios (using different discount rates) of the PV of lifetime customer bill savings to EECBG expenditures. At the standard discount rate of 2.7%, each dollar of EECBG funding results in lifetime savings of $1.76 if loan program expenditures include the cost of loan principal and $1.91 if loan principal costs are excluded. In either case, the PV ratio is well above the break-even point of 1.0.

Table 3-9: EECBG-attributable PV Ratio for all BPAs studied

Discount Rate	0.70%	2.70%	4.70%
Ratio of PV Bill Savings to PV Activity Funding (loan principal included)	2.18	1.76	1.44
Ratio of PV Bill Savings to PV Activity Funding (loan principal excluded)	2.37	1.91	1.57

3.2. Energy savings and on-site renewable generation

This section presents the following findings related to energy savings and renewable generation for each BPA:

- Energy savings and renewable generation for all fuel types and sectors combined
- Energy savings and renewable generation by fuel type
- Energy savings and renewable generation by sector

The impacts are reported in source MMBtu, which takes into account all energy saved including losses due to storage, transmission, and distribution of the energy to its final destination. Renewable generation source energy looks at the building perspective; therefore, on-site renewable generation has a site-source ratio of 1.0.

3.2.1. 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. A total of 86 separate activities were studied and the findings were expanded to the target population BPA, which consists of 2,187 activities totaling $1.1 billion in EECBG funding.

3.2.1.1. Energy impacts for all fuel types and sectors combined

The energy efficiency retrofits resulted in 71 million source MMBtu of EECBG-attributable energy savings over the 2009–2050 period. Figure 3-14 shows the impacts over time. Energy savings peak in 2012, followed by a steady decline to 2040, when savings impacts expire.

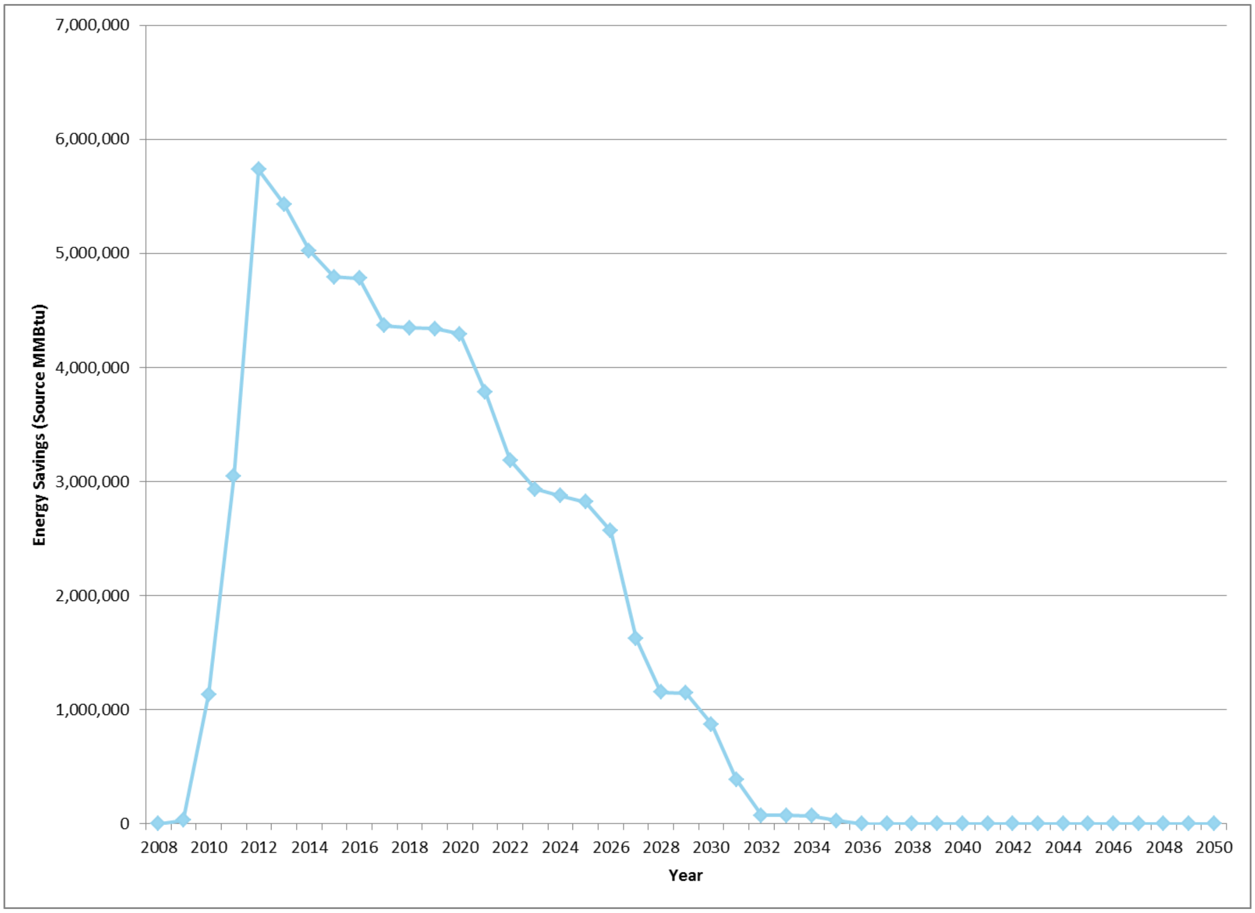

Figure 3-14: EECBG-attributable energy savings from energy efficiency retrofits over time (source MMBtu)

The energy efficiency retrofits BPA resulted in 157 thousand source MMBtu of on-site renewable generation over the 2009–2050 period. Figure 3-15 shows the impacts over time. The renewable generation peaks in 2012 followed by steep declines in 2024 and 2031 as the effective useful lifetimes of the associated renewable energy technologies expire.

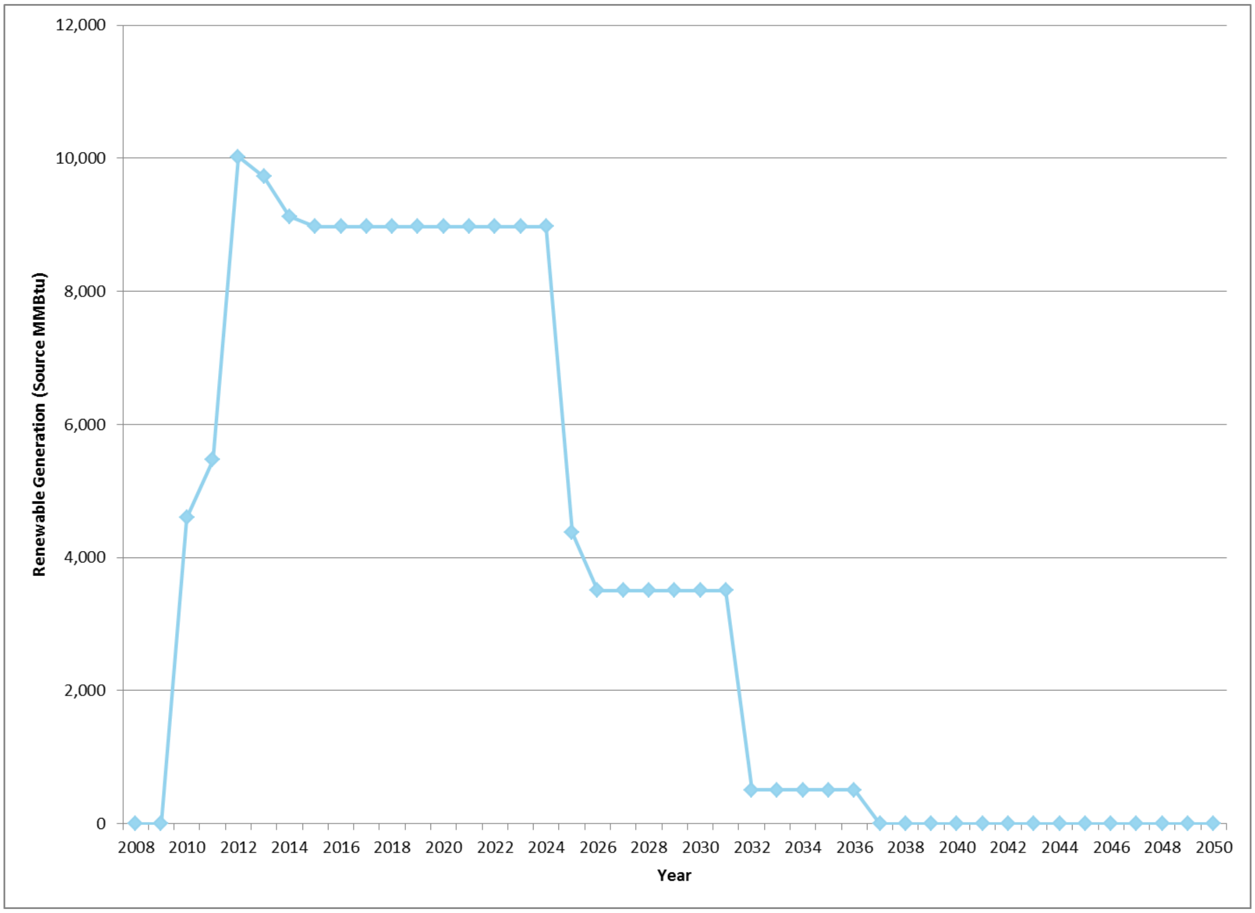

Figure 3-15: EECBG-attributable on-site renewable energy generation from energy efficiency retrofits over time (source MMBtu)

3.2.1.2. Energy impacts by fuel type

Table 3-10 shows energy savings over time by fuel type. The majority of energy savings, 56 million source MMBtu, result from electricity savings. Diesel savings amount to about 9 million source MMBtu. Natural gas savings are about 5 million source MMBtu. There are energy savings from wood and oil as well, but these are substantially smaller than for the other fuels mentioned above.

Table 3-11 shows on-site renewable generation over time by fuel type. For the energy efficiency retrofits BPA, all the renewable energy produced was in the form of electricity.

Table 3-10: EECBG-attributable energy savings (source MMBtu) from energy efficiency retrofit activities by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	28,393	913,943	2,271,149	4,840,836	4,570,703	4,180,154	21,982,879	16,314,403	507,907	-	55,610,368
Natural Gas	-	217,866	264,624	383,489	349,306	330,194	1,868,956	1,764,089	112,408	-	5,290,932
Oil	-	1,378*	18,182*	18,182*	18,182*	18,182*	109,090*	30,581	5,511*	-	219,286*
Propane	-	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	20,357*	20,357*	20,357*	20,357*	122,144*	101,787*	-	-	305,360*
Diesel	-	-	473,062*	473,062*	473,062*	473,062*	2,838,374*	4,730,623*	-	-	9,461,247*
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**28,393**	**1,133,186**	**3,047,375**	**5,735,927**	**5,431,610**	**5,021,949**	**26,921,443**	**22,941,482**	**625,826**	**-**	**70,887,192**

"-" 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 and column due to rounding or suppression of estimates that round to zero.

Table 3-11: EECBG-attributable renewable generation (source MMBtu) from energy efficiency retrofit activities by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Renewable Electricity Generated	-	4,599*	5,467*	10,022	9,727	9,127	53,834	57,785	6,033	-	156,594
Methane Produced	-	-	-	-	-	-	-	-	-	-	-
Landfill Gas (50% CH_4/50% CO_2) Produced	-	-	-	-	-	-	-	-	-	-	-
Digester Gas (Sewage or Biogas) Produced	-	-	-	-	-	-	-	-	-	-	-
Biodiesel Production	-	-	-	-	-	-	-	-	-	-	-
Ethanol Production	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**4,599***	**5,467***	**10,022**	**9,727**	**9,127**	**53,834**	**57,785**	**6,033**	**-**	**156,594**

"-" 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 and column due to rounding or suppression of estimates that round to zero.

3.2.1.3. Energy impacts by sector

Figure 3-16 displays energy savings by sector over time. As shown in this figure, the large majority of the energy savings occur in the public institutional sector.

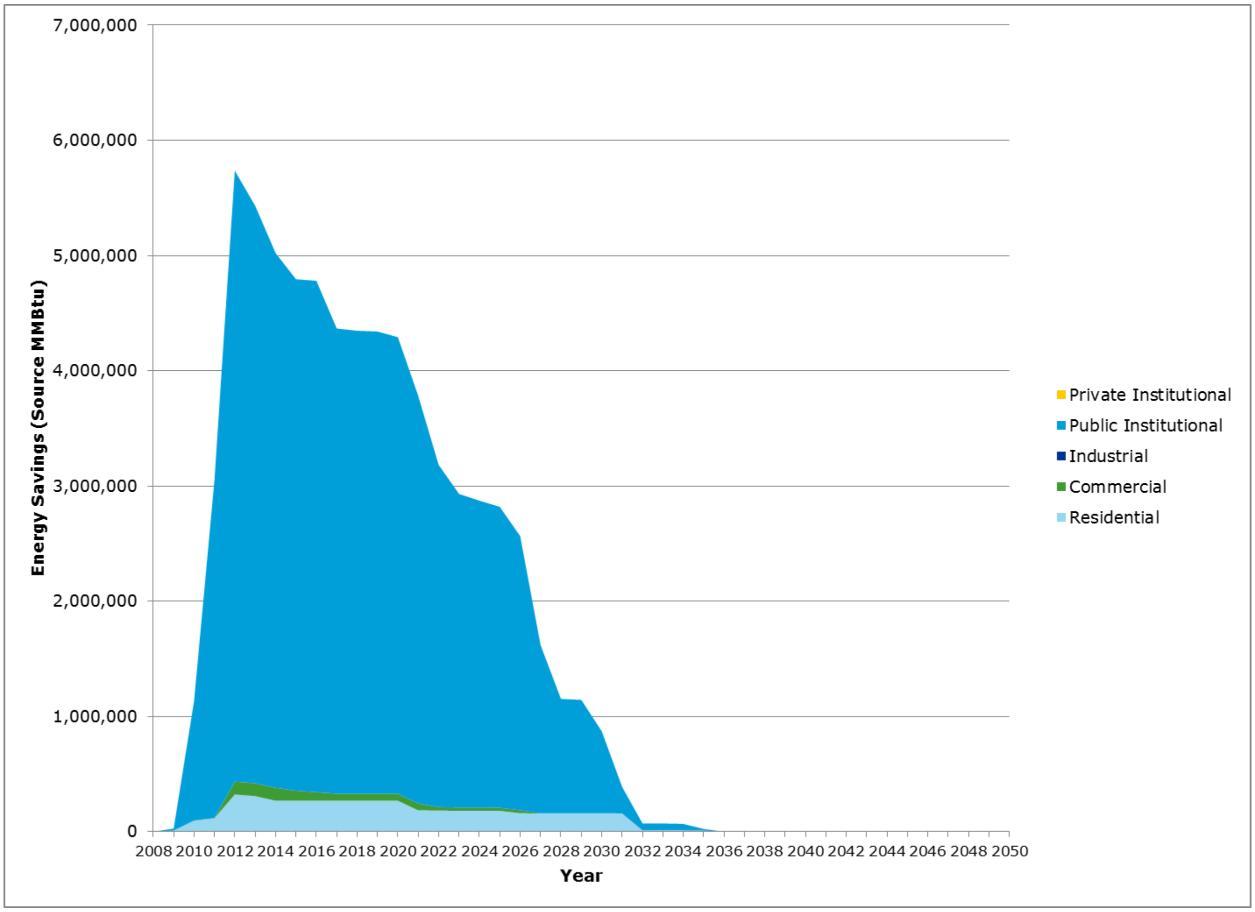

Figure 3-16: EECBG-attributable savings from energy efficiency retrofit activities by sector by year (source MMBtu)

Table 3-12 shows total energy savings by sector for all years combined.

Table 3-12: EECBG-attributable energy savings from energy efficiency retrofit activities by sector (source MMBtu)

	Attributable Savings
Residential	4,657,245
Commercial	929,323
Industrial	31,934*
Public Institutional	65,268,690
Private Institutional	-
Total	**70,887,192**

"-" 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.

Figure 3-17 displays on-site renewable generation by sector over time. The majority of renewable generation also occurs in the public institutional sector.

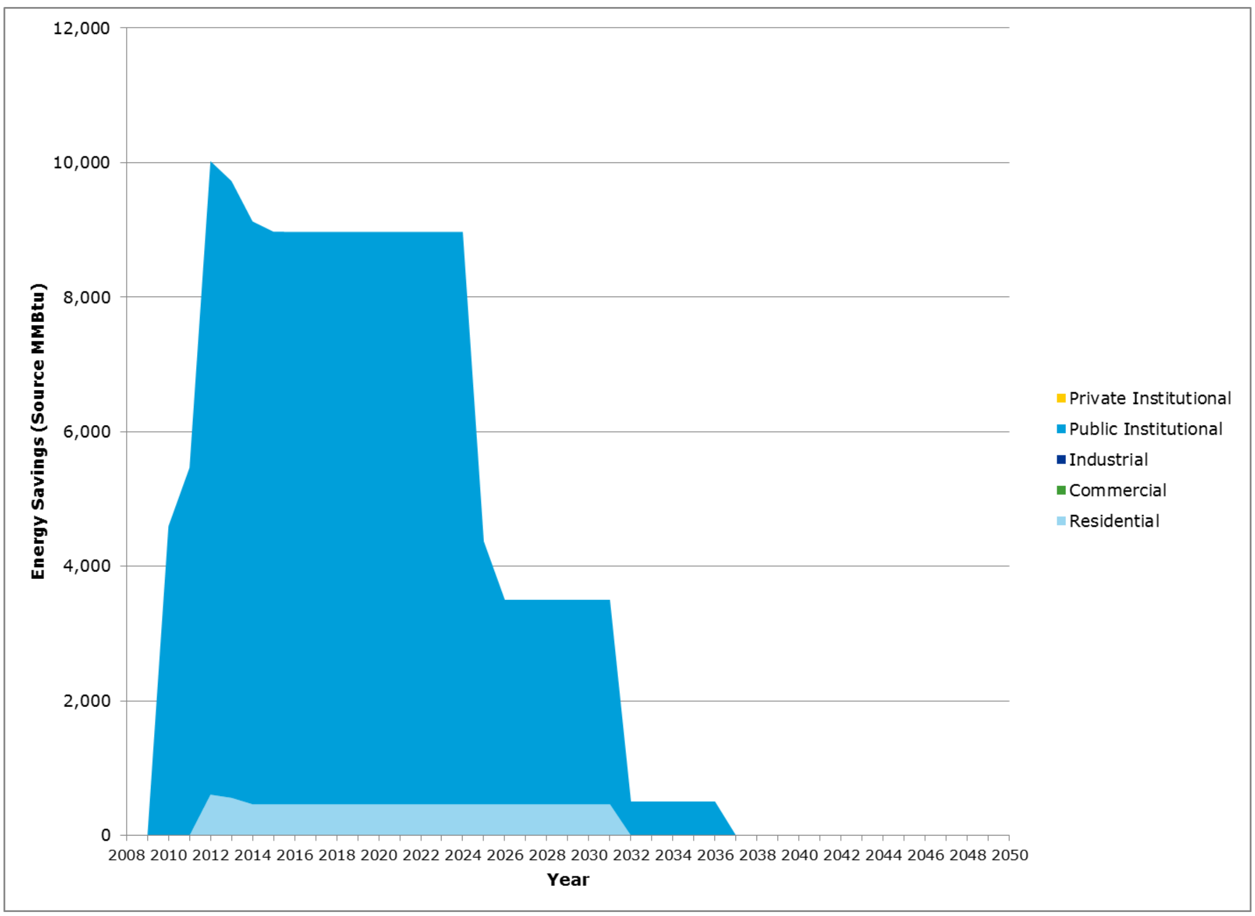

Figure 3-17: EECBG-attributable, on-site renewable generation from energy efficiency retrofit activities by sector by year (source MMBtu)

Table 3-13 shows total renewable generation by sector for all years combined.

Table 3-13: EECBG-attributable on-site renewable generation from energy efficiency retrofit activities by sector (source MMBtu)

	Attributable Savings
Residential	9,558*
Commercial	-
Industrial	-
Public Institutional	147,036
Private Institutional	-
Total	**156,594**

"-" 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.

3.2.2. Financial incentives

The financial incentives BPA encompasses activities that provide financial assistance for energy efficiency measures including rebates, financing, loans, third party loans, and local bank-guarantee loans. Some examples of programs included in this BPA include a solar reimbursement program, low-interest loan program for home owners to make energy efficient upgrades, and a hybrid vehicle conversion rebate program. Fourteen separate activities were studied and the findings were expanded to the target population BPA, which consists of 320 activities totaling $501 million in EECBG funding. Almost $385 million worth of rebates were paid out and $936 million in loans including revolved funds, were paid out during the study period.

3.2.2.1. Energy impacts for all fuel types and sectors combined

The financial incentives BPA resulted in 236 million source MMBtu of EECBG-attributable energy savings over the 2009–2050 period. Figure 3-18 shows the impacts over time. Energy savings continue to rise through 2031 in part due to revolving loan programs, which this evaluation assumes continue loaning money that is paid back from other loans for 20 years after the initial loan payout.[74] Savings persist through 2050, which is the final year of impacts studied in this evaluation.

[74] For more information on assumptions related to revolving loans, see Appendix F.7.

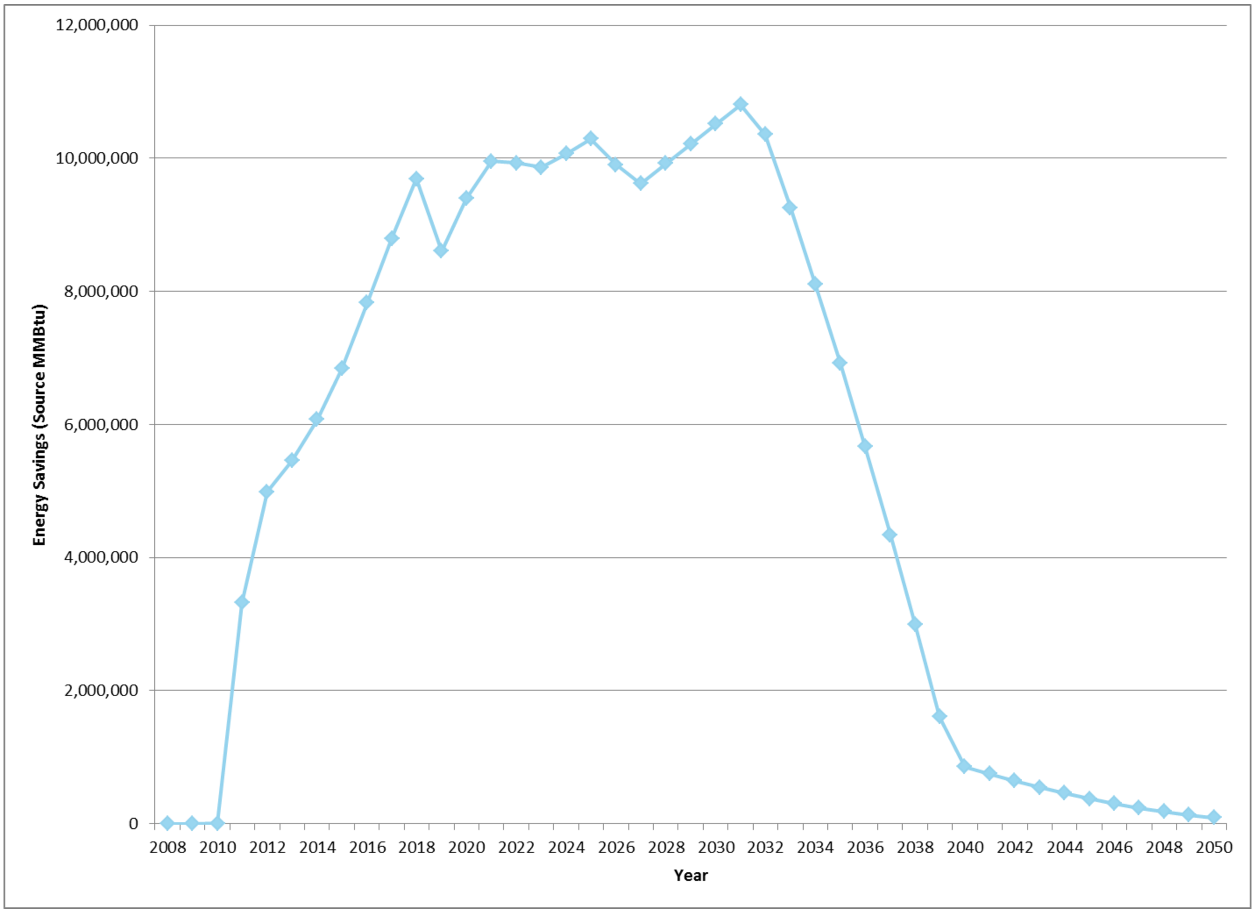

Figure 3-18: EECBG-attributable energy savings from financial incentive activities over time (source MMBtu)

The financial incentives BPA resulted in 771 thousand source MMBtu of on-site renewable generation over the 2009–2050 period. Figure 3-19 shows the impacts over time. The renewable generation levels off from 2012 through 2035. The steep declines in 2036 occur as the effective useful lifetimes of the associated renewable energy technologies expire.

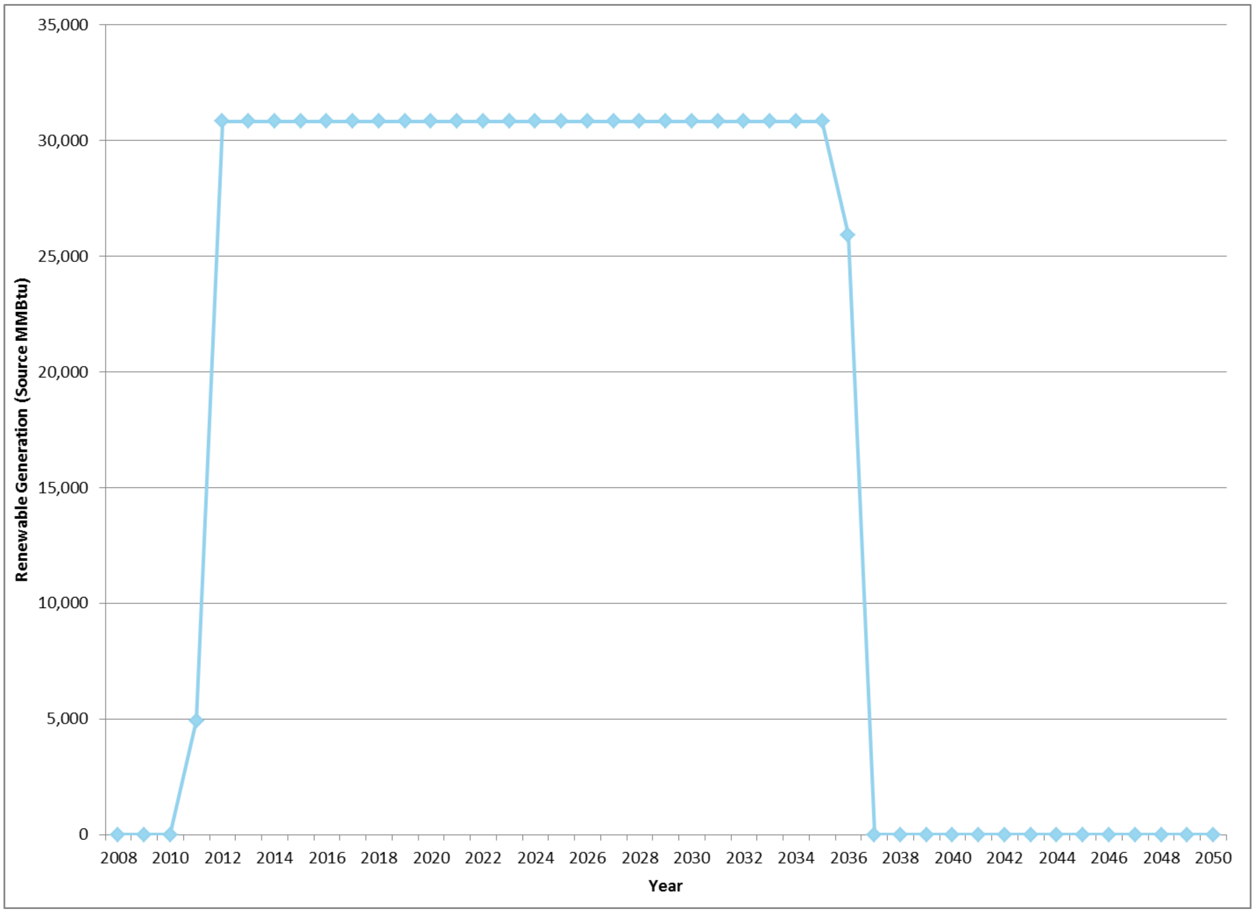

Figure 3-19: EECBG-attributable on-site renewable generation from financial incentive activities over time (source MMBtu)

3.2.2.2. Energy impacts by fuel type

Table 3-14 shows energy savings over time by fuel type. The majority of energy savings, 210 million source MMBtu, result from electricity savings. Natural gas savings amount to approximately 26 million source MMBtu. There are energy savings from gasoline as well, but these are substantially smaller than for the other fuels mentioned above.

Table 3-15 shows on-site renewable generation over time by fuel type. For the financial incentives BPA, all the renewable energy produced was in the form of electricity.

Table 3-14: EECBG-attributable energy savings (source MMBtu) from financial incentive activities by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	-	6,228*	2,508,151*	4,038,787	4,536,219	5,148,071	44,879,973	91,152,688*	55,512,615*	1,815,434	209,598,166
Natural Gas	-	90*	808,008*	945,165	913,641	923,867	6,254,294	9,131,463	5,393,183	1,892,157*	26,261,869
Oil	-	-	-	-	-	-	-	-	-	-	-
Propane	-	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	2,851*	2,851*	2,851*	2,851*	17,109*	2,851*	-	-	31,366*
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**6,317***	**3,319,011**	**4,986,803**	**5,452,712**	**6,074,790**	**51,151,375**	**100,287,003**	**60,905,799**	**3,707,591***	**235,891,401**

"-" 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 and column due to rounding or suppression of estimates that round to zero.

Table 3-15: EECBG-attributable renewable generation (source MMBtu) from financial incentive activities by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Renewable Electricity Generated	-	-	4,912*	30,834*	30,834*	30,834*	185,004*	308,341*	180,093*	-	770,852*
Methane Produced	-	-	-	-	-	-	-	-	-	-	-
Landfill Gas (50% CH_4/50% CO_2) Produced	-	-	-	-	-	-	-	-	-	-	-
Digester Gas (Sewage or Biogas) Produced	-	-	-	-	-	-	-	-	-	-	-
Biodiesel Production	-	-	-	-	-	-	-	-	-	-	-
Ethanol Production	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**-**	**4,912***	**30,834***	**30,834***	**30,834***	**185,004***	**308,341***	**180,093***	**-**	**770,852***

"-" 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 and column due to rounding or suppression of estimates that round to zero.

3.2.2.3. Energy impacts by sector

Figure 3-20 displays energy savings by sector over time. As shown in that figure, the large majority of the energy savings occur in the residential sector.

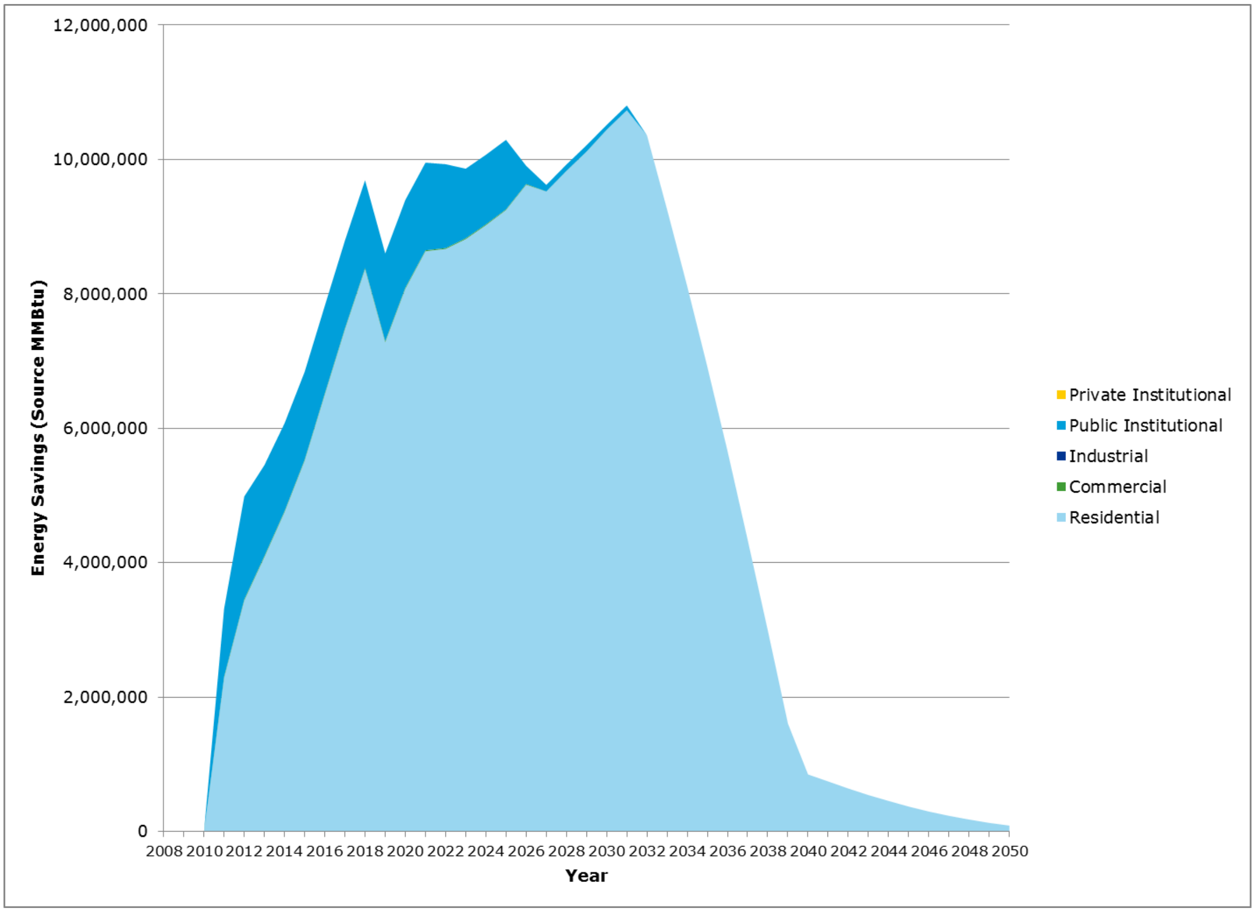

Figure 3-20: EECBG-attributable energy savings from financial incentive activities by sector by year (source MMBtu)

Table 3-16 shows total energy savings by sector for all years combined.

Table 3-16: EECBG-attributable energy savings from financial incentive activities by sector (source MMBtu)

	Attributable Savings
Residential	216,265,347
Commercial	257,372*
Industrial	-
Public Institutional	19,368,682
Private Institutional	-
Total	**235,891,401**

"-" 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.

Figure 3-21 displays on-site renewable generation by sector over time. The majority of renewable generation occurs in the public institutional sector.

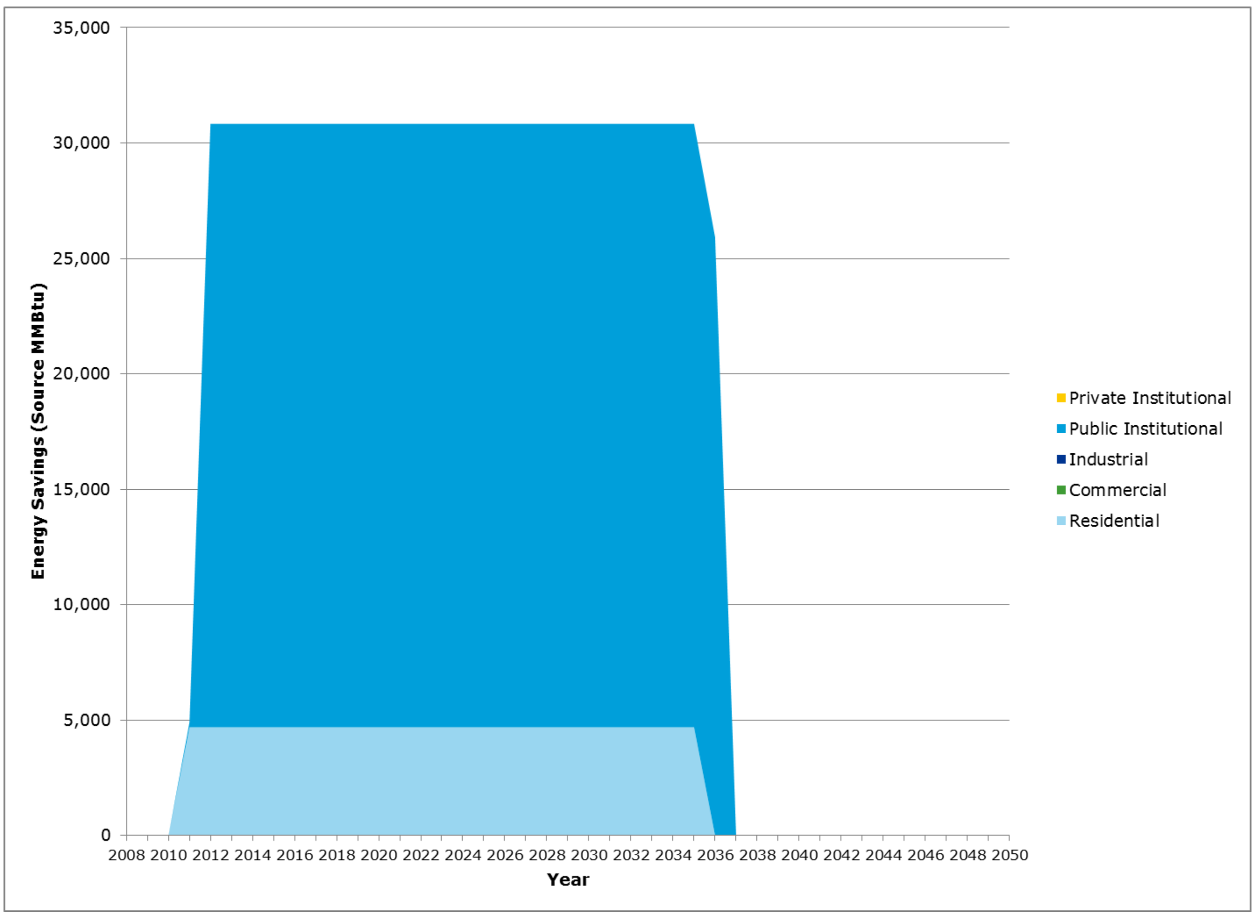

Figure 3-21: EECBG-attributable, on-site renewable generation from financial incentive activities by sector by year (source MMBtu)

Table 3-17 shows total renewable generation by sector for all years combined.

Table 3-17: EECBG-attributable, on-site renewable generation from financial incentives activities by sector (source MMBtu)

	Attributable Savings
Residential	117,255*
Commercial	-
Industrial	-
Public Institutional	653,597*
Private Institutional	-
Total	**770,852***

"-" 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.

3.2.3. 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. Eighteen separate activities were studied and the findings were expanded to the target population BPA, which consists of 667 activities totaling $211 million in EECBG funding. This BPA did not have any renewable generation impacts; therefore, this section will only discuss energy-savings impacts.

3.2.3.1. Energy impacts for all fuel types and sectors combined

The buildings and facilities BPA resulted in 30 million source MMBtu of EECBG-attributable energy savings over the 2009–2050 period. Figure 3-22 shows the impacts over time. Energy savings peak in 2012, followed by a steady decline to 2032 when savings impacts expire.

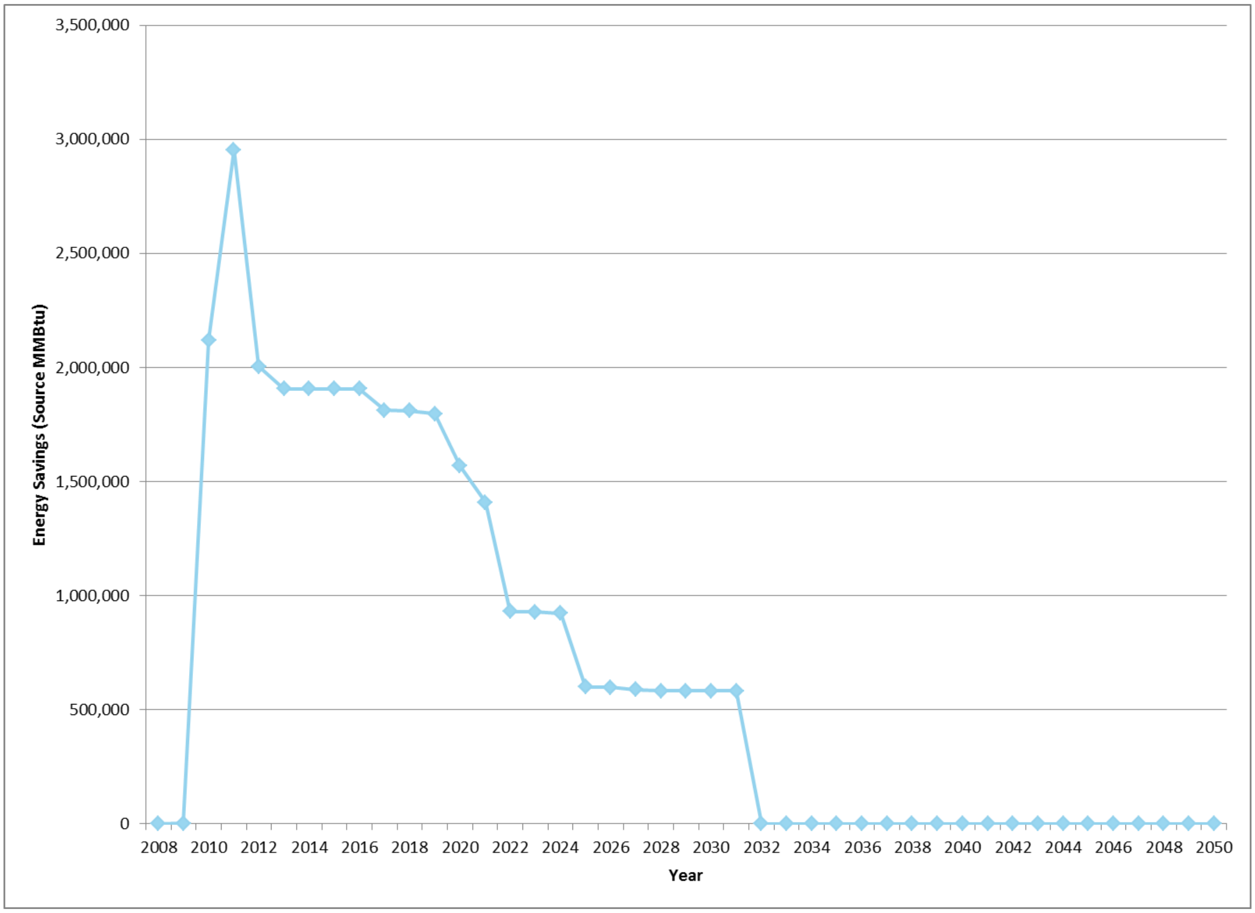

Figure 3-22: EECBG-attributable energy savings from buildings and facilities activities over time (source MMBtu)

3.2.3.2. Energy impacts by fuel type

Table 3-18 shows energy savings over time by fuel type. Almost all of the energy savings result from electricity savings. There are energy savings from natural gas as well, but these are substantially smaller than for electricity.

Table 3-18: EECBG-attributable energy savings (source MMBtu) from buildings and facilities activities by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	-	2,117,342	2,950,242	1,969,240	1,871,342	1,870,377	10,705,389	7,680,410	579,323*	-	29,743,664
Natural Gas	886*	1,573*	3,230	35,067*	35,067*	35,067*	90,880	35,120*	1,680*	-	238,571
Oil	-	-	-	-	-	-	-	-	-	-	-
Propane	-	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**886***	**2,118,915**	**2,953,472**	**2,004,307**	**1,906,409**	**1,905,444**	**10,796,269**	**7,715,530**	**581,003***	**-**	**29,982,236**

"-" 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 and column due to rounding or suppression of estimates that round to zero.

3.2.3.3. Energy impacts by sector

Figure 3-23 displays energy savings by sector over time. As shown in this figure, the large majority of the energy savings occur in the public institutional sector.

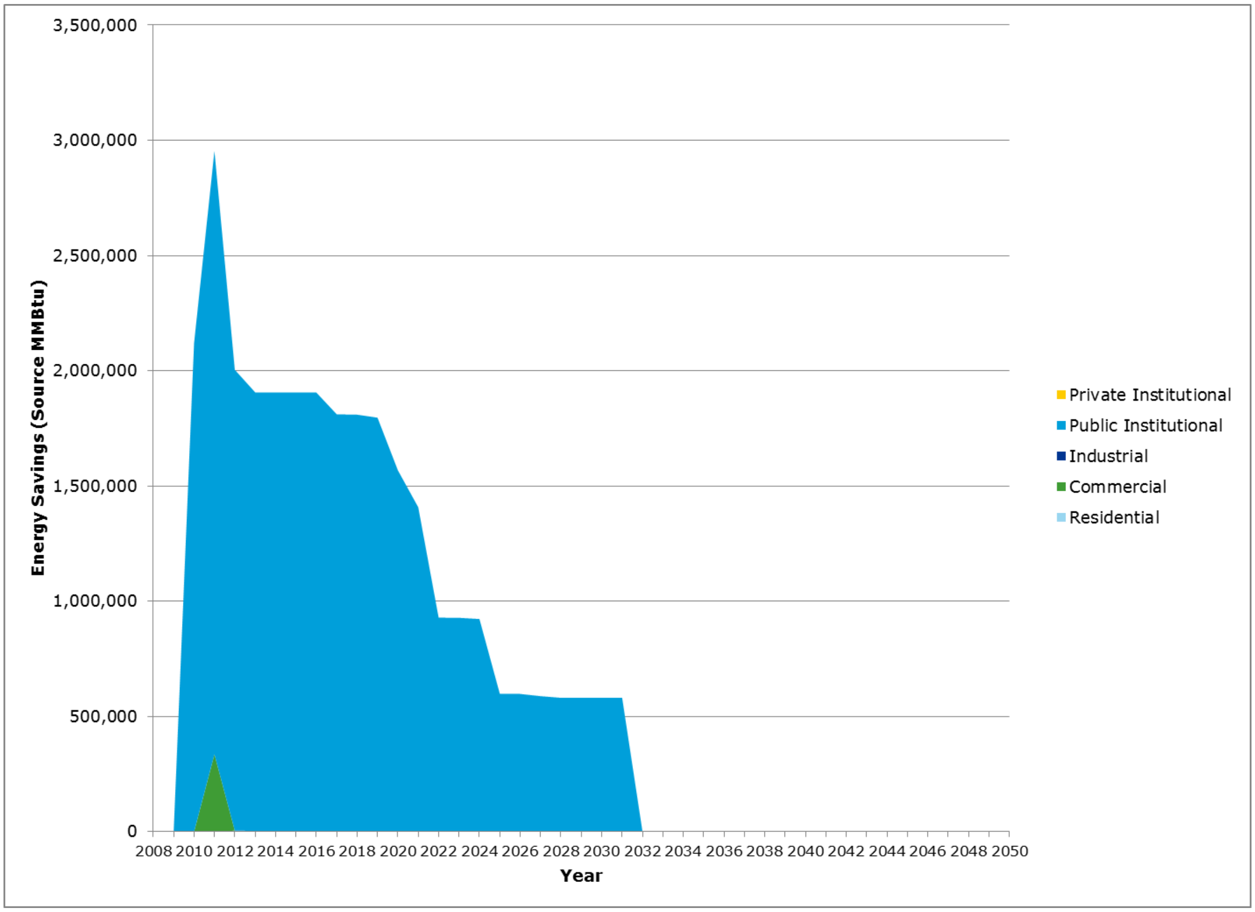

Figure 3-23: EECBG-attributable energy savings from buildings and facilities activities by sector by year (source MMBtu)

Table 3-19 shows total energy savings by sector for all years combined.

Table 3-19: EECBG-attributable energy savings from buildings and facilities activities by sector (source MMBtu)

	Attributable Savings
Residential	52,084*
Commercial	336,002*
Industrial	-
Public Institutional	29,594,150
Private Institutional	-
Total	**29,982,236**

"-" 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.

3.2.4. 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. Nineteen separate activities were studied and the findings were expanded to the target population BPA, which consists of 400 activities totaling $158 million in EECBG funding.

3.2.4.1. Energy impacts for all fuel types and sectors combined (source MMBtu)

The on-site renewables BPA resulted in 68 thousand source MMBtu of EECBG-attributable energy savings over the 2009–2050 period. Figure 3-24 shows the impacts over time. Energy savings have an initial peak in 2011 and 2012 from one group of measures. A second group of measures accrue most of the savings between 2014 and 2028.

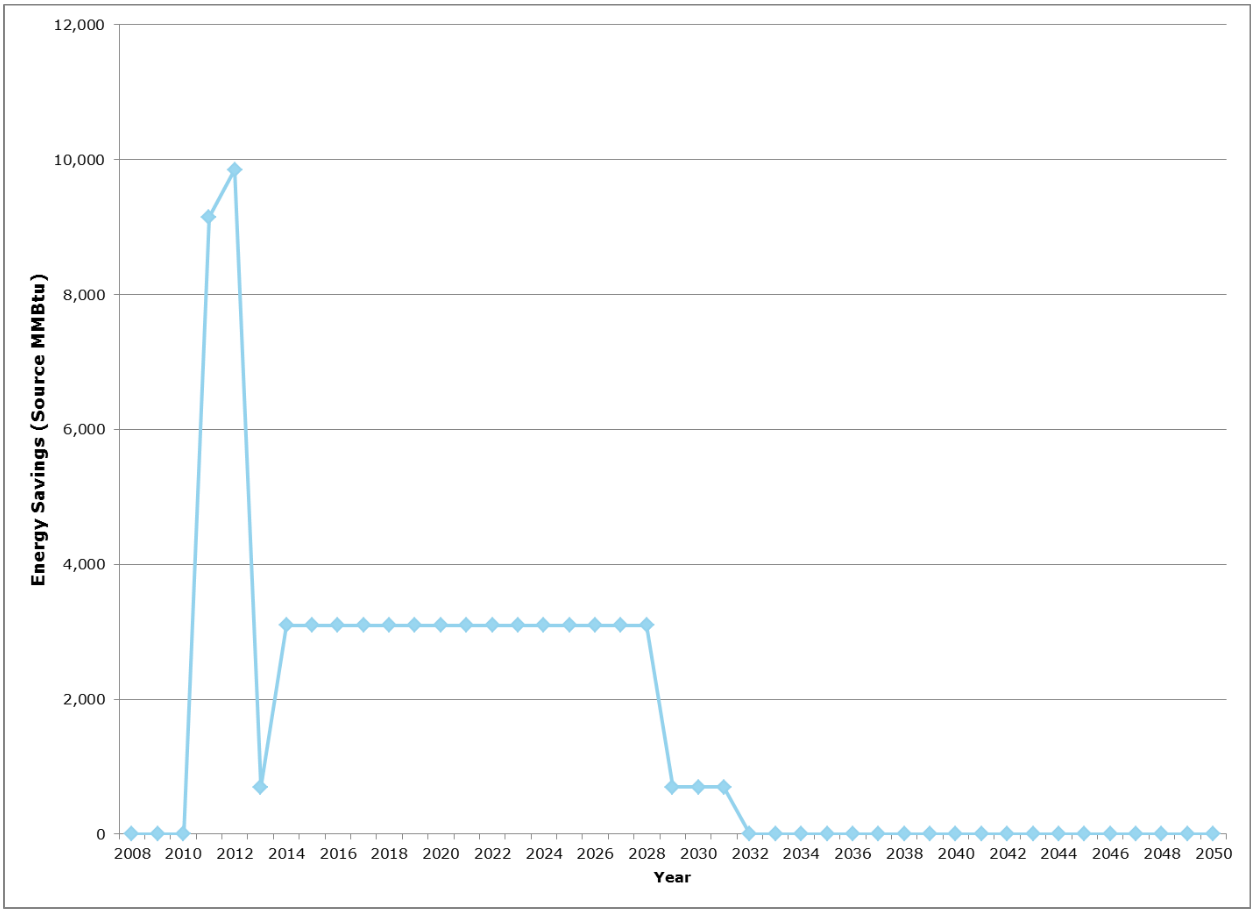

Figure 3-24: EECBG-attributable energy savings from on-site renewables activities over time (source MMBtu)

The on-site renewables BPA resulted in 3 million source MMBtu of on-site renewable generation over the 2009–2050 period. Figure 3-25 shows the impacts over time. The renewable generation reaches its peak in 2012 and remains steady through 2035. The steep declines in 2036 occur as the effective useful lifetimes of the associated renewable energy technologies expire.

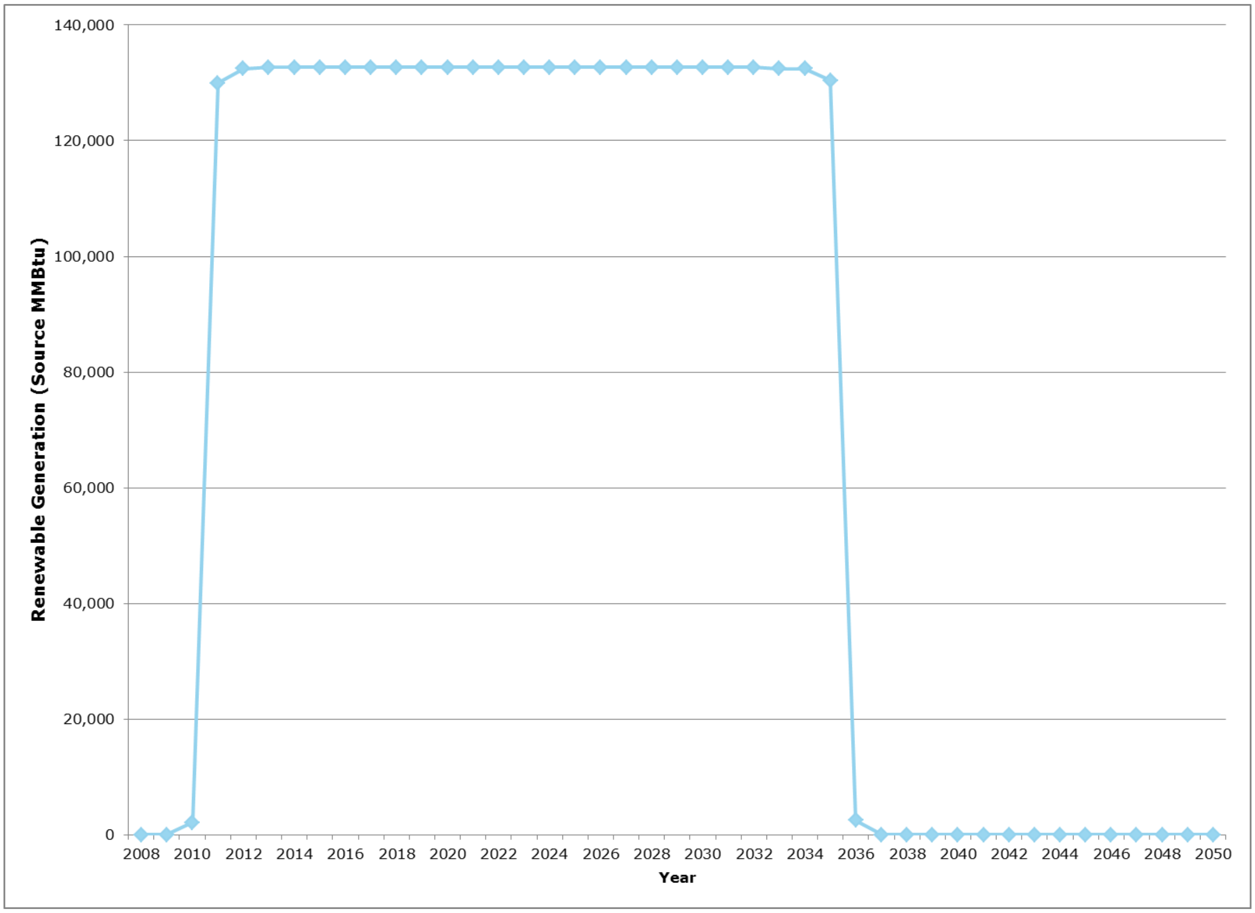

Figure 3-25: EECBG-attributable renewable generation from on-site renewables activities over time

3.2.4.2. Energy impacts by fuel type

Table 3-20 shows energy savings over time by fuel type. For the on-site renewables BPA, all the energy savings was from electricity savings.

Table 3-21 shows on-site renewable generation over time by fuel type. All the renewable energy produced was in the form of electricity.

Table 3-20: EECBG-attributable energy savings (source MMBtu) from on-site renewables activities by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	-	-	9,151*	9,852*	701*	3,094	18,567	26,157	701*	-	68,223
Natural Gas	-	-	-	-	-	-	-	-	-	-	-
Oil	-	-	-	-	-	-	-	-	-	-	-
Propane	-	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**-**	**9,151***	**9,852***	**701***	**3,094**	**18,567**	**26,157**	**701***	**-**	**68,223**

"-" 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 and column due to rounding or suppression of estimates that round to zero.

Table 3-21: EECBG-attributable renewable generation (source MMBtu) for on-site renewables BPA activities by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Renewable Electricity Generated	-	2,107*	129,983	132,488	132,682	132,682	796,091	1,326,818	663,226	-	3,316,077
Methane Produced	-	-	-	-	-	-	-	-	-	-	-
Landfill Gas (50% CH_4/50% CO_2) Produced	-	-	-	-	-	-	-	-	-	-	-
Digester Gas (Sewage or Biogas) Produced	-	-	-	-	-	-	-	-	-	-	-
Biodiesel Production	-	-	-	-	-	-	-	-	-	-	-
Ethanol Production	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**2,107***	**129,983**	**132,488**	**132,682**	**132,682**	**796,091**	**1,326,818**	**663,226**	**-**	**3,316,077**

"-" 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 and column due to rounding or suppression of estimates that round to zero.

3.2.4.3. Energy impacts by sector

Figure 3-26 displays energy savings by sector over time. As shown in that figure, the public institutional sector has an initial spike in energy savings, but the residential sector has the majority of savings once activities ramp up in 2014.

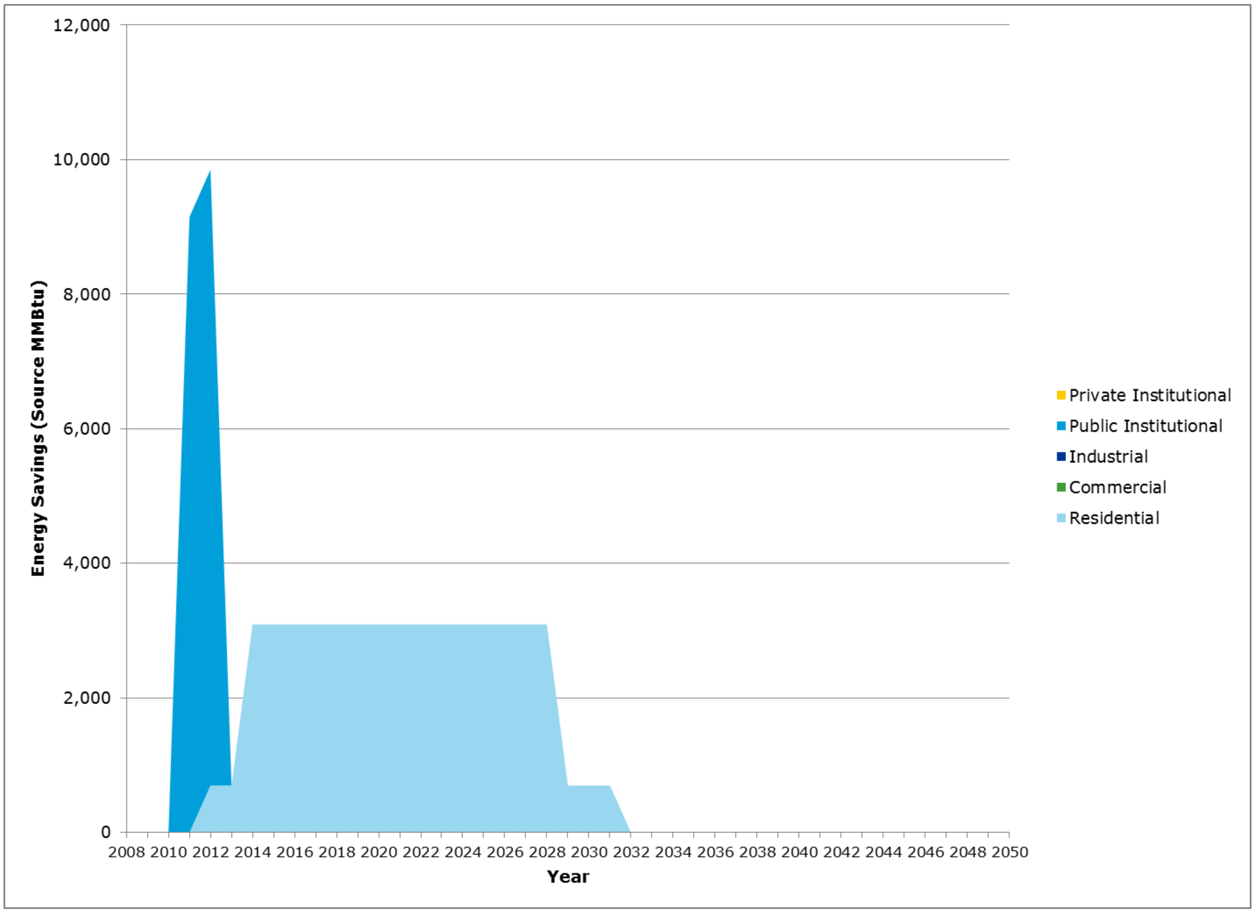

Figure 3-26: EECBG-attributable energy savings for on-site renewables BPA activities by sector by year (source MMBtu)

Table 3-22 shows total energy savings by sector for all years combined.

Table 3-22: EECBG-attributable energy savings for on-site renewables BPA activities by sector (Source MMBtu)

	Attributable Savings
Residential	49,921
Commercial	-
Industrial	-
Public Institutional	18,302*
Private Institutional	-
Total	**68,223**

"-" 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.

Figure 3-27 displays on-site renewable generation by sector over time. All of the renewable generation occurs in the public institutional sector.

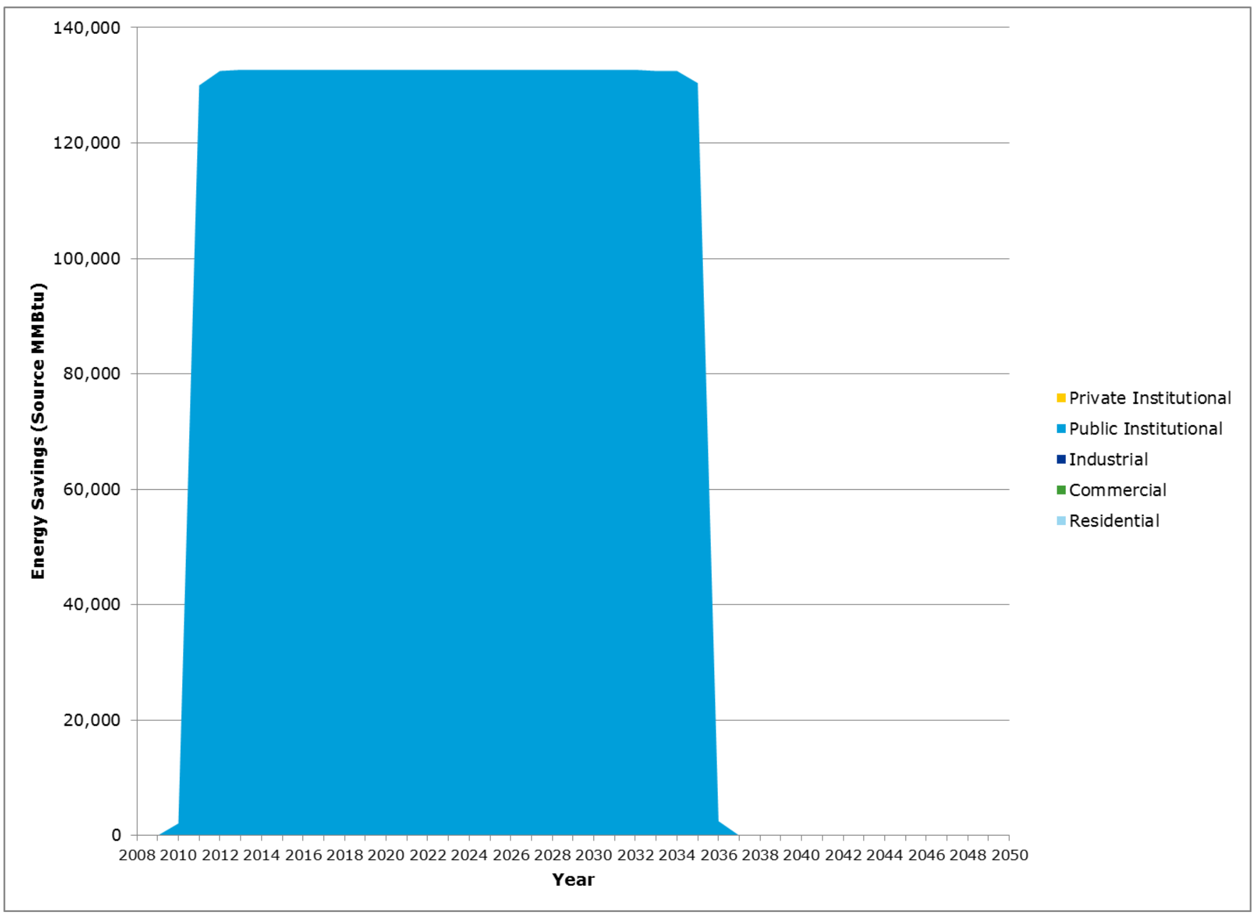

Figure 3-27: EECBG-Attributable on-site renewable generation for on-site renewables activities by sector by year (source MMBtu)

Table 3-23 shows total renewable generation by sector for all years combined.

Table 3-23: EECBG-attributable on-site renewable generation for on-site renewables activities by sector (source MMBtu)

	Attributable Savings
Residential	-
Commercial	-
Industrial	-
Public Institutional	3,316,077
Private Institutional	-
Total	**3,316,077**

"-" 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.

3.2.5. Lighting

The lighting BPA encompasses activities that focus on the replacement of traffic lighting and street lighting with energy-efficient lighting technologies. Twenty-seven separate activities were studied and the findings were expanded to the target population BPA, which consists of 572 activities totaling $193 million in EECBG funding. This BPA did not have any renewable generation impacts; therefore, this section will only discuss energy-savings impacts.

3.2.5.1. Energy impacts for all fuel types and sectors combined

The lighting BPA resulted in 71 million source MMBtu of EECBG-attributable energy savings over the 2009–2050 period. Figure 3-28 shows the impacts over time. Energy savings have an initial peak in 2011 through 2013 from one group of measures. A second group of measures accrue most of the savings between 2011 and 2030.

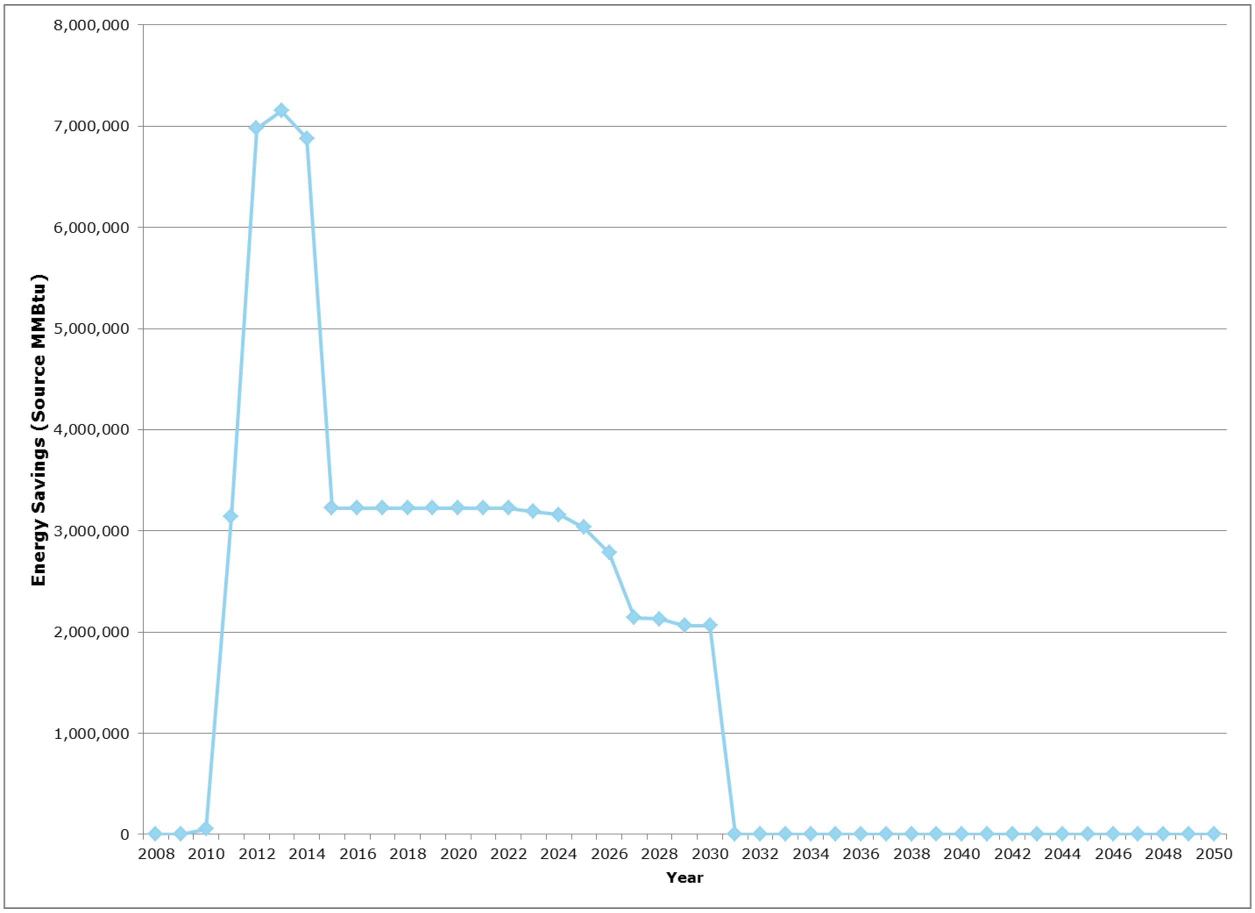

Figure 3-28: EECBG-attributable lighting energy savings over time (source MMBtu)

3.2.5.2. Energy impacts by fuel type

Table 3-24 shows energy savings over time by fuel type. For the lighting BPA, more than half of the energy savings, 40 million source MMBtu, was from gasoline resulting from lower idling times caused by the increased timing efficiency of new traffic signals. The rest of the energy savings, 31 million source MMBtu, was from electricity.

Table 3-24: EECBG-attributable energy savings (source MMBtu) for lighting activities by fuel type over time (source MMBtu)

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	-	56,200	1,152,586	4,991,938*	5,162,532	4,892,873*	7,428,213	7,145,160	-	-	30,829,502
Natural Gas	-	-	-	-	-	-	-	-	-	-	-
Oil	-	-	-	-	-	-	-	-	-	-	-
Propane	-	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	1,988,029*	1,988,029*	1,988,029*	1,988,029*	11,928,175*	19,880,292*	-	-	39,760,583*
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**56,200**	**3,140,615**	**6,979,967**	**7,150,561**	**6,880,902**	**19,356,388**	**27,025,452**	**-**	**-**	**70,590,085**

"-" 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 and column due to rounding or suppression of estimates that round to zero.

3.2.5.3. Energy impacts by sector

Figure 3-29 displays energy savings by sector over time. As shown in that figure, the public institutional sector has an initial spike in energy savings, but the residential sector has the majority of overall savings.

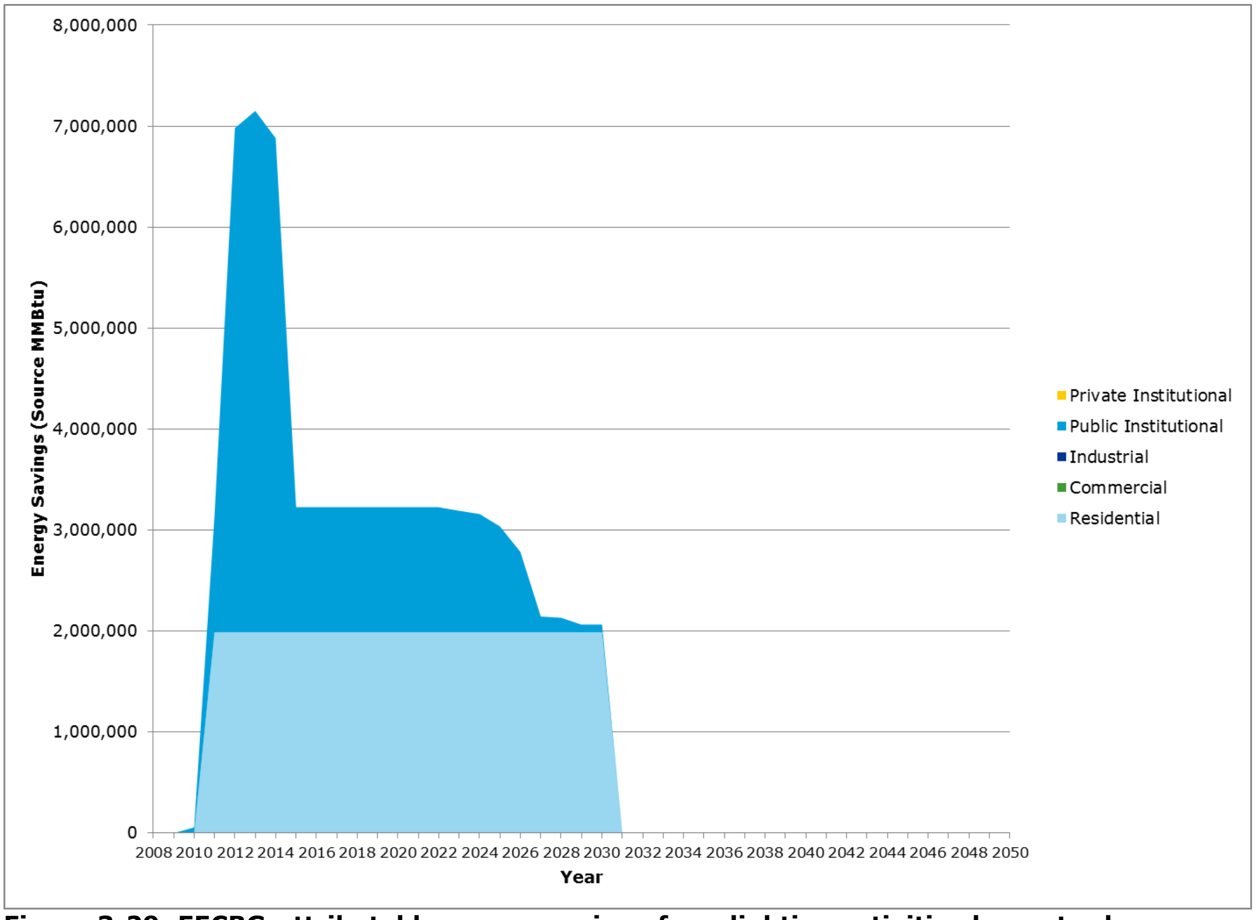

Figure 3-29: EECBG-attributable energy savings from lighting activities by sector by year (source MMBtu)

Table 3-25 shows total energy savings by sector for all years combined.

Table 3-25: EECBG-attributable energy savings from lighting activities by sector (source MMBtu)

	Attributable Savings
Residential	39,760,583*
Commercial	-
Industrial	-
Public Institutional	30,829,502
Private Institutional	-
Total	**70,590,085**

"-" 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.

3.2.6. Energy efficiency and conservation strategy (direct grants)

The energy efficiency and conservation strategy (direct grants[75]) BPA encompasses activities that cover a wide range of policies and programs being implemented by grant recipients that do not easily fit into other categories. Secondary source materials were used to determine the energy savings achieved by activities in the Energy Efficiency and Conservation Strategy BPA. In many cases, funds in this BPA were used for activities such as building operator training or the development of education modules. To estimate savings for those activities, the evaluation team researched similar programs that had been implemented and evaluated previously. Verified savings from the researched studies on a per-unit basis (such as per student or per training) were identified and applied to the EECBG activity to estimate overall savings. Five separate activities were studied and the findings were expanded to the target population BPA, which consists of 560 activities totaling $66 million in EECBG funding.

3.2.6.1. Energy impacts for all fuel types and sectors combined

The energy efficiency and conservation strategy (direct grants) BPA resulted in 1.9 million source MMBtu of EECBG-attributable energy savings over the 2009–2050 period. Figure 3-30 shows the impacts over time. Energy savings peak between 2012 and 2022 from one group of measures. In 2023, impacts drop off and then decline through 2037 when savings impacts expire.

[75] The energy efficiency and conservation strategy BPA has been split in this table into direct grants, which are provided directly to the entity using the funds, and indirect grants, which are provided to states that in turn issued funding. This was done because the indirect portion of this BPA is outside the target population for this evaluation. Indirect grants in this BPA are excluded due to the inability to obtain a respondent in this group for this evaluation.

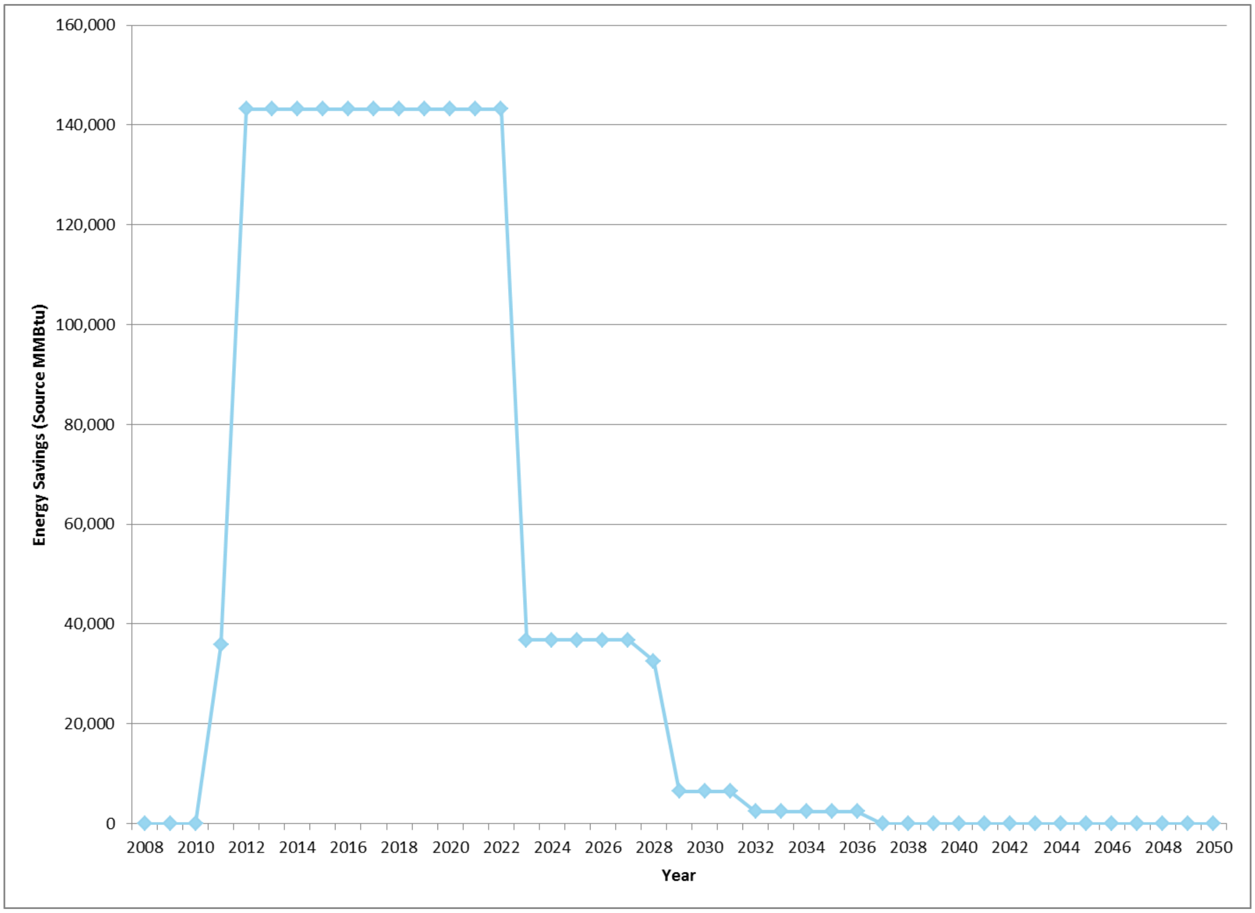

Figure 3-30: EECBG-attributable energy savings from energy efficiency and conservation strategy (direct grants) activities over time (source MMBtu)

The energy efficiency and conservation strategy (direct grants) BPA resulted in 2,000 source MMBtu of on-site renewable generation over the 2009–2050 period. Figure 3-31 shows the impacts over time. The renewable generation reaches its peak in 2013 and remains steady through 2027. The steep declines in 2036 occur as the effective useful lifetimes of the associated renewable energy technologies expire.

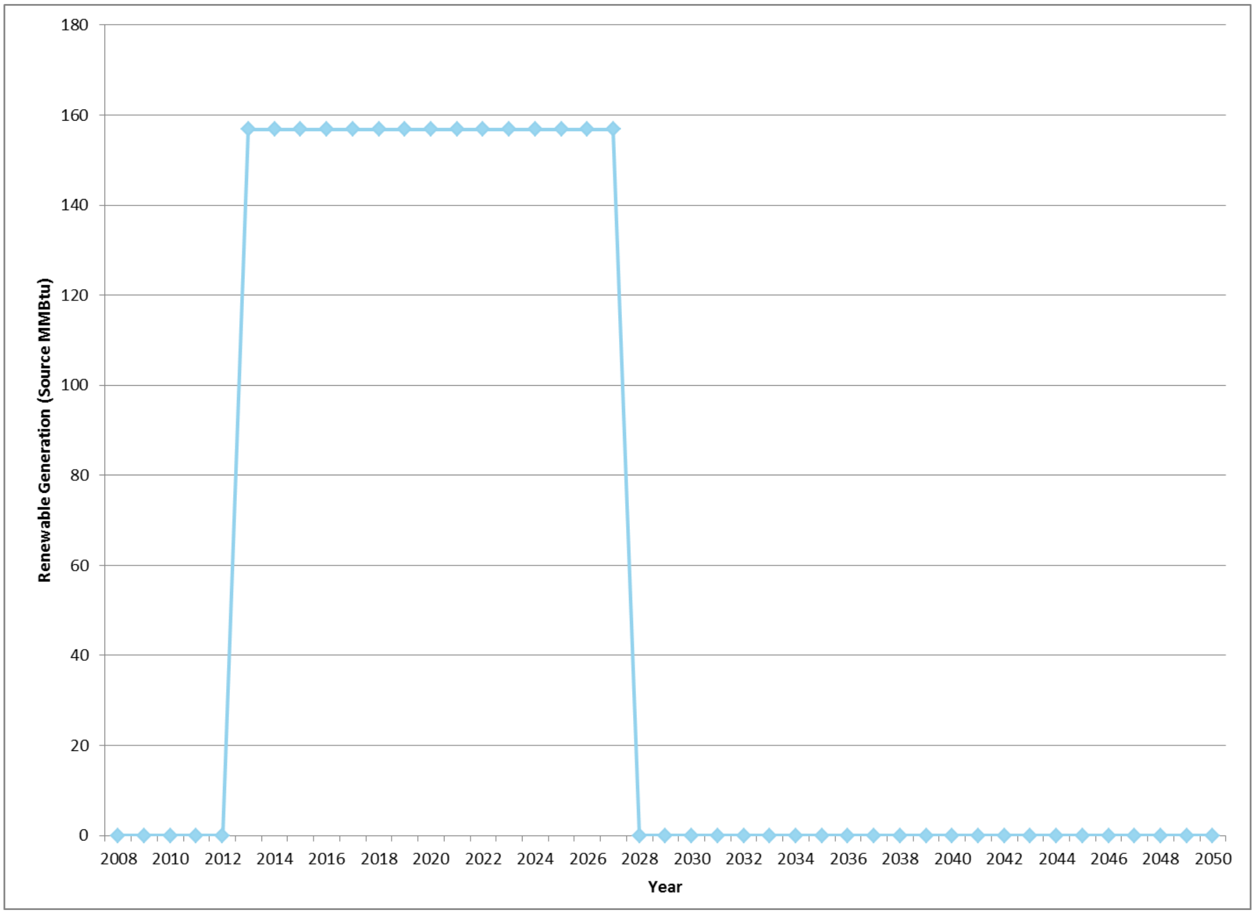

Figure 3-31: EECBG-attributable, on-site renewable generation from energy efficiency and conservation strategy (direct grants) activities over time (source MMBtu)

3.2.6.2. Energy impacts by fuel type

Table 3-26 shows energy savings over time by fuel type. For the energy efficiency and conservation strategy (direct grants) BPA, about two-thirds of the savings was from natural gas. The other third came from electricity.

Table 3-27 shows on-site renewable generation over time by fuel type. All of the renewable energy produced was in the form of electricity.

Table 3-26: EECBG-attributable energy savings (source MMBtu) from energy efficiency and conservation strategy (direct grants) activities by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	-	-	35,836*	36,709*	36,709*	36,709*	220,256*	253,877*	992*	-	621,088*
Natural Gas	-	-	-	106,496*	106,496*	106,496*	638,978*	261,980*	17,644*	-	1,238,091*
Oil	-	-	-	-	-	-	-	-	-	-	-
Propane	-	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**-**	**35,836***	**143,206***	**143,206***	**143,206***	**859,234***	**515,857***	**18,636***	**-**	**1,859,179***

"-" 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 and column due to rounding or suppression of estimates that round to zero.

Table 3-27: EECBG-attributable renewable generation (source MMBtu) from energy efficiency and conservation strategy (direct grants) activities by fuel type over time

	2009	2010	2011	2012	2013	2014	2015-2020	2021-2030	2031-2040	2041-2050	Total
Renewable Electricity Generated	-	-	-	-	157*	157*	941*	1,098*	-	-	2,352*
Methane Produced	-	-	-	-	-	-	-	-	-	-	-
Landfill Gas (50% CH_4/50% CO_2) Produced	-	-	-	-	-	-	-	-	-	-	-
Digester Gas (Sewage or Biogas) Produced	-	-	-	-	-	-	-	-	-	-	-
Biodiesel Production	-	-	-	-	-	-	-	-	-	-	-
Ethanol Production	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**-**	**-**	**-**	**157***	**157***	**941***	**1,098***	**-**	**-**	**2,352***

"-" 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 and column due to rounding or suppression of estimates that round to zero.

3.2.6.3. Energy impacts by sector

Figure 3-32 displays energy savings by sector over time. The public institutional and residential sectors account for a large majority of energy savings.

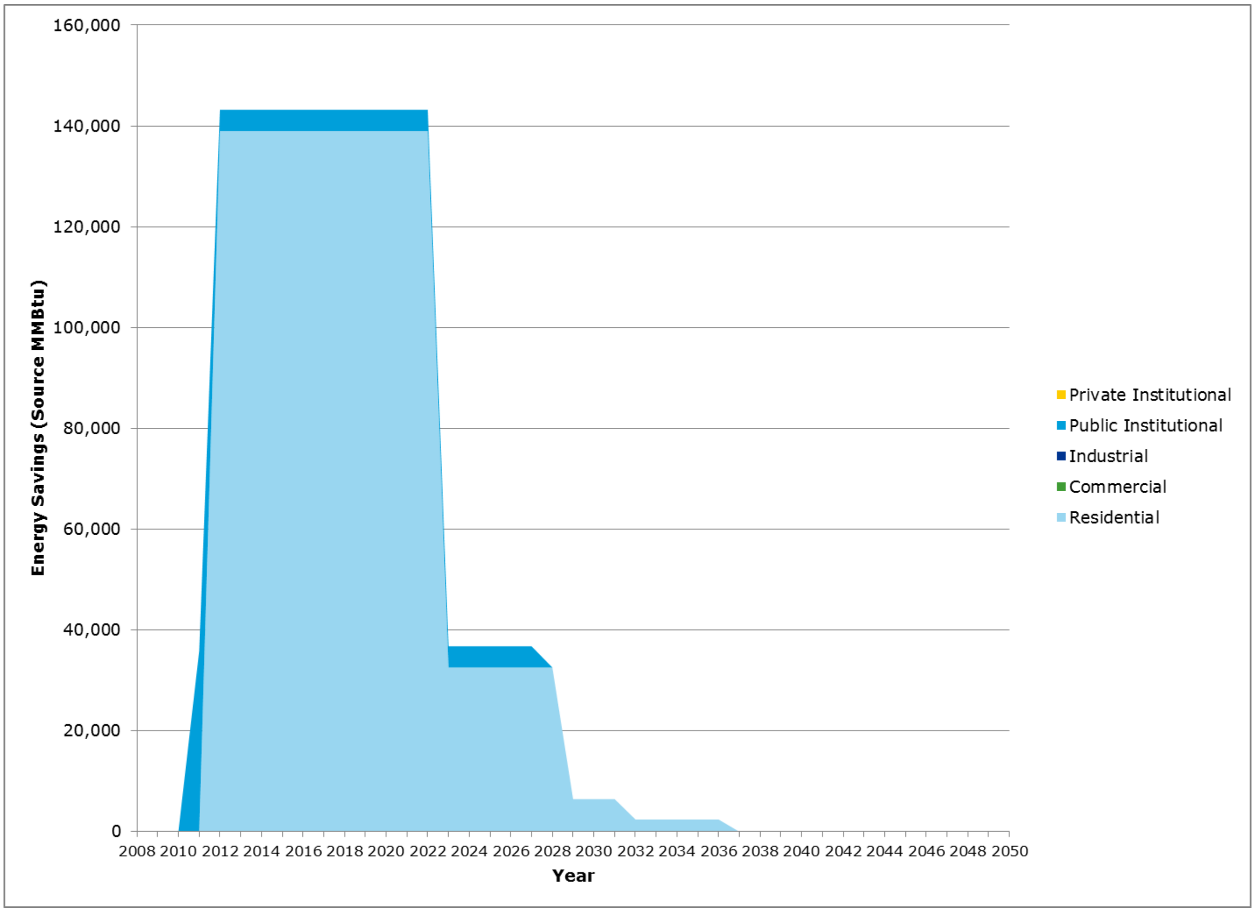

Figure 3-32: EECBG-attributable energy savings from energy efficiency and conservation strategy (direct grants) activities by sector by year (source MMBtu)

Table 3-28 shows total energy savings by sector for all years combined.

Table 3-28: EECBG-attributable energy savings from energy efficiency and conservation strategy (direct grants) activities by sector (source MMBtu)

	Attributable Savings
Residential	1,756,020*
Commercial	-
Industrial	-
Public Institutional	103,159*
Private Institutional	-
Total	**1,859,179***

"-" 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.

Figure 3-33 displays on-site renewable generation by sector over time. All of the renewable generation occurs in the residential sector.

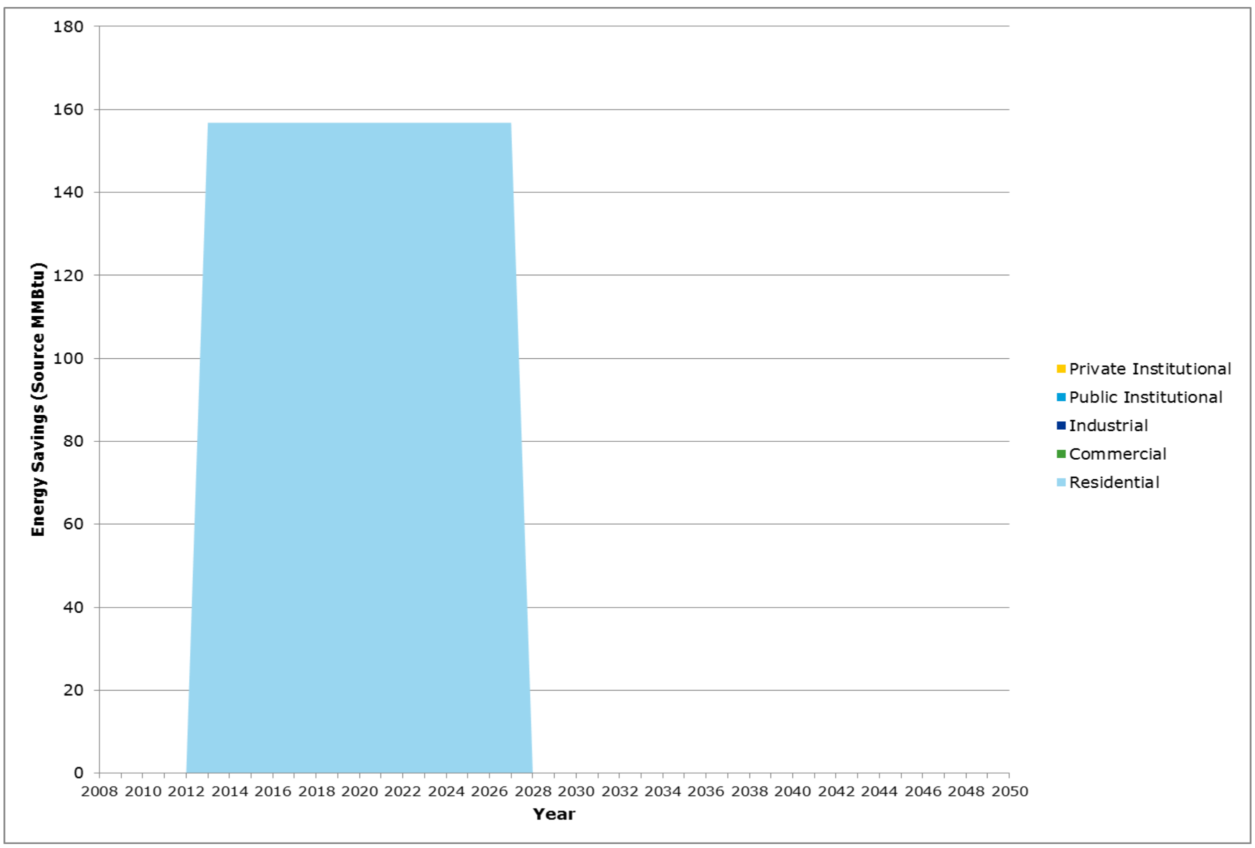

Figure 3-33: EECBG-attributable on-site renewable generation from energy efficiency and conservation strategy (direct grants) activities by sector by year (source MMBtu)

Table 3-29 shows total renewable generation by sector for all years combined.

Table 3-29: EECBG-attributable on-site renewable generation from energy efficiency and conservation strategy (direct grants) activities by sector (source MMBtu)

	Attributable Savings
Residential	2,352*
Commercial	-
Industrial	-
Public Institutional	-
Private Institutional	-
Total	**2,352***

"-" 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.

3.3. Labor impacts

This section addresses the labor impacts for each of the six BPAs studied in this evaluation. Labor impacts are presented in terms of jobs created or retained and direct job years resulting from EECBG activities funded by ARRA.

3.3.1. Energy efficiency retrofits

This section presents EECBG-attributable job impact results for the energy efficiency retrofits BPA. The following BPA characteristics influence the pattern and magnitude of the observed job impacts:

- Residential, public, and commercial and industrial customer segments participated
- The Great Lakes region did not have commercial and industrial participation
- Projects required $554 million of US-manufactured equipment and $388 million of installation labor through 2013
- Segment-specific bill savings persist to 2036 for residential and municipal, 2031 for industrial, and 2026 for commercial

This section presents the longer-term job generation effects of EECBG funding for energy-efficient retrofit activities and it also presents job impact inclusive of the multiplier effects (the indirect and induced effects). The values are annual job changes since this section is reporting for the assumed life cycle of the portfolio of project installations.

Table 3-30 shows the total employment impact over the life of EECBG funding for retrofit activities. The major influence behind this trajectory of annual job changes is the initial project deployment stimulus, particularly in 2011; the decay in the persistence of energy savings; the expiration of bill savings for both participating customer segments in the 2031–2040 interval; and reduced demand for electricity and natural gas. Job years needed through 2036 are 31,112.

Table 3-30: Direct, indirect, and induced jobs created in the US from energy efficiency retrofit EECBG activities (2009-2050)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Total US	2,137	7,957	8,855	5,035	1,118	3984	2,210	(184)	-	31,112

"-" indicates estimate rounds to zero and is considered imprecise.

The annual series of total job changes from the EECBG retrofit activities over time are shown in Figure 3-34. This figure shows the upfront stimulus of project investment and program administration through 2013. Beyond 2013, the job impacts shift to a profile associated with the regime of only the net savings influencing the regional economies, first through a ramp-up and then the decay of bill savings as energy-consuming devices installed through these activities reach the end of their service life.

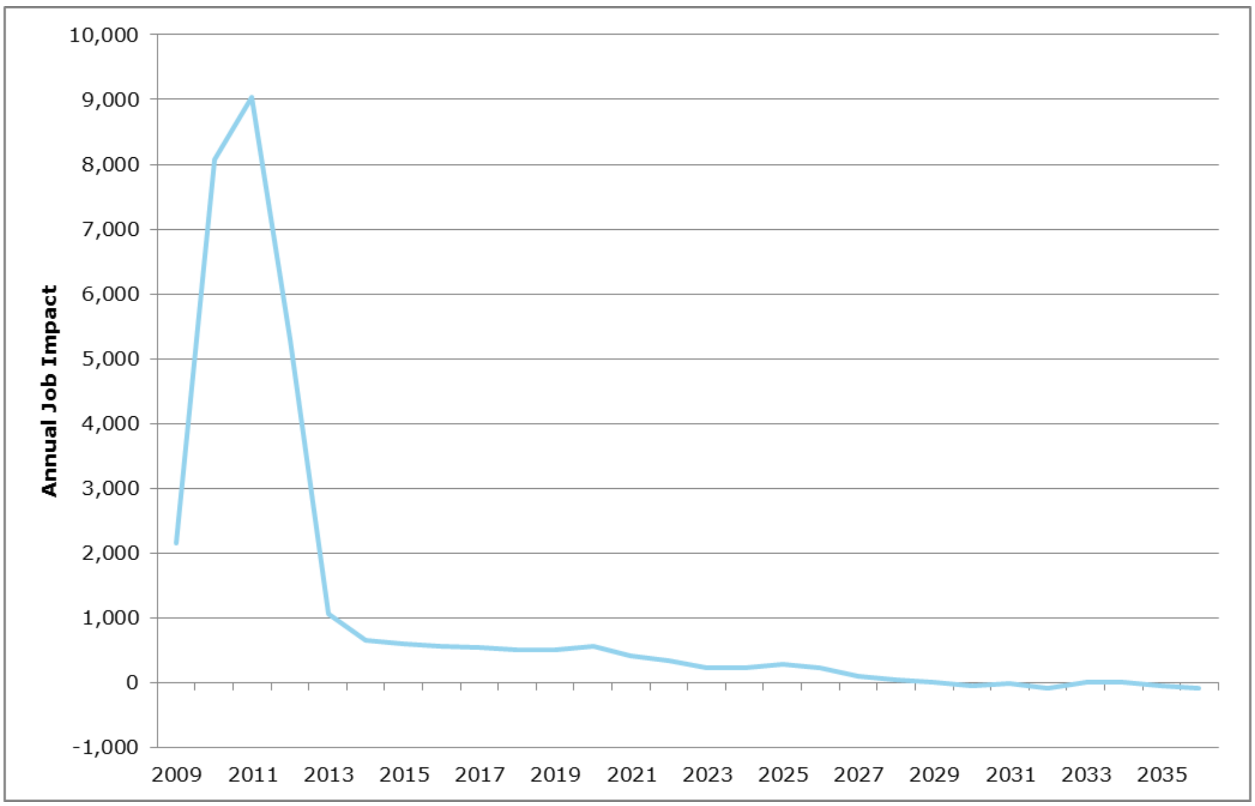

Figure 3-34: Direct, indirect, and induced job changes created in the US from energy efficiency retrofit EECBG activities

A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.

Figure 3-35 presents a snapshot of job impacts for two specific years in the analysis period. These job impacts are inclusive of multiplier effects. In 2009, when project deployment activity is starting, almost every sector experiences positive job impacts. Of note are job impacts for the State/Local (S/L) government sector due to program administration and construction, manufacturing, and professional and technical services associated with the project investments. The job impacts falling into other sectors in 2009 result from indirect and induced transactions that stem from the activity in the four aforementioned sectors.

In 2022, all participating customer segments are still experiencing the effects of bill savings. As noted above, the public institutional segment has the largest bill savings; hence more public spending is possible. This finding supports more S/L government employees. The utilities and mining sectors shed some jobs in light of lower demand for electricity and natural gas. However, all other private sector activities gain jobs in 2022 through either a direct bill savings effect or a multiplier effect.

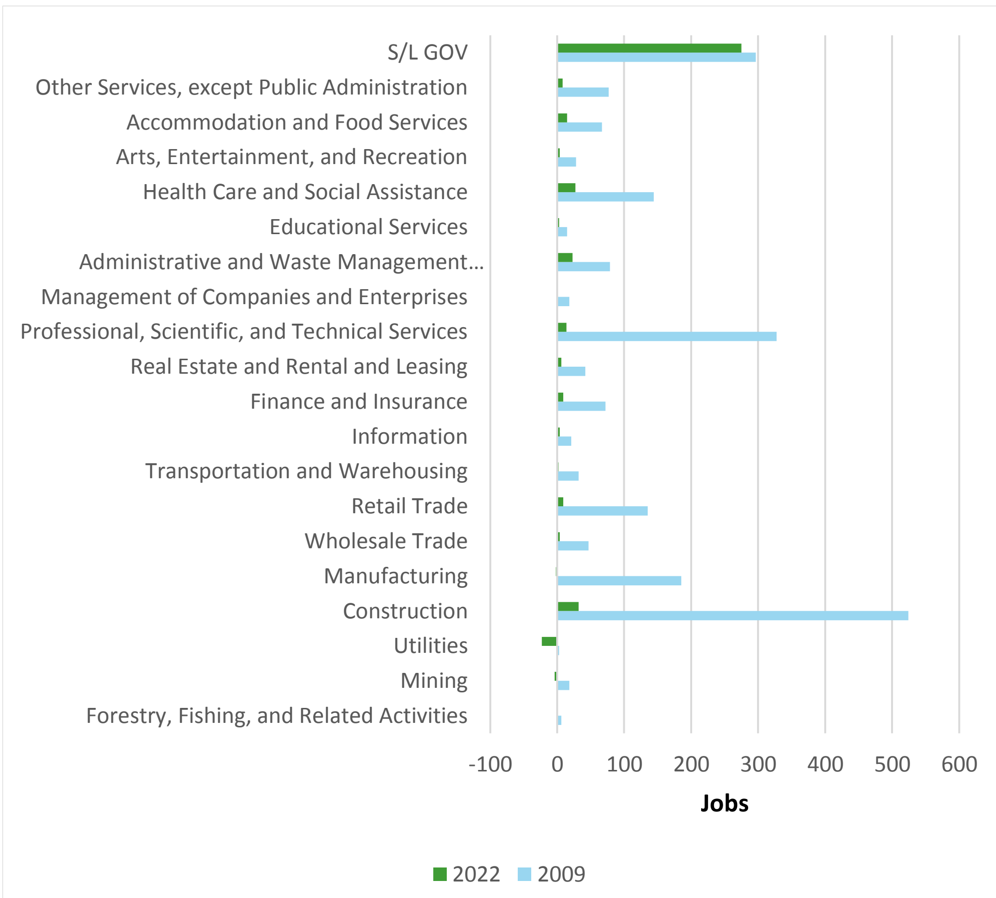

Figure 3-35: Job Impact of energy efficiency retrofit EECBG activities, by NAICS sector

Table 3-31 shows the direct job effects of 9,600 job years occurring in the short-term as a result of the project deployment-period funding for energy efficiency retrofit activities.

Table 3-31: Direct jobs created in the US from energy efficiency retrofit EECBG activities

Year	2009	2010	2011	2012	2013	2014-2033	Job Years
All US	797	3,289	3,592	1,776	177	0	9,631

3.3.2. Financial incentives

This section presents EECBG-attributable job impact results for the financial incentives BPA. The following BPA characteristics influence the pattern and magnitude of job impacts observed:

- Residential, commercial, and public institutional customer segments participated across all regions.
- Incentives were issued to all three customer segments.
- Loan financing was also available to the residential segment.
- Loans revolve until 2033 (paid off by 2027); therefore, residential energy savings persist (albeit decaying) through 2050, the last year evaluated as part of this study.[76]
- Residential participant outlays to make improvements extend to 2033 along with the program administration on the revolving loans.
- These outlays created about $604 million worth of orders for US-manufactured goods and another $449 million of business related to installations and technical services. Another $63 million covered wages and salaries in the state and local government sector related to program administration.
- The value of cumulative bill savings to each customer segment (after accounting for up-front outlays to make improvements and offsetting incentives) is:
  - $1.9 billion residential (after loan prepayment costs net savings are $0.9 billion)
  - $0.01 billion commercial lasting through 2030
  - $0.18 billion public institutional lasting through 2036.

This section presents the longer-term job generation effects of funding into financial incentives activities, and it also presents job impact inclusive of the multiplier effects (the *indirect* and *induced* effects). The values are annual *job changes* for the assumed life cycle of the portfolio of project installations. Table 3-32 shows the total employment impact over the lifetime of financial incentives EECBG activities. The major influence behind this trajectory of annual job changes is bill savings, which drives job requirements despite some net job losses due in part to reduced customer purchases of electricity and gas. There are 9,420 job years created through 2050.

Table 3-32: Direct, indirect, and induced jobs created in the US from financial incentive EECBG activities (2009–2050)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total

[76] This evaluation studied impacts through the year 2050. Any impacts that occurred past 2050 are not covered as part of this evaluation.

Total	1,474	2,072	2,103	2,159	740	-426	1,632	1,568	-1,903	9,420

"-" indicates estimate rounds to zero and is considered imprecise.

Figure 3-36 shows the direct, indirect, and induced job years created from the financial incentive activities over time. The maximum job impact occurs in 2012 and is due to the stimulus of program administration spending and project deployment. After 2013, a three-year interval of modest job losses occurs for the US economy (hence the negative value shown in Table 3-32 for the 2014 to 2020 interval). These result from (a) a step down in the pace of project deployment post-ARRA period and the transition to the revolving loan assumptions, and (b) the adverse employment impacts from utility generation offset are stronger than the positive job impacts from participant savings, due in large part because the residential participants have loan obligations for these improvements. The time series shows the effects of the termination of bill savings in the small commercial sector of the BPA (2030) and similarly for the public segment (2036). The remaining influences on the pattern of annual job impacts are from residential customers participating through the revolving loan and the effects of remaining utility sector generation offsets.

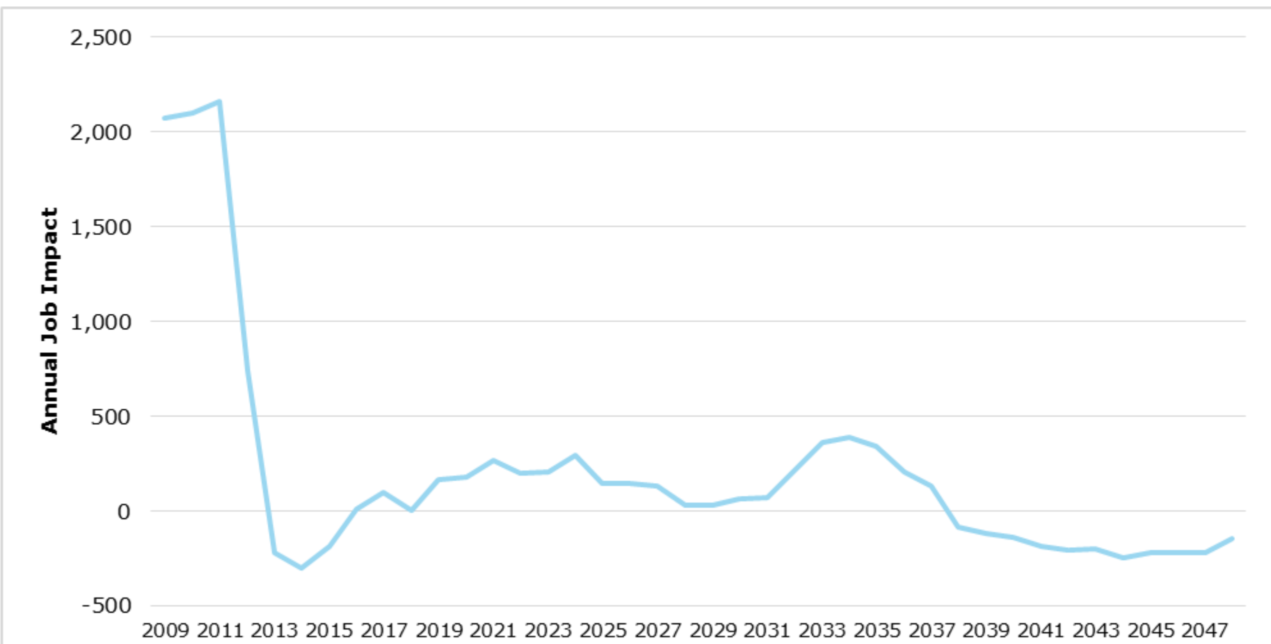

Figure 3-36: Direct, indirect, and induced job changes created in the US from financial incentive EECBG activities

A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix M provides precision for estimates used as primary inputs to this figure, such as energy impacts.

Figure 3-37 presents a snapshot of job impacts for two specific years in the analysis period. These job impacts are inclusive of multiplier effects. The sector profile of affected jobs reflects:

- Those sectors directly involved with delivering projects do not ramp up until 2011(e.g., construction labor, professional and technical services, and manufacturing); in 2009, there is only program administration activity from the public realm);
- Sectors affected when energy consumers redirect some of their budget away from general household or business expenditures and into making energy improvement; and,
- Job effects when customers make fewer energy purchases and redirect those dollars into more household spending for other goods and services, and commercial and industrial customers ramp up production in response to the market share they have gained as a result of the energy savings lowering their cost of doing business.

The size of the programs with this BPA targeted to commercial businesses is small. Therefore, any job gains for industries within the commercial sector are not from bill savings but from normal business activity and from the multiplier effects. The industrial sector does not participate in this BPA, but US manufacturers will gain jobs from short-term (to 2033) project deployment activity and multiplier effects. In 2022, the utilities sector shows a job reduction due to the reduction in demand for electric and gas consumption under higher energy efficiency in the economy. Private sectors may also see an increase in jobs as a result of households having more discretionary income to spend. The state and local sector increases jobs as a result of redirecting saved energy budget into other forms of public spending.

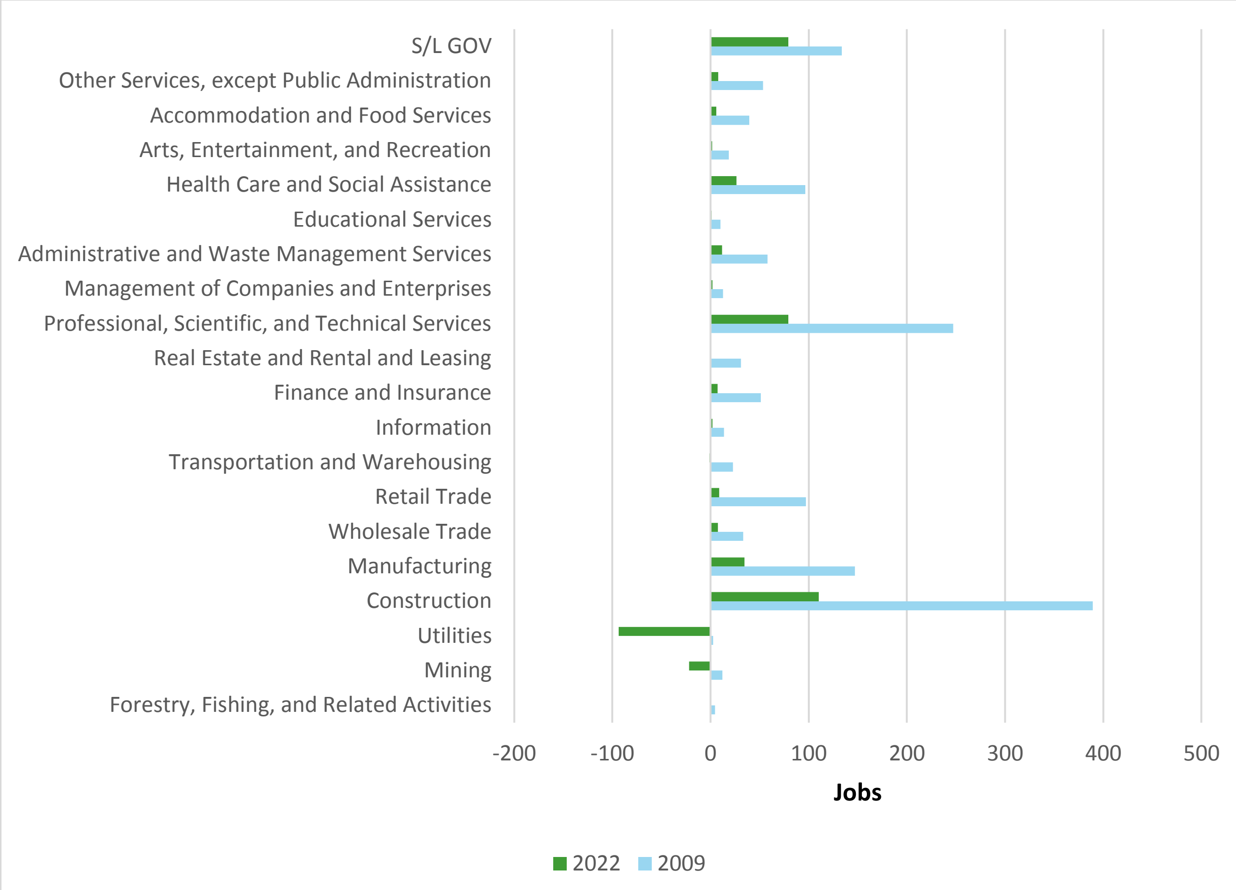

Figure 3-37: Job impact of financial incentive EECBG activities, by NAICS sector

Table 3-33 presents the direct job effects occurring in the short-term project deployment activities as a result of financial incentive EECBG activities. The values reported are annual impacts within the interval that funds were to be disbursed. Some 5,455 job years will be required in the US through 2013. Due to the revolving loan structure, program administration and project deployment activities decline through 2033. The job years through 2033 are more than 9,800 for the US economy.

Table 3-33: Direct jobs created in the US from financial incentives EECBG-funded activities

Year	2009	2010	2011	2012	2013	2014-2033	Job Years
All US	620	1,403	1,465	1,303	665	4,361	9,816

"-" indicates estimate rounds to zero and is considered imprecise.

3.3.3. Buildings and facilities

This section presents EECBG-attributable job impact results for the buildings and facilities BPA. The following BPA characteristics influence the pattern and magnitude of job impacts observed:

- Commercial and public institutional customer segments participate across all regions.

- Project investments created about $157 million worth of orders for US manufactured goods, and $110 million for installation labor through 2013.
- Bill savings persist through 2031 for the public institutional segment; the commercial segment has pilot project savings limited to a single year, 2011.
- The cumulative value of bill savings by segment with net savings shown in parentheses (net is after accounting for up-front outlays to make improvements plus customer rebate income) are:
- Commercial $3.0 million ($5.5 million)
- Public institutional $246 million ($163 million)

Table 3-34 shows the total employment impact over the life of the EECBG-funded projects among buildings and facilities activities. There were almost 8,433 job years added through 2031.

Table 3-34: Direct, indirect, and induced jobs created in the US from EECBG-funded buildings and facilities EECBG activities (2009–2031)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Total US	473	1,483	1,806	948	489	2,235	966	33	-	8,433

"-" indicates estimate rounds to zero and is considered imprecise.

This section also presents the longer-term job generation effects of EECBG funding for building and facilities activities and the job impacts inclusive of the multiplier effects (the indirect and induced effects). The values are annual job changes as this section is reporting across the assumed life cycle of the portfolio of project installations. Figure 3-38 shows the direct, indirect, and induced job impacts created from the EECBG buildings and facilities activities over time.

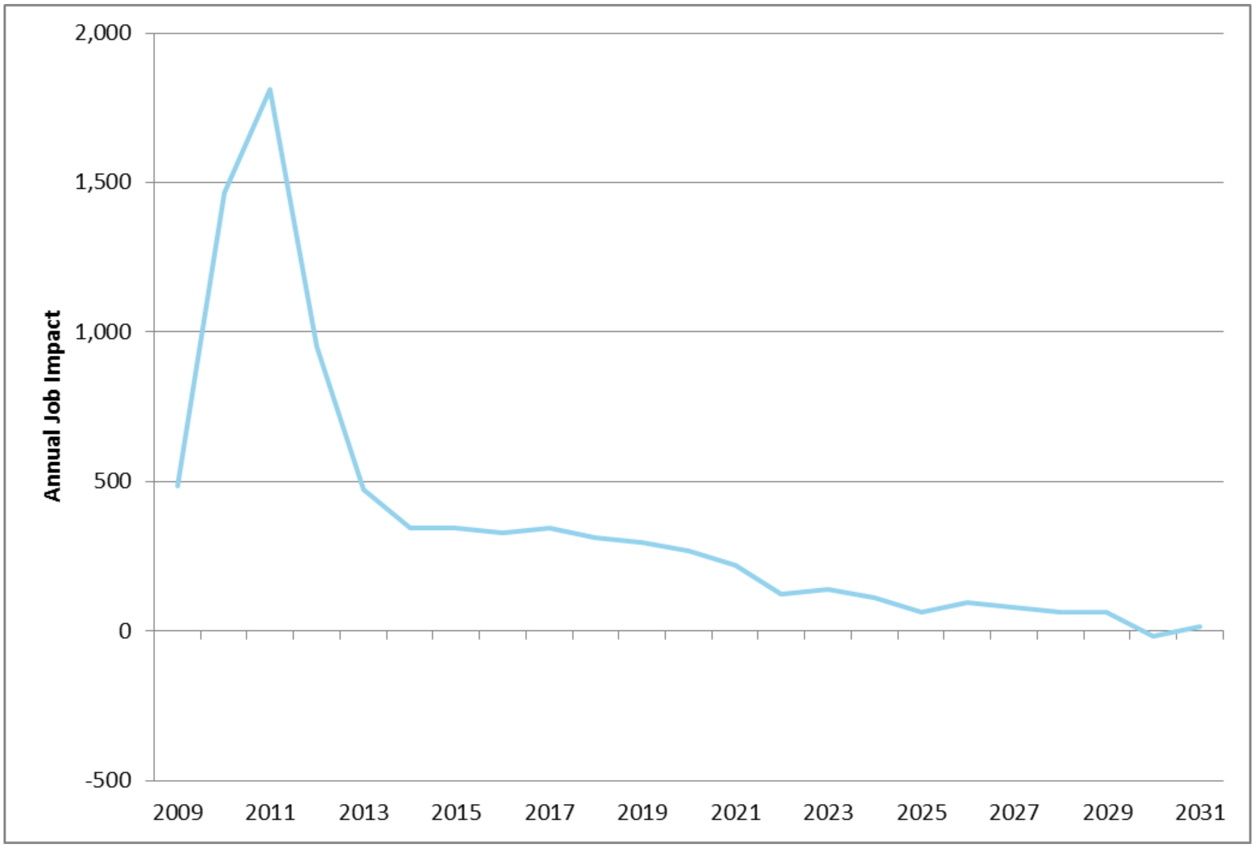

Figure 3-38: Direct, indirect, and induced job changes created in the US from buildings and facilities EECBG activities

A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.

Figure 3-39 presents a snapshot of job impacts inclusive of multiplier effects for two specific years in the analysis period. Total job impacts for 2009 show the stimulus across numerous sectors from project-related purchases. Though program administration in 2009 supports S/L government jobs, the public institutional segment absorbs greater project-related costs than they reap in bill savings in 2009. Therefore, the net change in public budgets is a reduction that includes lowering its payroll. The multiplier effect accounts for the jobs created more broadly as a result of households having increased wage opportunities (e.g., retail, general services, and healthcare) through the induced effect and from the business-to-business supplier effects (the indirect effect).

The total jobs impacts for 2022 reflect the effects from public institutional bill savings alone (since the commercial segment savings disappear after 2011). Estimated impacts show the S/L government sector gaining jobs as a result of bill savings, which leads to more public spending—a large portion of which is spent on payroll. The lower demand for electricity leads to some job losses in the utilities and mining sectors. Job impacts for other sectors occur through the multiplier effects of indirect and induced transactions that are subsequently triggered.

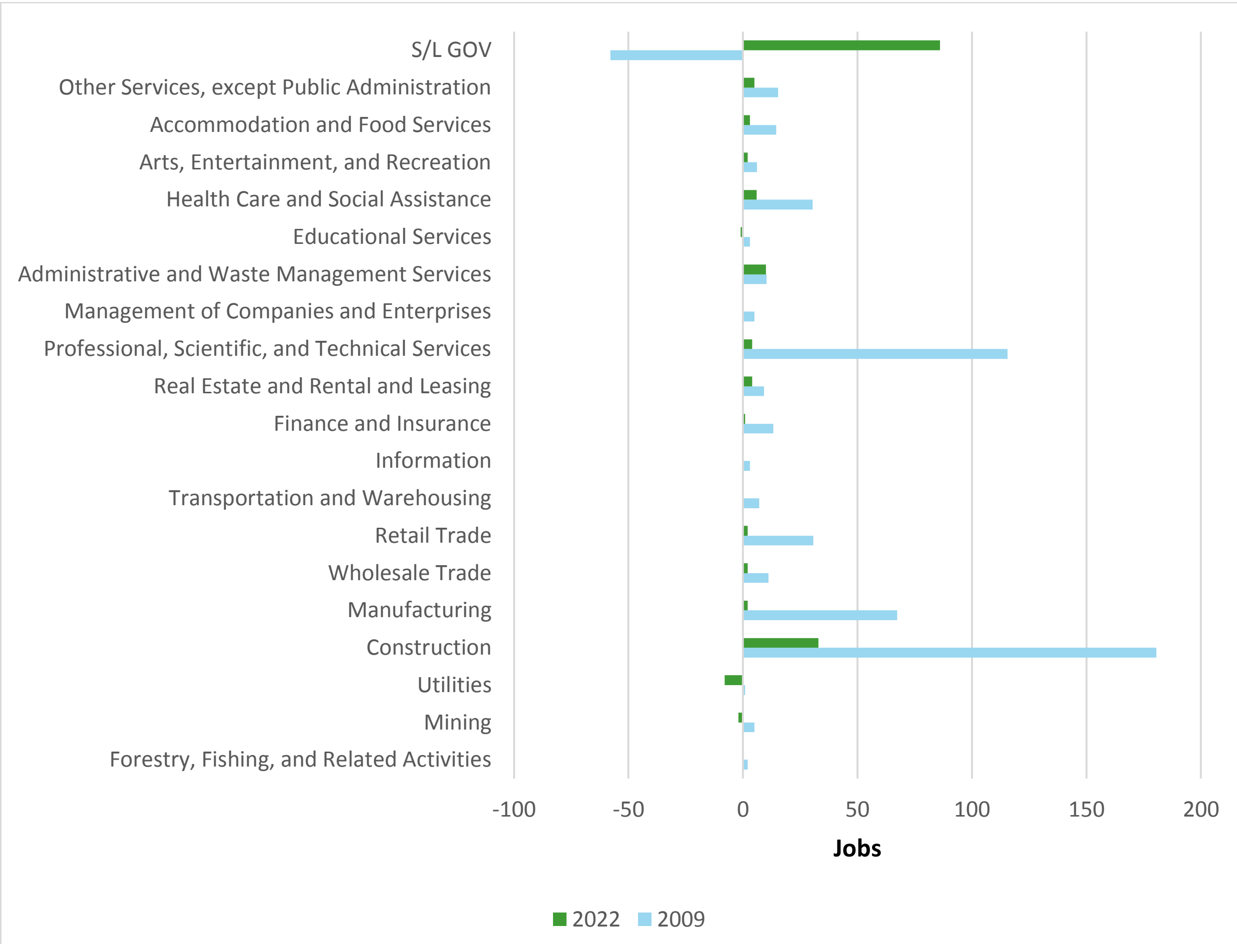

Figure 3-39: Job impact of buildings and facilities EECBG activities, by NAICS sector

Table 3-35 shows the direct job impacts of 2,640 job years from 2009–2013 as a result of EECBG project deployment funding for building and facilities activities. The values reported are annual impacts within the interval that funds were to be disbursed.

Table 3-35: Direct jobs created in the US from buildings and facilities EECBG-funded activities

Year	2009	2010	2011	2012	2013	2014-2033	Job-years
All US	321	911	709	481	226	0	2,648

3.3.4. On-site renewables

This section presents EECBG-attributable job impact results for the on-site renewables BPA. The following BPA characteristics influence the pattern and magnitude of job impacts observed:

- This BPA predominantly targets the public institutional customer segment across all regions; there is a small amount of residential segment participation across all regions as well.
- Project investments created about $158 million worth of orders for US manufactured goods and $27 million for installation labor through 2013.
- Bill savings persist through 2036 for the public institutional segment and 2031 for the residential segment.

This section presents the longer-term job generation effects of EECBG funding for on-site renewable activities and it also presents job impacts inclusive of the multiplier effects (the indirect and induced effects). The values are annual job changes as this section is reporting for the assumed life cycle of the portfolio of project installations.

Table 3-36 shows the total employment impact over the life of the EECBG on-site renewables activities. There are approximately 3,900 job years added through 2036.

Table 3-36: Direct, indirect, and induced jobs created in the US from on-site renewables EECBG activities (2009-2036)

	2009	2010	2011	2012	2013	2014 2020	2021-2030	2031-2040	2041-2050	Total
Total US	162	1,122	515	121	-10	690	1,093	224	-	3,916

"-" indicates estimate rounds to zero and is considered imprecise.

Figure 3-40 shows the direct, indirect, and induced job impacts created from EECBG on-site renewable activities over time. The most pronounced job impacts occur in 2010 due to the stimulus of short-term project deployment and program administration in that year. By 2013, project deployment and program administration have tapered to a reduced level and the public institutional segment begins to experience positive net savings (bill savings *less* project costs). The remaining trajectory of total job impacts post-2013 is the result of (a) the pattern of decaying net savings for the public institutional segment, (b) reduced demand for electricity that will affect jobs in the utility sector, and (c) the multiplier effects on all of these events.

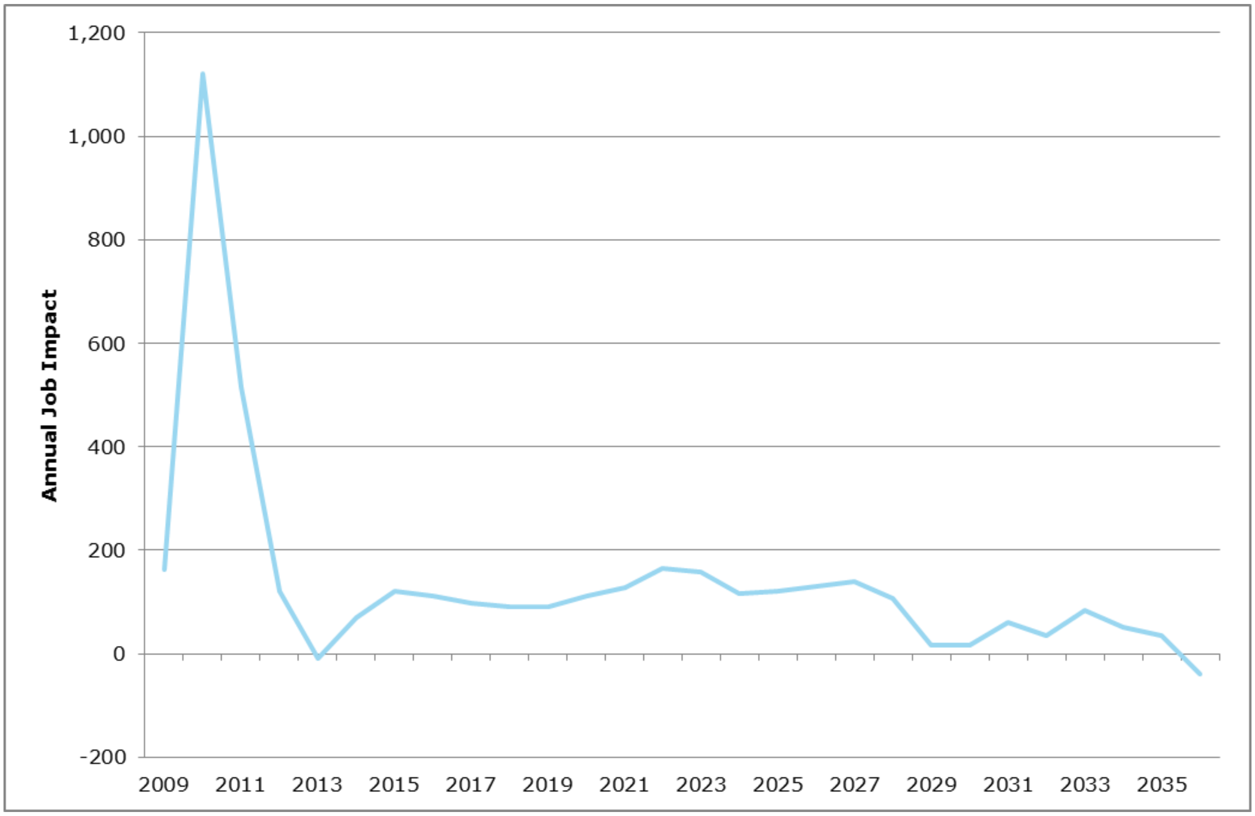

Figure 3-40: Direct, indirect, and induced job changes created in the US from on-site renewables EECBG activities

A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.

Figure 3-41 presents a snapshot of job impacts for two specific years in the analysis period. These job impacts are inclusive of multiplier effects. The sector profile of affected jobs reflects:

- In 2009, the public institutional segment (S/L government) has positive job impacts as the result of program administration activities because this segment's net positive bill savings do not occur until 2013.
- Additionally, for 2009, numerous sectors experience a stimulus to their jobs from project-related purchases, through the multiplier effects related to more household spending (e.g., retail,

general services, and healthcare), and from the business-to-business supplier effects on initial US-manufactured orders and installation activities.

- The total jobs impacts for 2022 predominantly reflect the interactions that emanate from continued extra public spending as a result of existing bill savings for the public institutional segment (because the residential savings are small by comparison), and from the effects of reduced demand on the utility sector.

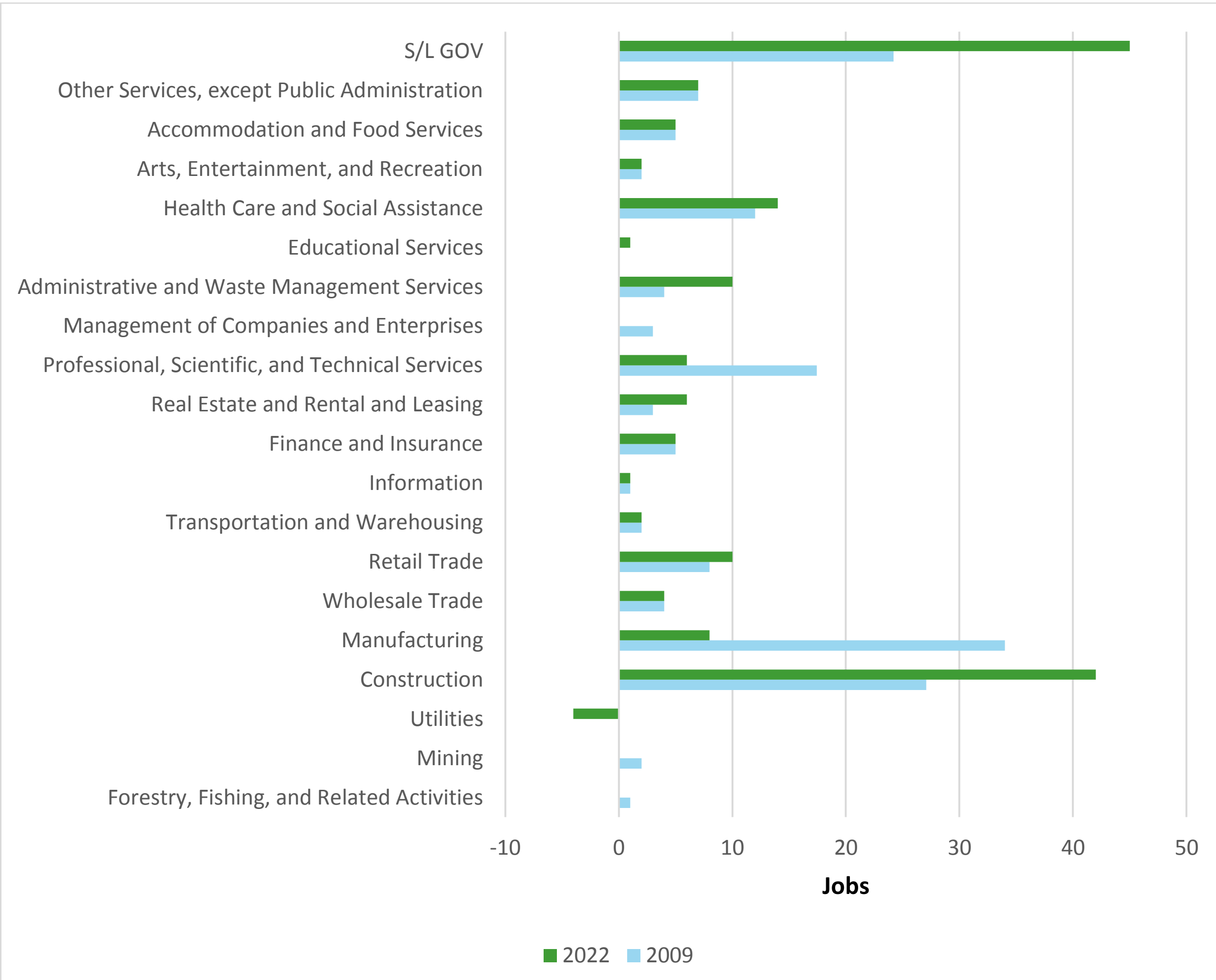

Figure 3-41: Job impact of on-site renewables EECBG activities, by NAICS sector

Table 3-37 shows the direct job effects of 994 job years from 2009–2012 as a result of project deployment funding for on-site renewable activities. The values reported are annual impacts within the interval that funds were to be disbursed.

Table 3-37: Direct jobs created in the US from on-site renewables EECBG activities

Year	2009	2010	2011	2012	2013	2014-2033	Job years
All US	65	510	305	107	8	0	994

3.3.5. Lighting

This section presents EECBG-attributable job impact results for the lighting BPA. The following BPA characteristics influence the pattern and magnitude of the observed job impacts:

- This BPA targets the public institutional customer segment across all regions.
- Project investments created about $183 million worth of orders for US manufactured goods and $87 million for installation labor through 2013.
- Bill savings on electricity persist through 2030 for the public institutional segment.
- Better traffic lights reduced idling at intersections and reduced gasoline consumption. We assign these benefits to the household segment, which increased consumer spending by approximately $1 billion.

This section presents the long-term job effects of EECBG funding of lighting activities inclusive of the multiplier effects (the indirect and induced effects). The values are annual job changes as this section is reporting for the assumed life cycle of the portfolio of project installations.

Table 3-38 shows the total employment impact over the life of the EECBG-funded projects among lighting activities. There are almost 8,090 job years added through 2030.

Table 3-38: Direct, indirect, and induced jobs created in the US from lighting EECBG activities (2009–2030)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Total US	-33	1,060	1,021	1,321	1,465	1,765	1,486	-	-	8,085

"-" indicates estimate rounds to zero and is considered imprecise.

Figure 3-42 shows the direct, indirect, and induced job impacts created from the EECBG lighting activities over time. Project deployment and program administration activities led to the largest surge of job impacts through 2013. Afterward, the pattern of job impacts is attributable to (a) the added public sector spending from bill savings (following the decay of those energy savings out to 2030), (b) the redirected consumption by households from gasoline savings from less idling at intersections, and (c) the multiplier effects from these two events after 2013.

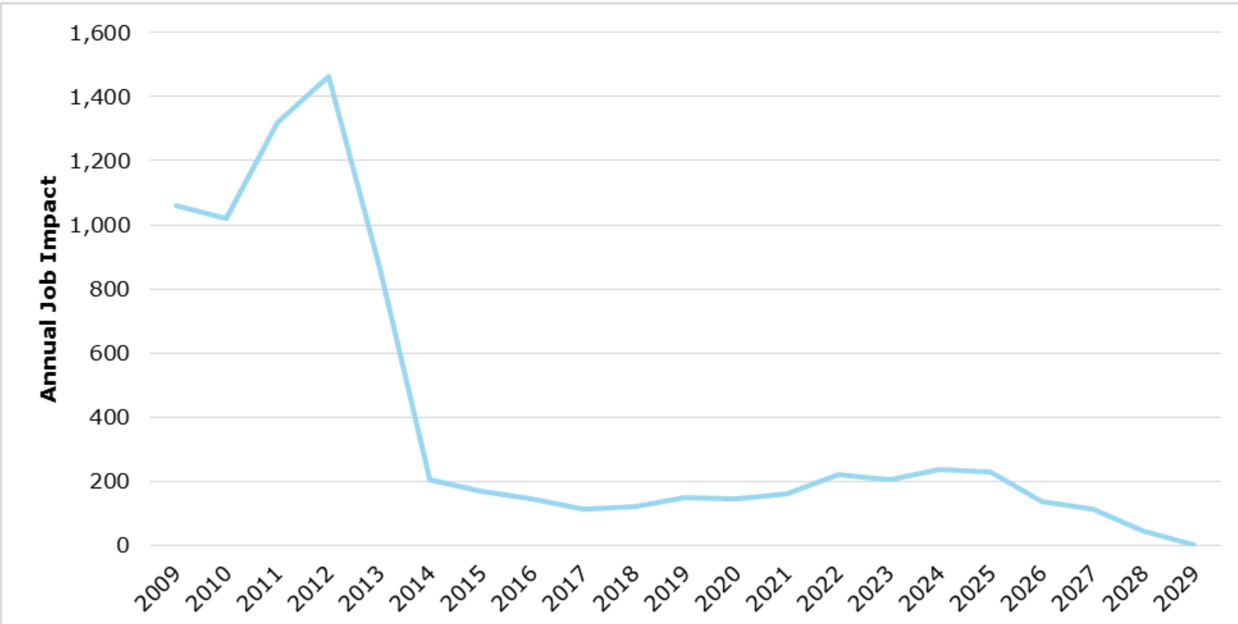

Figure 3-42: Direct, indirect, and induced job changes created in the US from lighting EECBG activities

A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.

Figure 3-43 presents a snapshot of job impacts for two specific years in the analysis period inclusive of multiplier effects. The sector profile of affected jobs reflects:

- In 2009, the public institutional segment (S/L government) has added project-related expenses but their bill savings, which start relatively small, do not commence until 2010.
- This aside, total job impacts for 2009 shows stimulus across numerous sectors from project-related purchases and program administration staffing. The multiplier effect accounts for the jobs created more broadly as a result of households having wage opportunities (e.g., retail, general services, and healthcare), which is the induced effect, and from business-to-business supplier effects (the indirect effect).
- For 2022, the jobs shed in the retail sector result from the reduced level of gasoline purchases, which also implicates the wholesale trade sector for jobs. However, the money not being spent for gasoline is buying some household services related to healthcare, arts and entertainment, and food and beverage outside of the home. The S/L government sector shows job impacts from the

bill savings that this sector channels into added public spending, a large portion of which supports payroll. The job impacts occurring in the utility and mining sectors are due to the reduced demand for electricity.

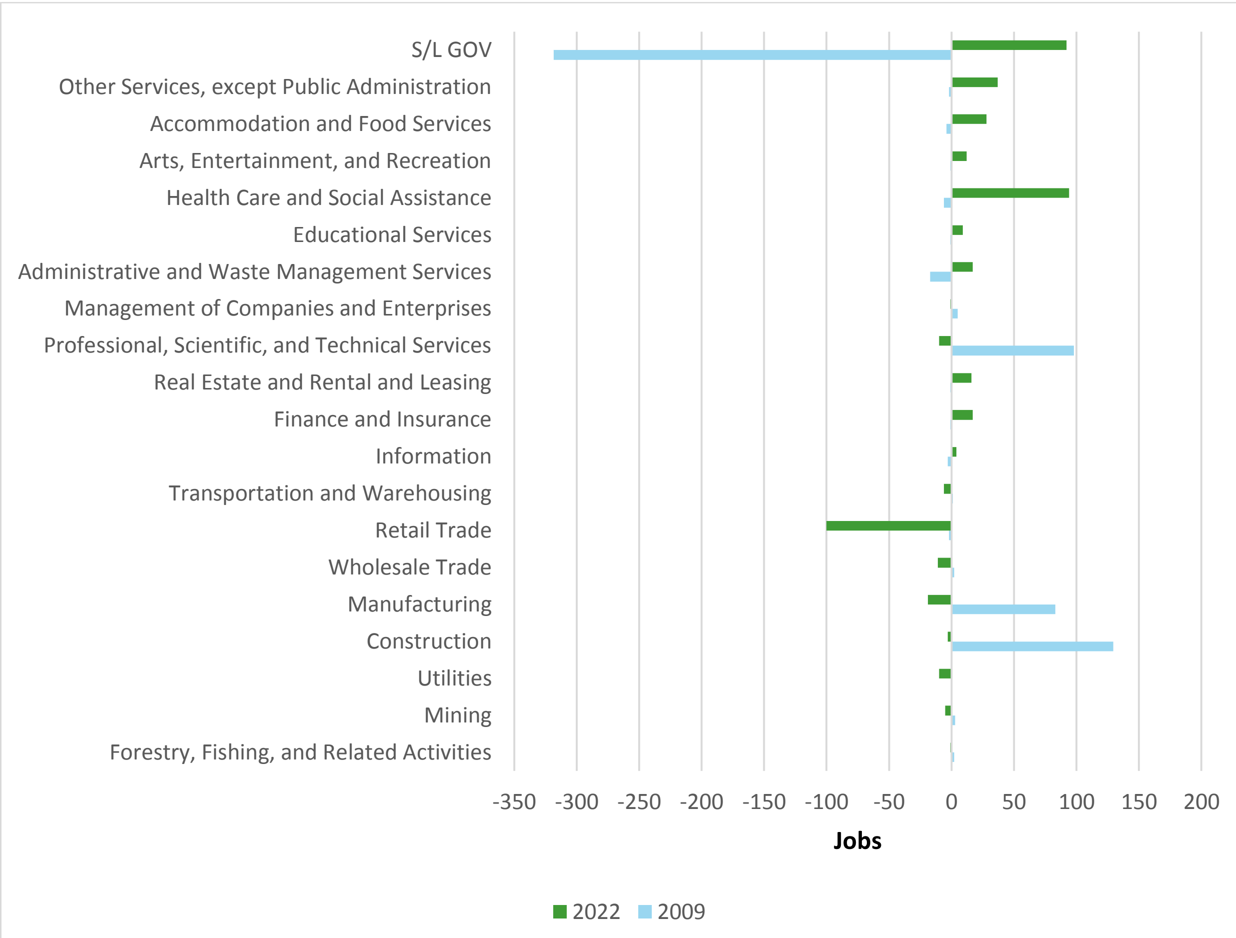

Figure 3-43: Job impact of lighting EECBG activities, by NAICS sector

Table 3-39 shows the direct job effects occurring in the short-term as a result of project deployment-period funding for lighting activities. The values reported are annual impacts within the interval that funds were to be disbursed. Some 2,200 job years will be required in the US from 2009–2013.

Table 3-39: Direct jobs created in the US from lighting funded activities

Year	2009	2010	2011	2012	2013	2014-2033	Job years
All US	352	680	716	194	273	-	2,215

"-" indicates estimate rounds to zero and is considered imprecise.

3.3.6. Energy efficiency and conservation strategy (direct grants)

This section presents EECBG-attributable job impact results for the energy efficiency and conservation strategy BPA. The following characteristics influence the pattern and magnitude of job impacts observed:

- Residential and public institutional customer segments participated across all regions.
- Through 2013, project activity required $12.5 million for US manufactured goods and $9.5 million in installer contracts.
- The residential segment is awarded with the largest bill savings ($18 million through 2036), followed by the public institutional segment ($1 million through 2027). With rebate income, the residential segment receives $34 million of combined savings and the public institutional segment $20 million.

This section presents the longer-term job generation effects of funding for energy efficiency and conservation strategy activities and it also presents job impact inclusive of the multiplier effects (the indirect and induced effects). The values are annual job changes since this section is reporting for the assumed life cycle of the portfolio of project installations.

Table 3-40 shows the lifetime total employment impact from the funding into energy efficiency and conservation strategy EECBG activities. Bill savings is the primary driver of job growth despite some net job losses due in part to reduced customer purchases of electricity and gas. The table shows that there are 1,906 job years created through 2036.

Table 3-40: Direct, indirect, and induced jobs created in the US from energy efficiency and conservation strategy EECBG activities

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Total	180	508	564	523	34	83	16	-3	0	1,906

Figure 3-44 shows the direct, indirect, and induced job years created from EECBG energy efficiency and conservation activities over time. The early job impact spike is related to project deployment activities and the fact that the residential and public institutional segments received significant rebate income between 2009 and 2013. From 2014 onward, we see the job impact trajectory from bill savings and lower energy demand. The reduction of job impacts is a function of the eventual decay of bill savings.

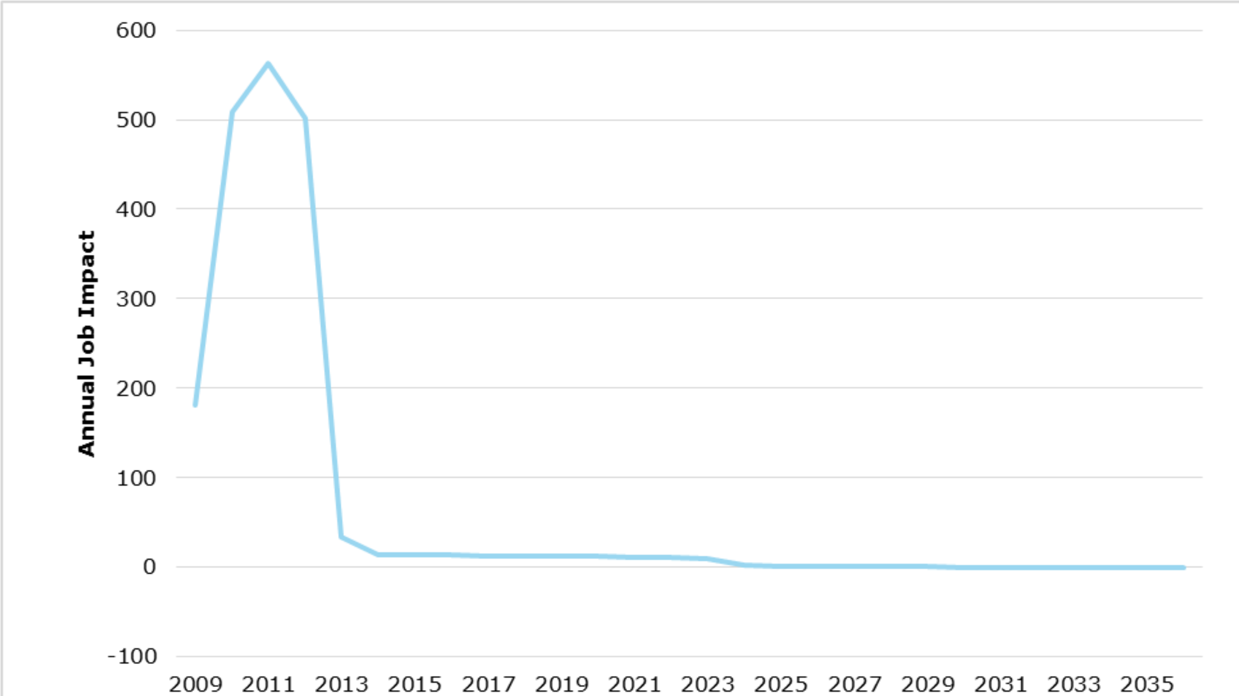

Figure 3-44: Direct, indirect, and induced job changes created in the US from energy efficiency and conservation strategy EECBG activities

A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix M provides precision for estimates used as primary inputs to this figure, such as energy impacts.

Figure 3-45 presents a snapshot of job impacts for two specific years in the analysis period. The impacts are inclusive of multiplier effects. The sector profile of affected jobs reflects:

- Those sectors directly involved with projects in 2009 do not ramp up until 2010 and 2011 (e.g., construction labor, professional and technical services, and manufacturing, as well as program administration from the public realm). The pronounced state and local government sector job increases has to do in part with the fact that in 2009 this segment received incentives without incurring project costs (those started in 2010), and as a result added to public budgets that require more staff. Bill savings do not start to accrue until 2011 for the state and local segment and 2012 for the residential segment;
- Sectors affected when energy consumers redirect some of their budget away from general household or business expenditures and into making energy improvement; and,
- The jobs effects from when customers make fewer energy purchases and redirect those dollars into more household spending for other goods and services, and from when municipalities have gained program budget dollars. In 2022, all participating segments are beyond their project-related costs and experience net bill savings. The reduction in utility sector jobs is due to reduced purchases of electricity and natural gas.

In this BPA, with no commercial or industrial customer segment participation occurring, the positive job impacts are the result of households having more discretionary income to spend, municipalities spending more, and from associated multiplier effects.

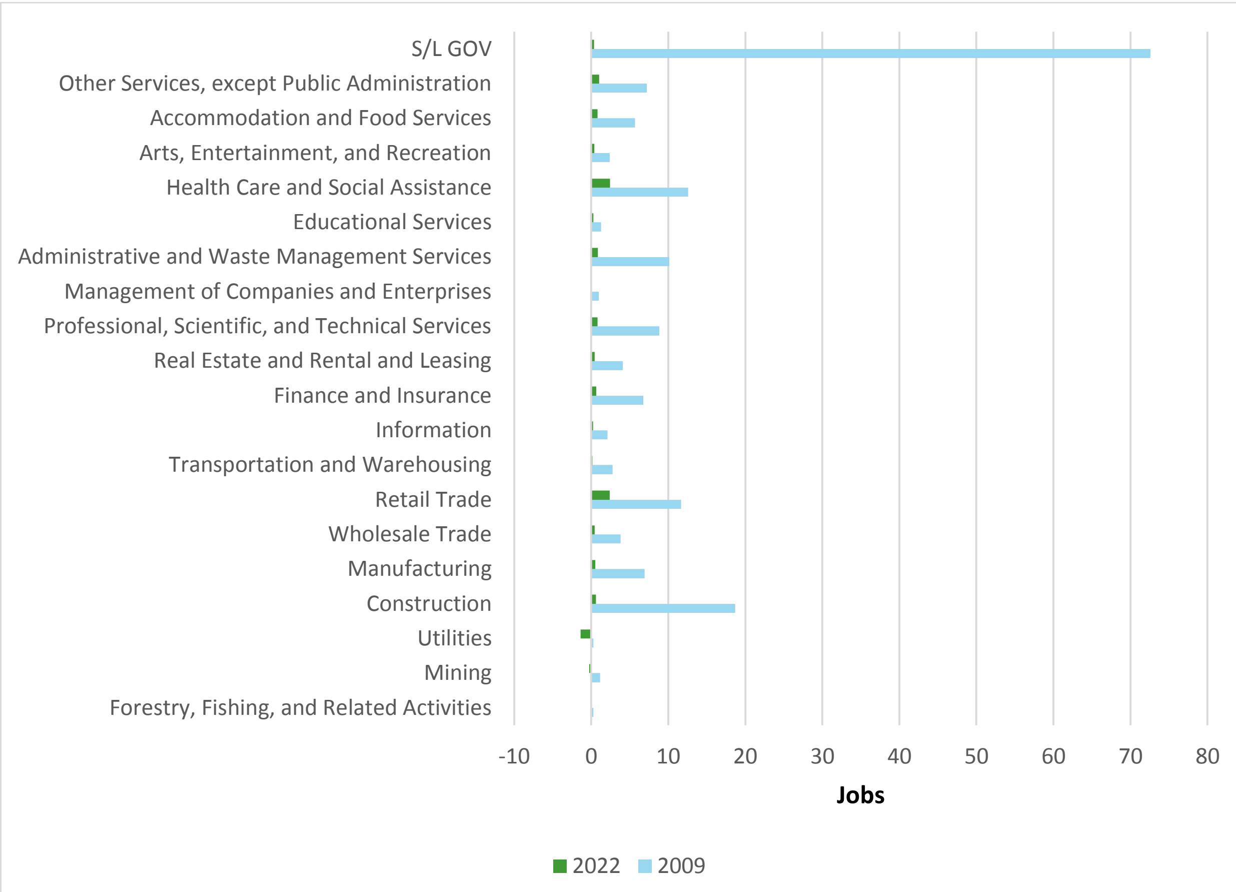

Figure 3-45: Job impacts from energy efficiency and conservation EECBG activities, by NAICS sector

Table 3-41 presents the direct job effects occurring in the short-term project deployment activities as a result of funding into energy efficiency and conservation strategy activities. The values reported are annual impacts within the interval that funds were to be disbursed. Approximately 264 job years will be required in the US for this interval.

Table 3-41: Direct jobs created in the US from EECBG energy efficiency and conservation strategy activities

Year	2009	2010	2011	2012	2013	2014-2033	Job-years
All US	6	83	94	79	2	0	264

3.4. Avoided carbon emissions and associated social costs

This section addresses avoided carbon emissions and the avoided social costs of carbon for each BPA studied in this evaluation. The avoided emissions impacts are all reported in million metric tons of carbon equivalent. The avoided social costs are reported in 2009 US dollars.

EPA defines the social cost of carbon as the economic damages associated with a small increase in carbon dioxide (CO_2) emissions in a year.[77] The avoided social cost is the monetary value of avoided damages for that carbon not having been emitted.

3.4.1. Energy efficiency retrofits

3.4.1.1. Avoided carbon emissions

The energy efficiency retrofits BPA avoided 4.6 MMTCE of EECBG-attributable emissions over the 2009–2050 period. Figure 3-46 shows the annual carbon emissions avoided that are attributable to the energy efficiency retrofit activities by year.

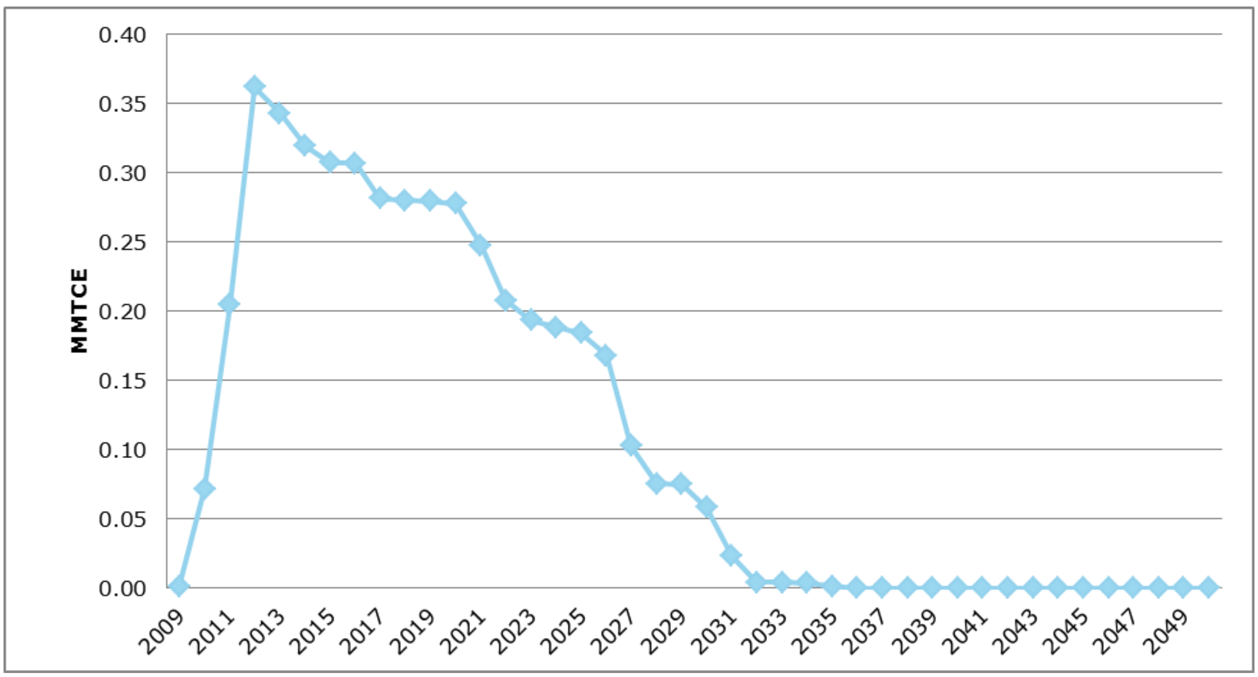

Figure 3-46: Annual carbon emissions avoided due to energy efficiency retrofit activities by year (MMTCE)

[77] United States Environmental Protection Agency. The Social Cost of Carbon. November, 2013. http://www.epa.gov/climatechange/EPAactivities/economics/scc.html

Figure 3-47 shows how these carbon impacts are distributed by sector. Public institutions have the greatest avoided carbon emissions from energy efficiency retrofits of 4.3 MMTCE.

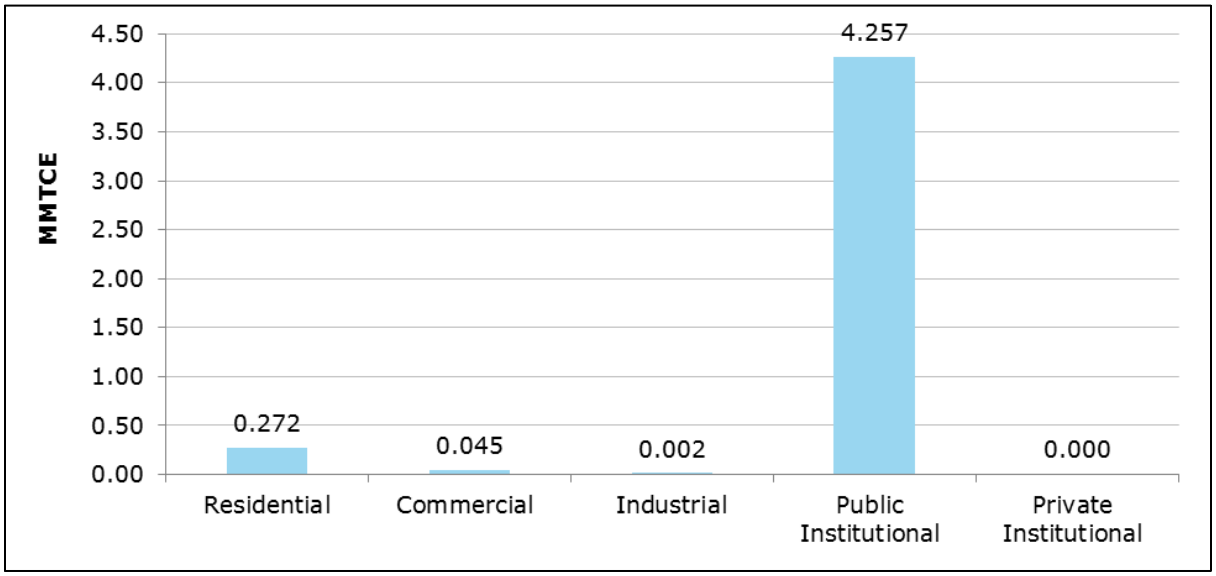

Figure 3-47: Avoided carbon emissions due to energy efficiency retrofit activities by sector (MMTCE)

Figure 3-48 shows how total carbon savings are distributed by mode of impact: energy savings and displaced energy from renewable generation. Energy efficiency retrofits mostly avoided carbon emissions through energy savings.

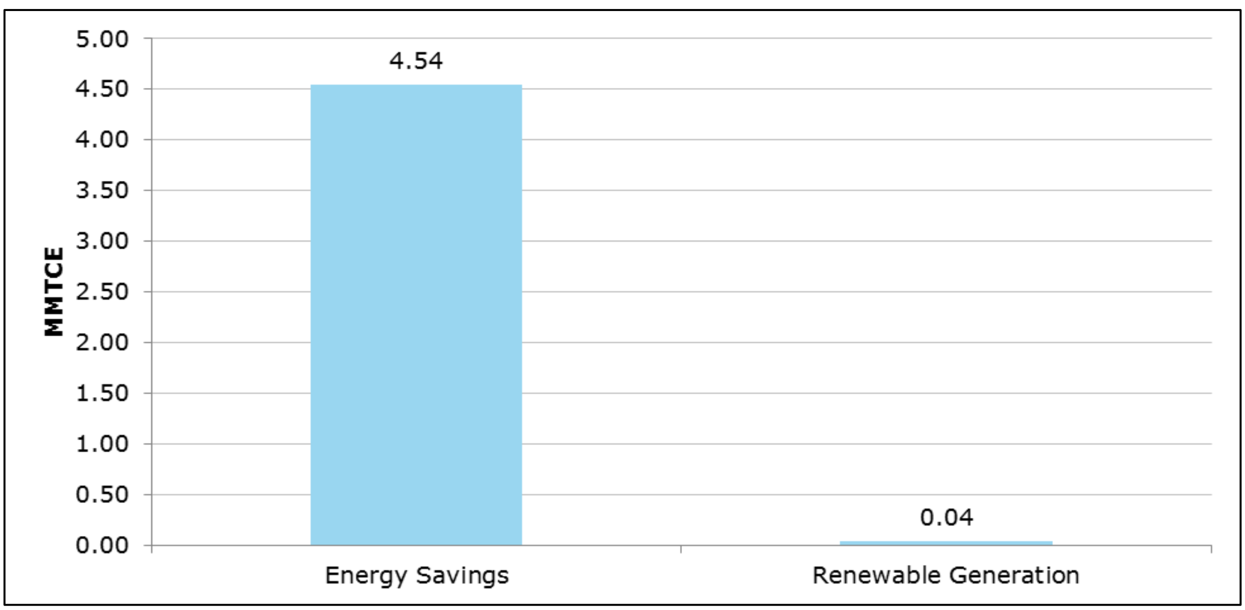

Figure 3-48: Avoided carbon emissions due to energy efficiency retrofit activities by mode of impact (MMTCE)

3.4.1.2. Social costs of carbon impacts

The energy efficiency retrofits BPA avoided $296 million in social costs according to the methodology described in Appendix J. Figure 3-49 illustrates how those avoided social costs are distributed over time.

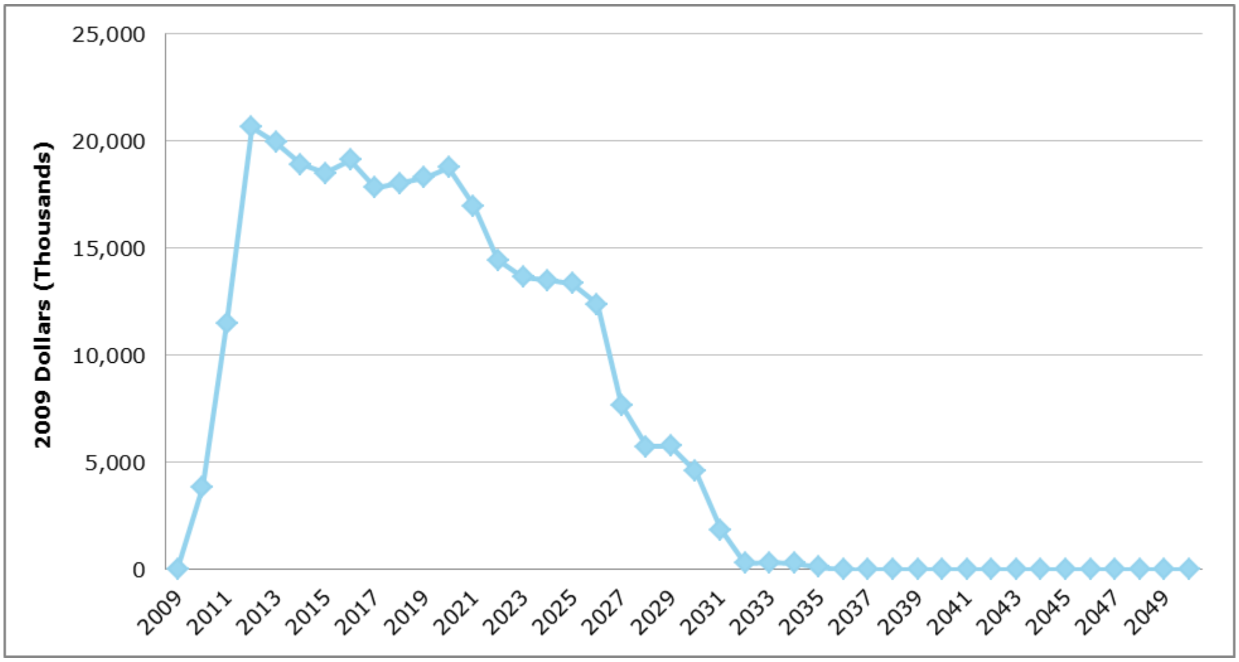

Figure 3-49: Social costs not incurred due to avoided carbon emissions from energy efficiency retrofit activities by year (thousands of 2009 US$)

Figure 3-50 illustrates how those impacts are distributed across various sectors. The large majority of avoided social costs result from carbon emission savings in the public institutional sector.

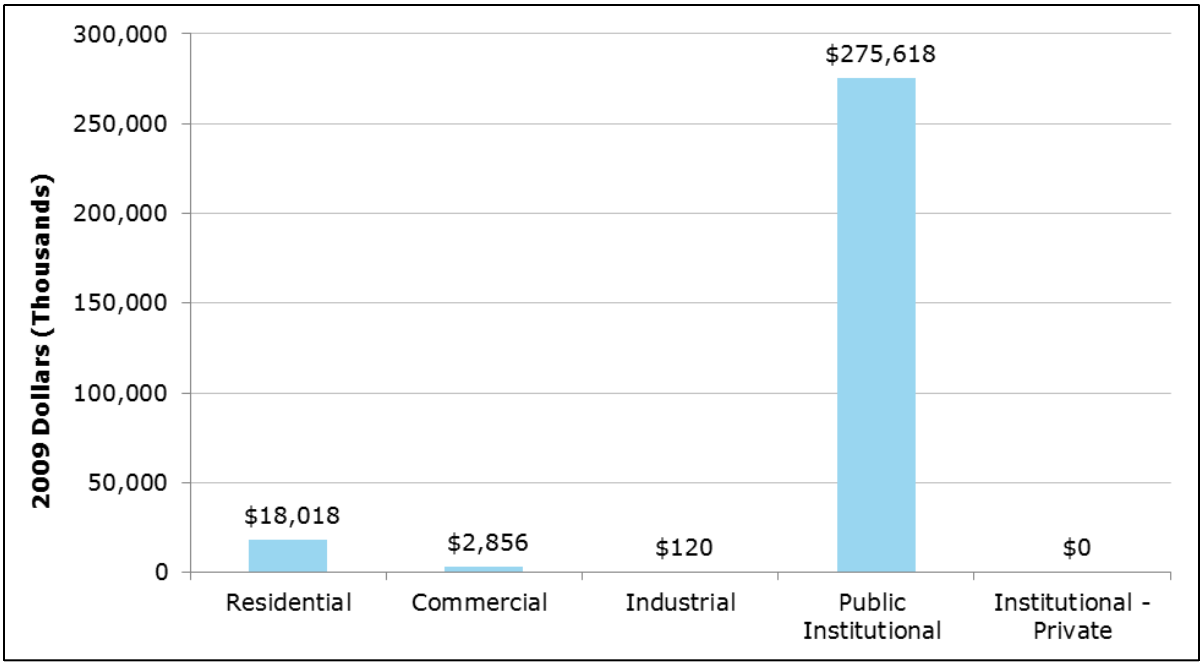

Figure 3-50: Social costs not incurred due to avoided carbon emissions from energy efficiency retrofit activities by sector (2009 US$)

Figure 3-51 shows that avoided social costs stemming from retrofit activities are mostly due to energy efficiency savings rather than renewable generation.

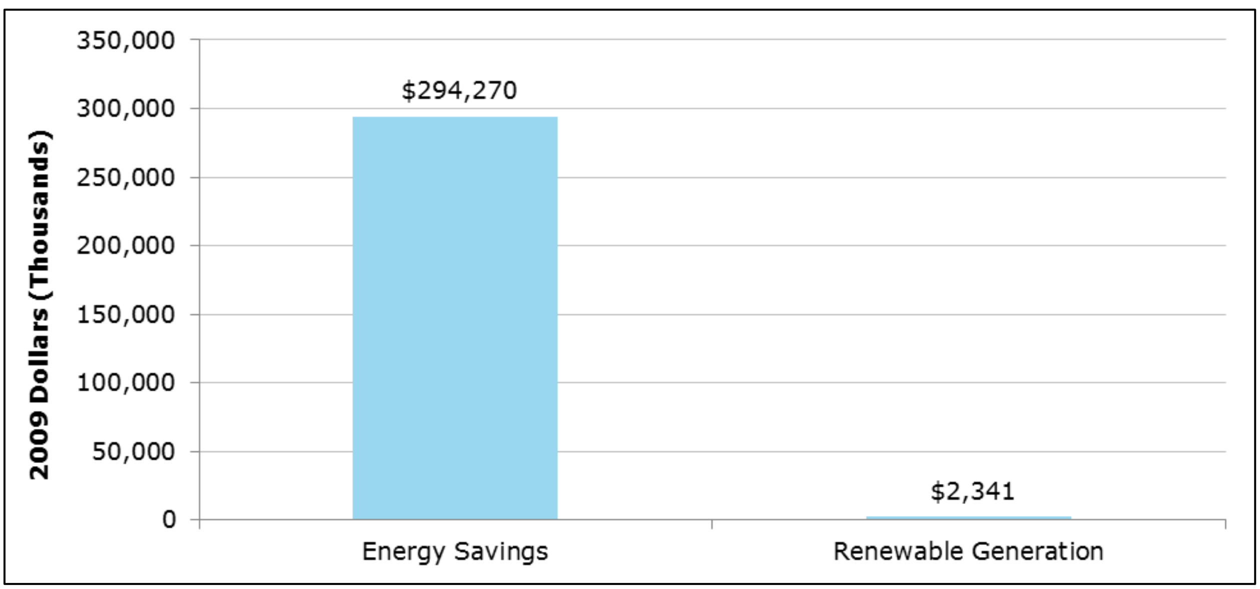

Figure 3-51: Social costs not incurred due to avoided carbon emissions from energy efficient retrofit activities by mode of impact (2009 US$)

3.4.2. Financial incentives

3.4.2.1. Avoided carbon emissions

The financial incentives BPA avoided 14.1 MMTCE of EECBG-attributable emissions over the 2009–2050 period. Figure 3-52 shows the annual carbon emissions avoided that are attributable to the financial incentive activities by year.

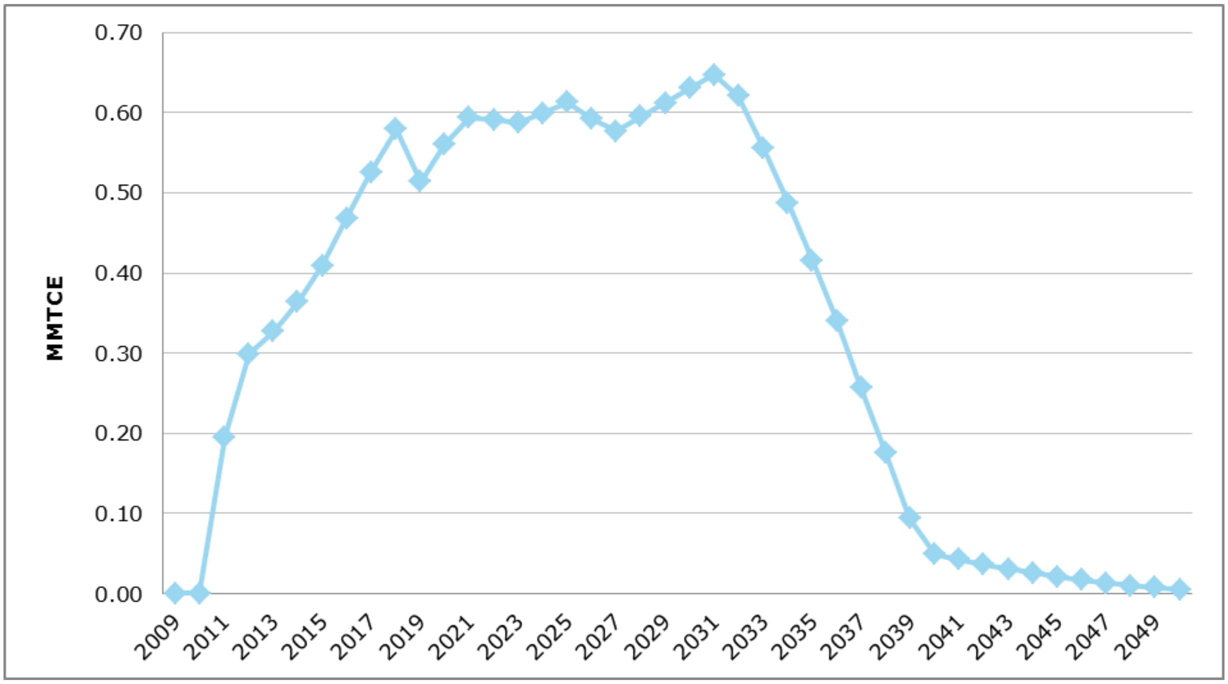

Figure 3-52: Annual carbon emissions avoided due to financial incentive activities by year (MMTCE)

How these carbon impacts are distributed by sector are displayed in Figure 3-53. The residential sector has the greatest avoided carbon emissions.

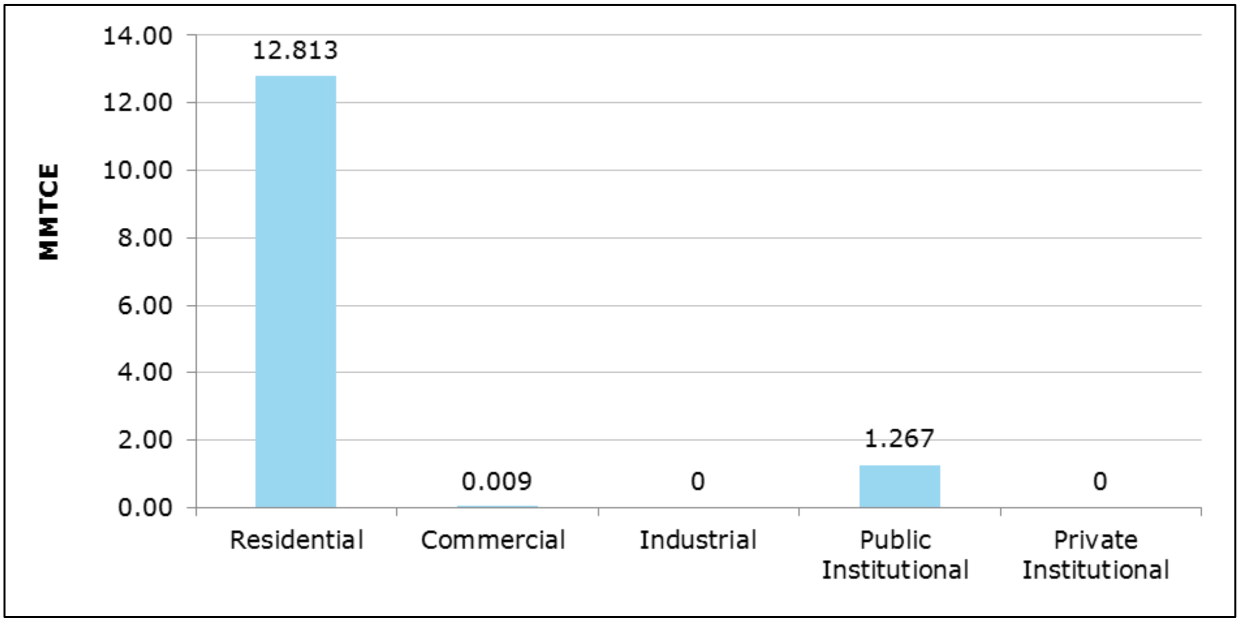

Figure 3-53: Avoided carbon emissions due to financial incentive activities by sector (MMTCE)

Avoided carbon emissions from financial incentive activities mainly were in the form of energy savings rather than renewable generation (Figure 3-54).

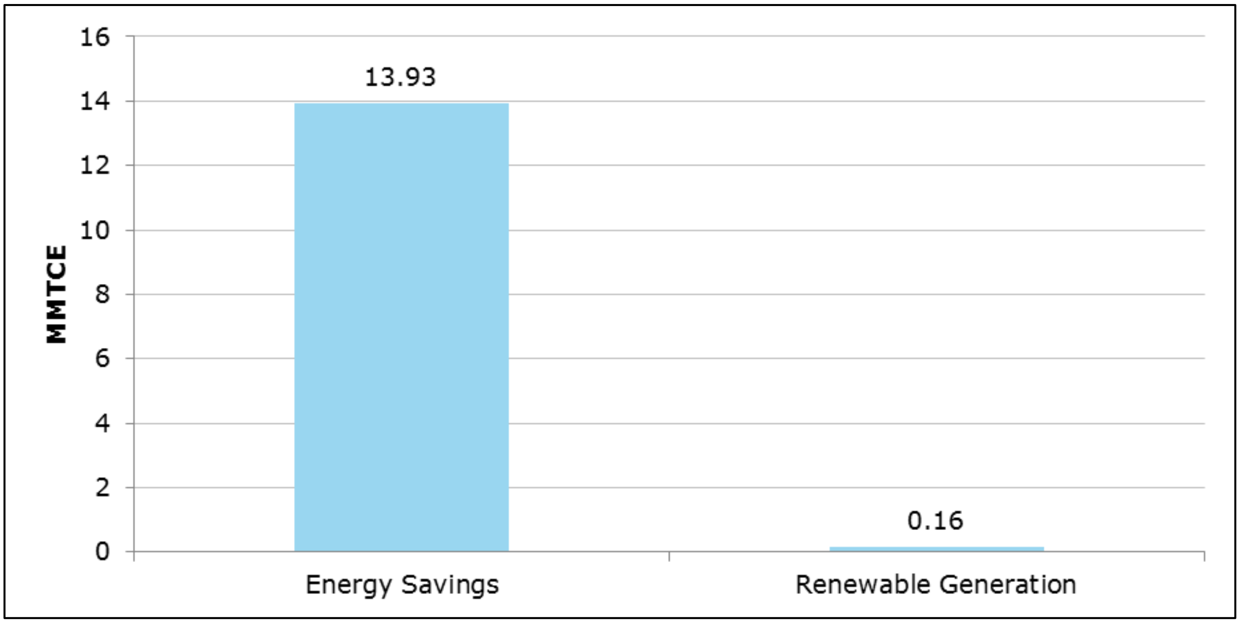

Figure 3-54: Avoided carbon emissions due to financial incentive activities by mode of impact (MMTCE)

3.4.2.2. Social costs of carbon impacts

The financial incentive BPA avoided $1,026 million in social costs according to the methodology described in Appendix J. Figure 3-55 illustrates how those avoided social costs are distributed over time.

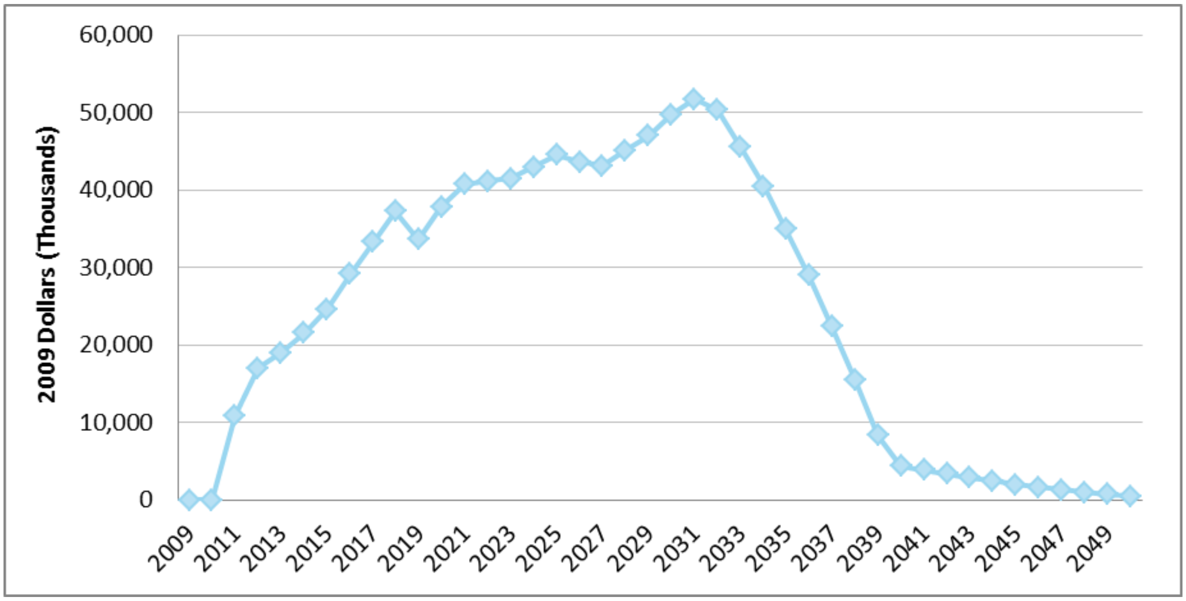

Figure 3-55: Social costs not incurred due to avoided carbon emissions from financial incentive activities by year

Figure 3-56 illustrates how those impacts are distributed across various sectors. The figure shows that the majority of avoided social costs result from carbon emission savings in the residential sector.

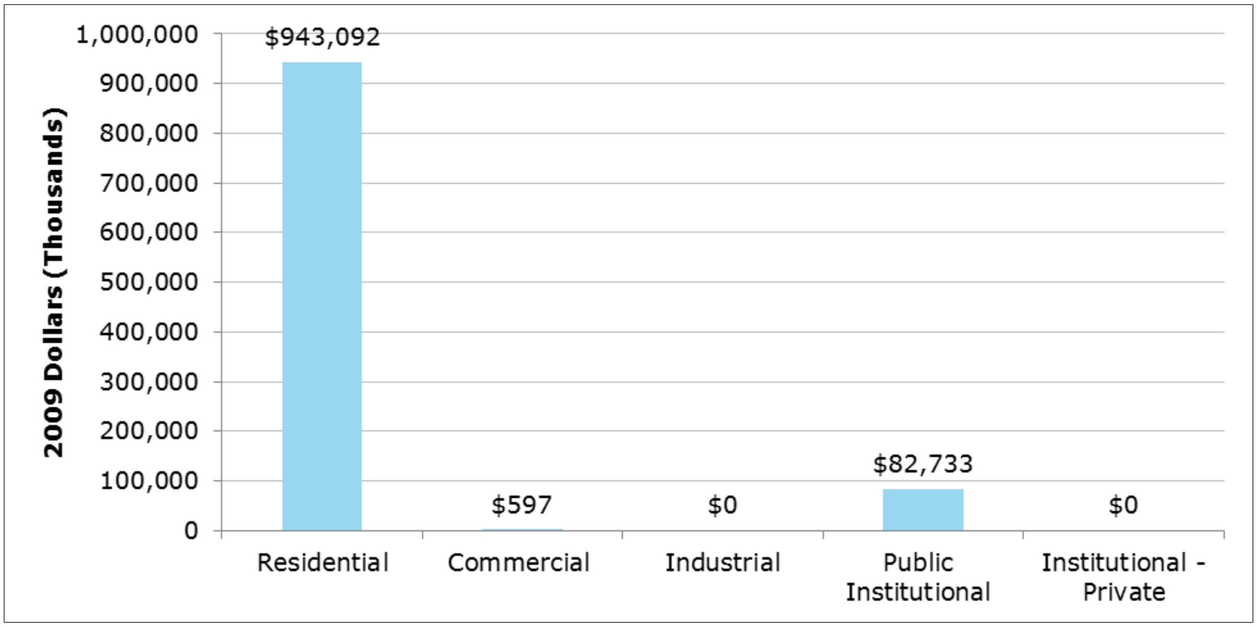

Figure 3-56: Social costs not incurred due to avoided carbon emissions from financial incentive activities by sector (2009 US$)

Figure 3-57 shows the deferred social costs due to avoided carbon emissions from financial incentive activities are mostly due to energy efficiency savings.

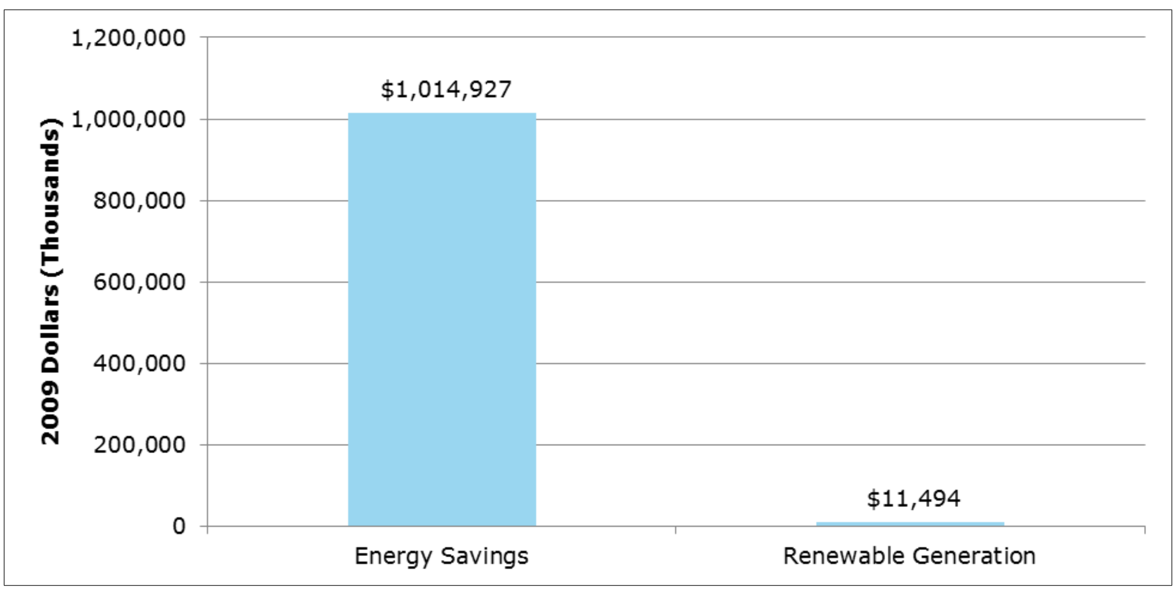

Figure 3-57: Social costs not incurred due to avoided carbon emissions from financial incentive activities by mode of impact (thousands of 2009 US$)

3.4.3. Buildings and facilities

3.4.3.1. Avoided carbon emissions

The buildings and facilities BPA avoided 1.9 MMTCE of EECBG-attributable emissions over the 2009–2050 period. Figure 3-58 shows the annual carbon emissions avoided that are attributable to the buildings and facilities activities by year.

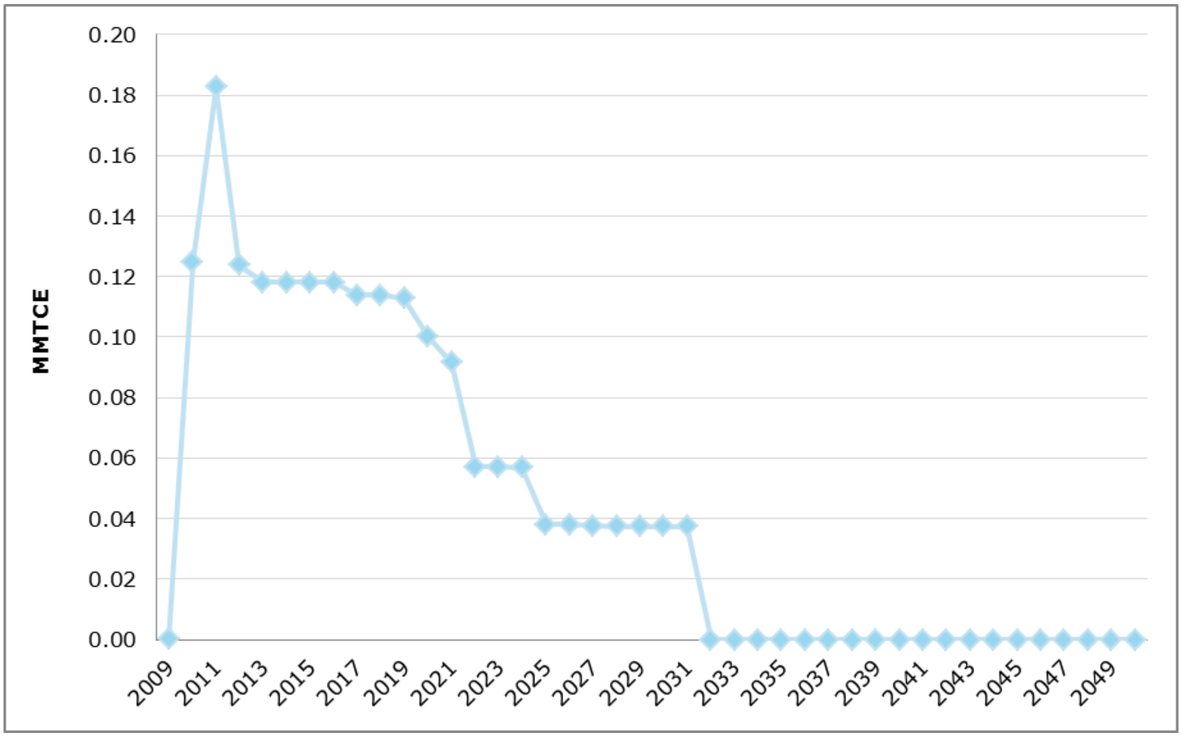

Figure 3-58: Annual carbon emissions avoided due to buildings and facilities EECBG activities by year

Figure 3-59 shows how these carbon impacts are distributed by sector, with the public institutional sector's savings resulting in the large majority of the carbon reduction.

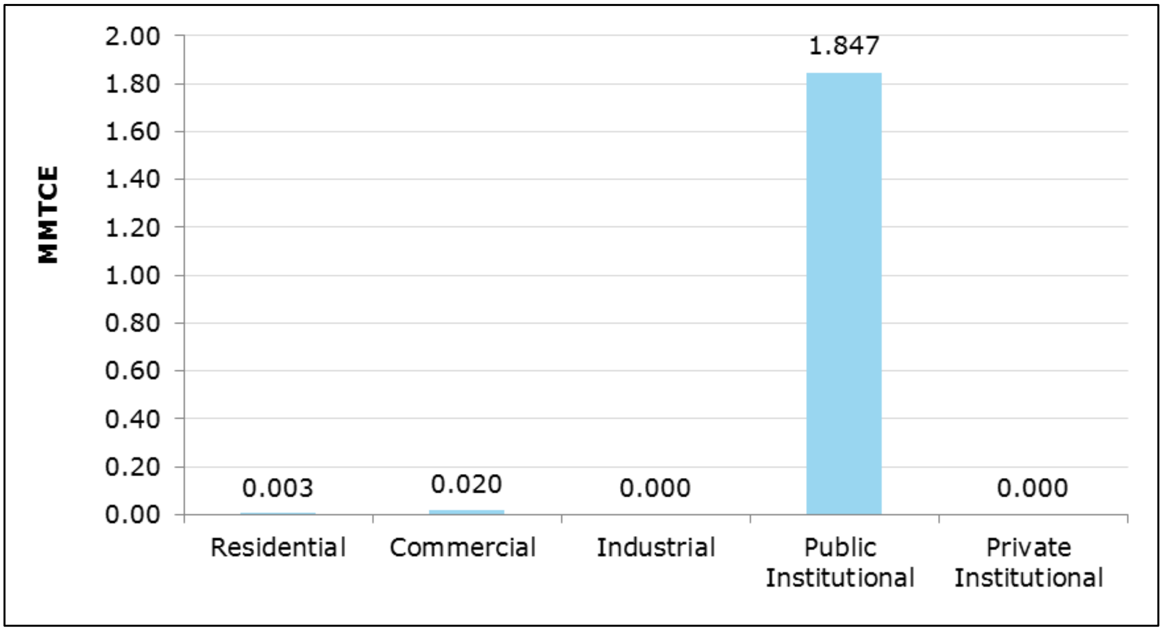

Figure 3-59: Avoided carbon emissions due to buildings and facilities activities by sector (MMTCE)

Figure 3-60 shows how total carbon savings from buildings and facilities activities are distributed by mode of impact. For this BPA, all avoided carbon emissions is due to energy savings.

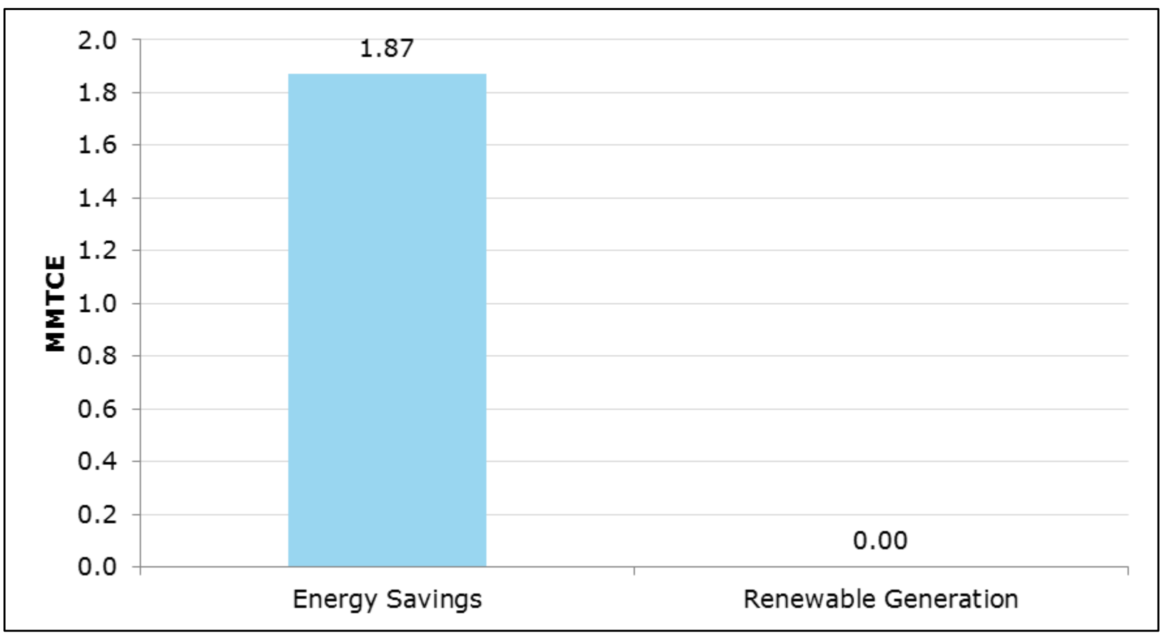

Figure 3-60: Avoided carbon emissions due to buildings and facilities EECBG activities by mode of impact (MMTCE)

3.4.3.2. Social costs of carbon impacts

The buildings and facilities BPA avoided $119 million in social costs according to the methodology described in Appendix J. Figure 3-61 illustrates how those avoided social costs are distributed over time.

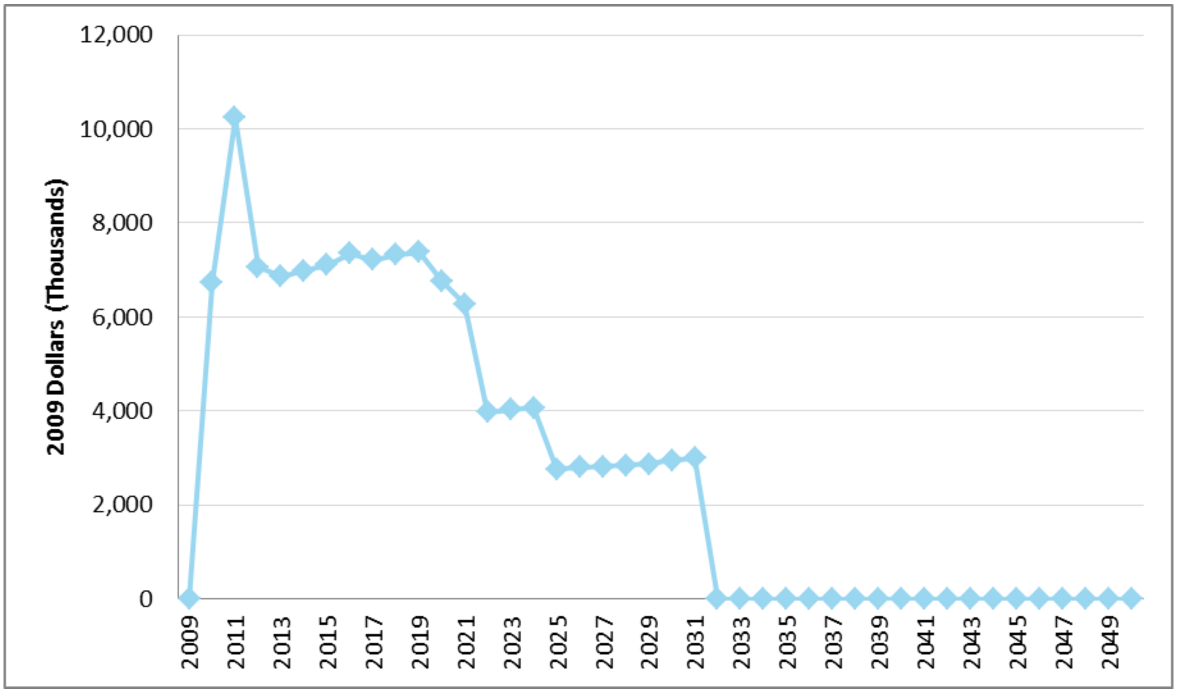

Figure 3-61: Social costs not incurred due to avoided carbon emissions from buildings and facilities activities by year (thousands of 2009 US$)

Figure 3-62 illustrates how those impacts are distributed across various sectors. The figure shows that the large majority of avoided social costs result from carbon emission savings in the public institutional sector.

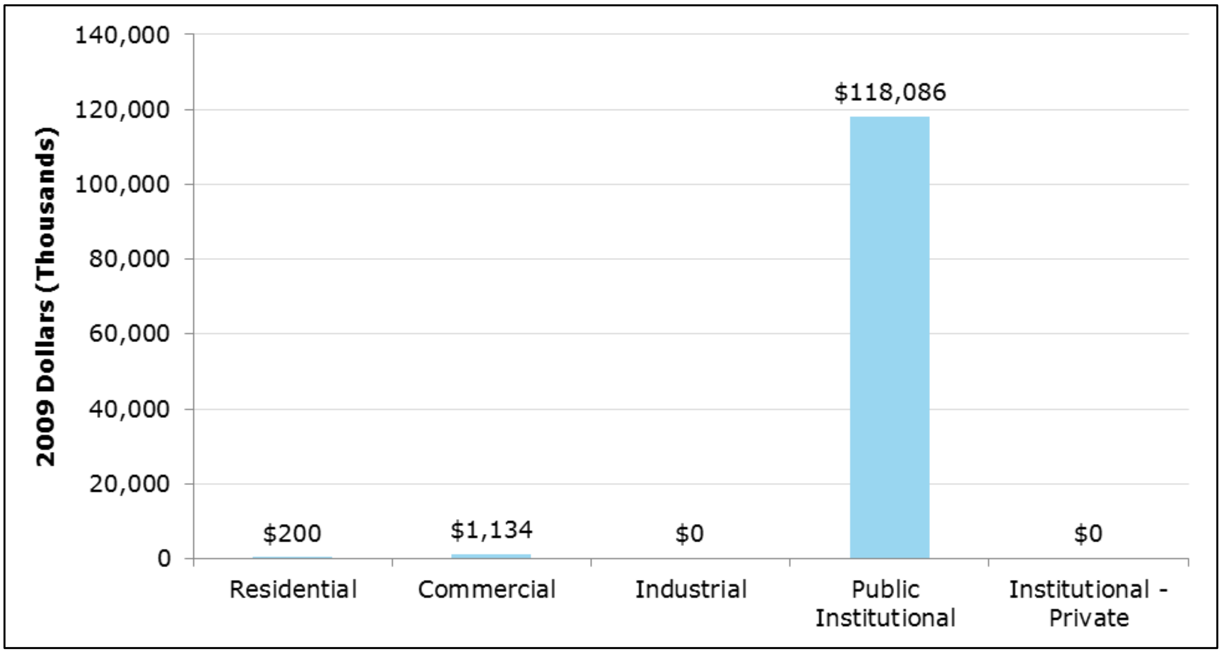

Figure 3-62: Social costs not incurred due to avoided carbon emissions from buildings and facilities activities by sector (2009 US$)

The deferred social costs resulting from avoided carbon emissions due to buildings and facilities activities are all due to energy savings (Figure 3-63).

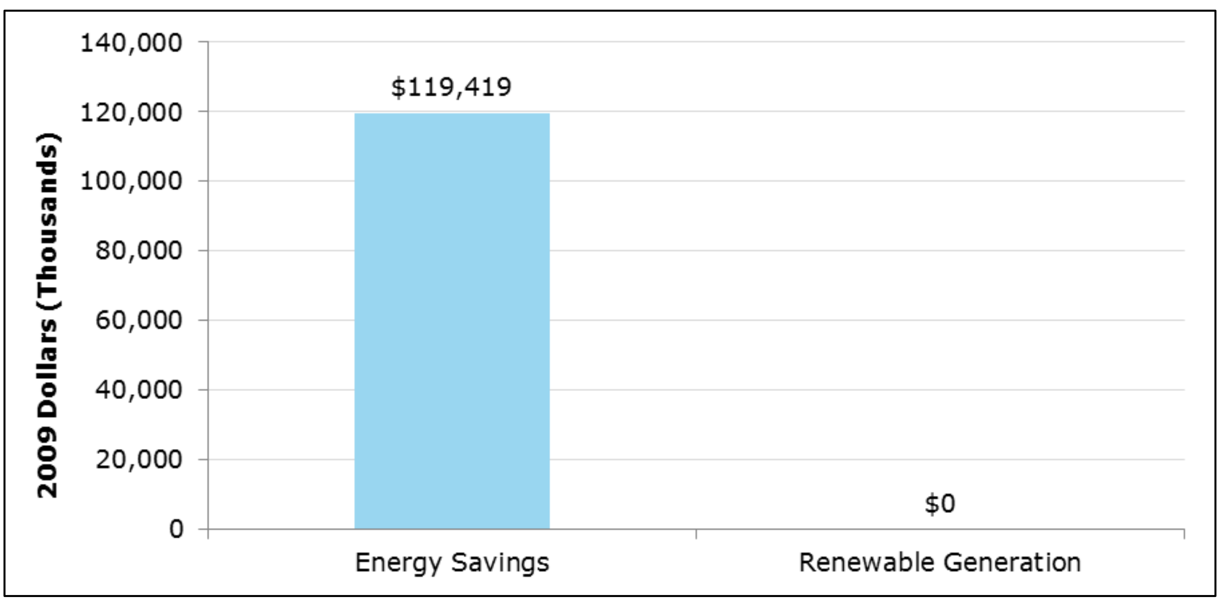

Figure 3-63: Social costs not incurred due to avoided carbon emissions from buildings and facilities activities by mode of impact (thousands of 2009 US$)

3.4.4. On-site renewables

3.4.4.1. Avoided carbon emissions

The on-site renewables BPA avoided 0.7 MMTCE of EECBG-attributable emissions over the 2009–2050 period. Figure 3-64 shows the annual carbon emissions avoided that are attributable to the on-site renewable activities by year.

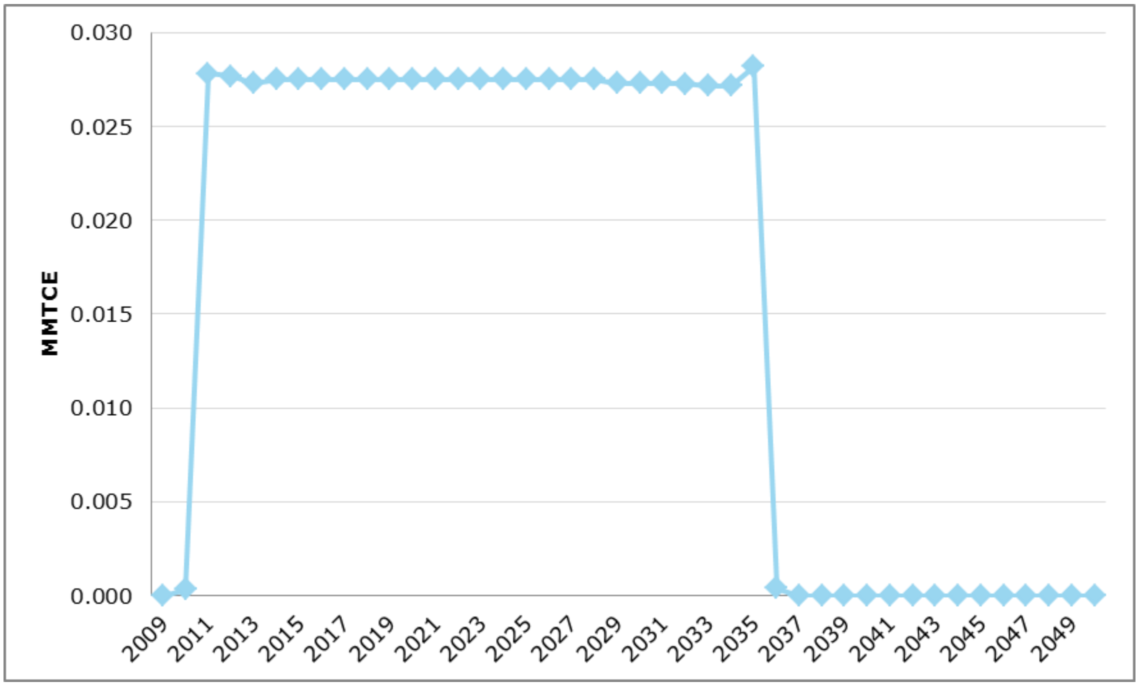

Figure 3-64: Annual carbon emissions avoided due to on-site renewable activities by year (MMTCE)

Figure 3-65 shows how the public institutional sector had the vast majority of avoided carbon emissions resulting from on-site renewable activities, with a small amount coming from the residential sector as well.

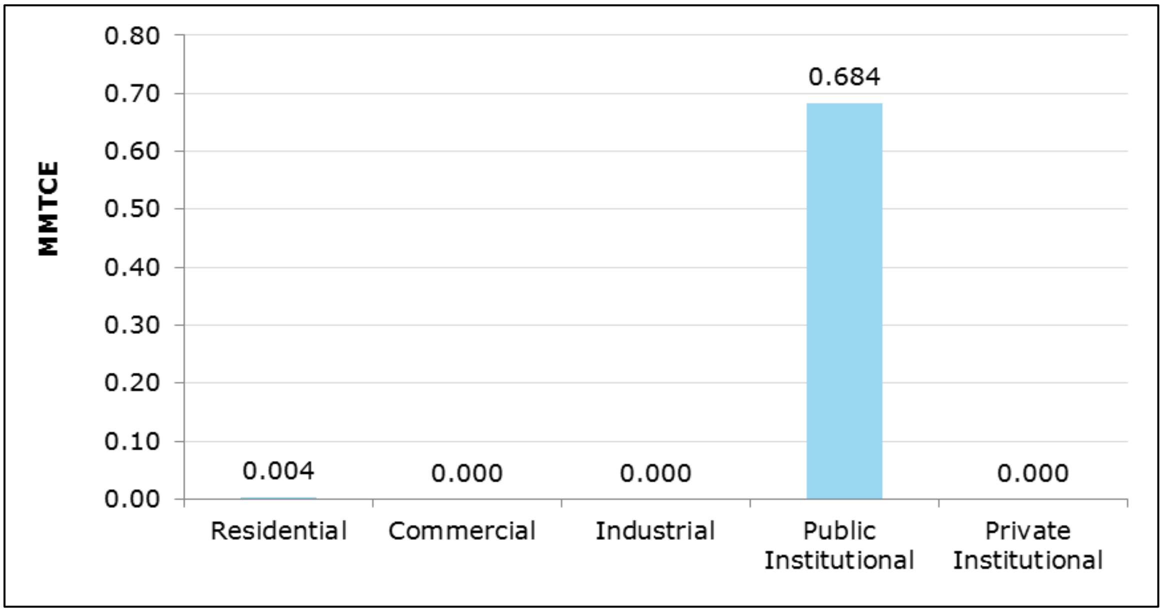

Figure 3-65: Avoided carbon emissions due to on-site renewable activities by sector (MMTCE)

On-site renewable activities mostly realized carbon savings through renewable energy generation rather than energy savings (Figure 3-66).

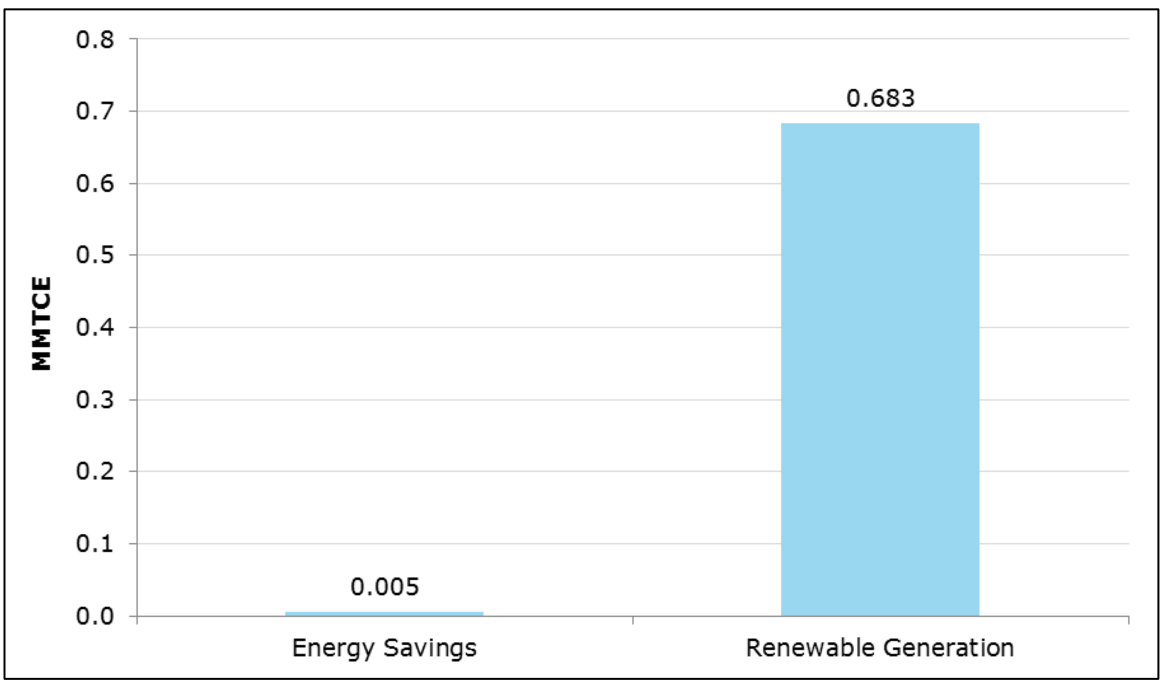

Figure 3-66: Avoided carbon emissions due to on-site renewable activities by mode of impact (MMTCE)

3.4.4.2. Social costs of carbon impacts

The on-site renewables BPA avoided $48 million in social costs according to the methodology described in Appendix J. Figure 3-67 illustrates how those avoided social costs are distributed over time.

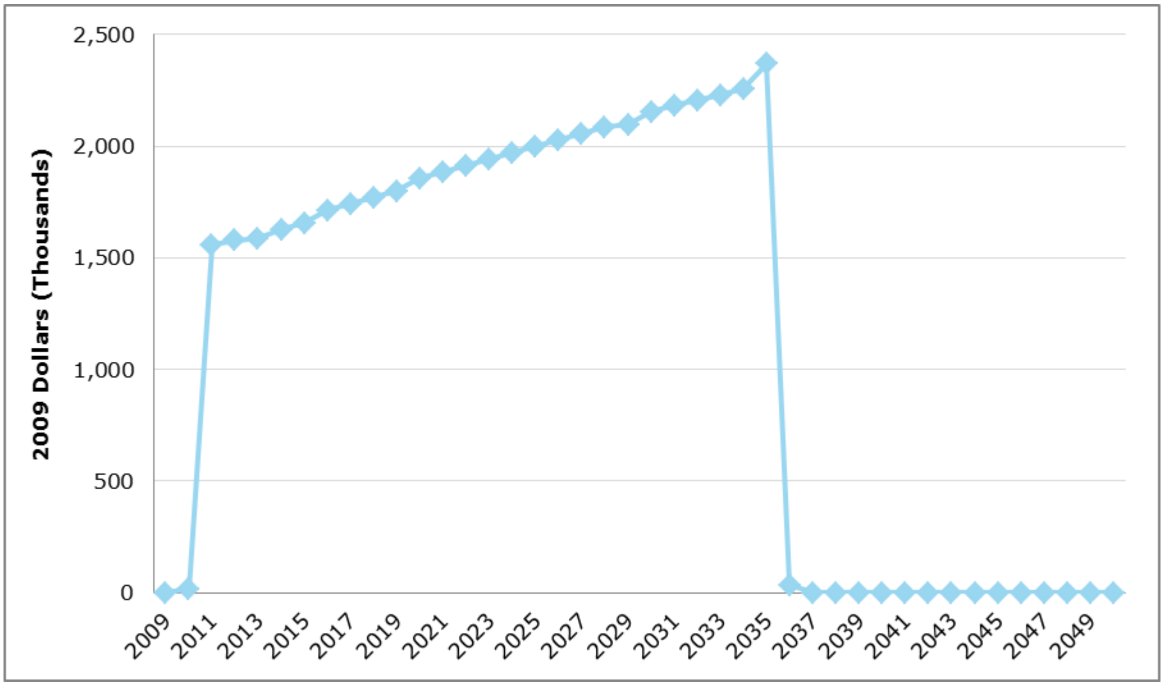

Figure 3-67: Social costs not incurred due to avoided carbon emissions from on-site renewable activities by year (thousands of 2009 US$)

How those impacts are distributed across various sectors is illustrated in Figure 3-68. The vast majority of avoided social costs result from carbon emission savings in the public institutional sector.

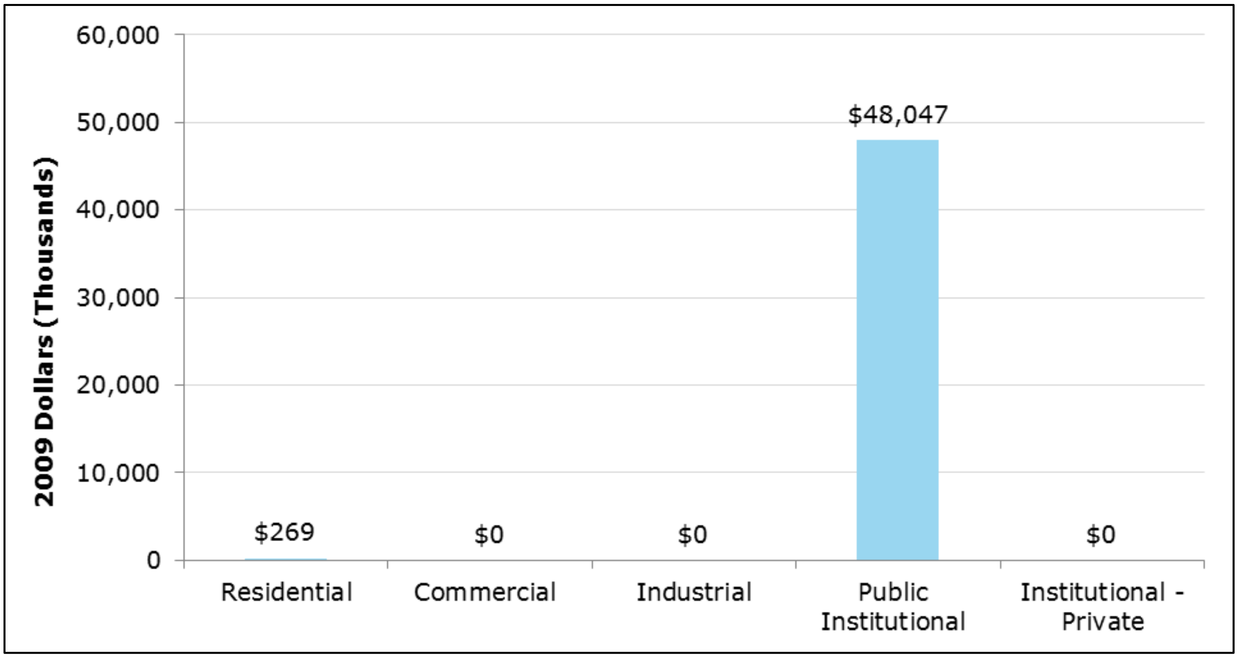

Figure 3-68: Social costs not incurred due to avoided carbon emissions from on-site renewable activities by sector (thousands of 2009 US$)

Figure 3-69 shows that renewable energy generation accounted for the greatest deferred social cost of carbon emissions from on-site renewable activities.

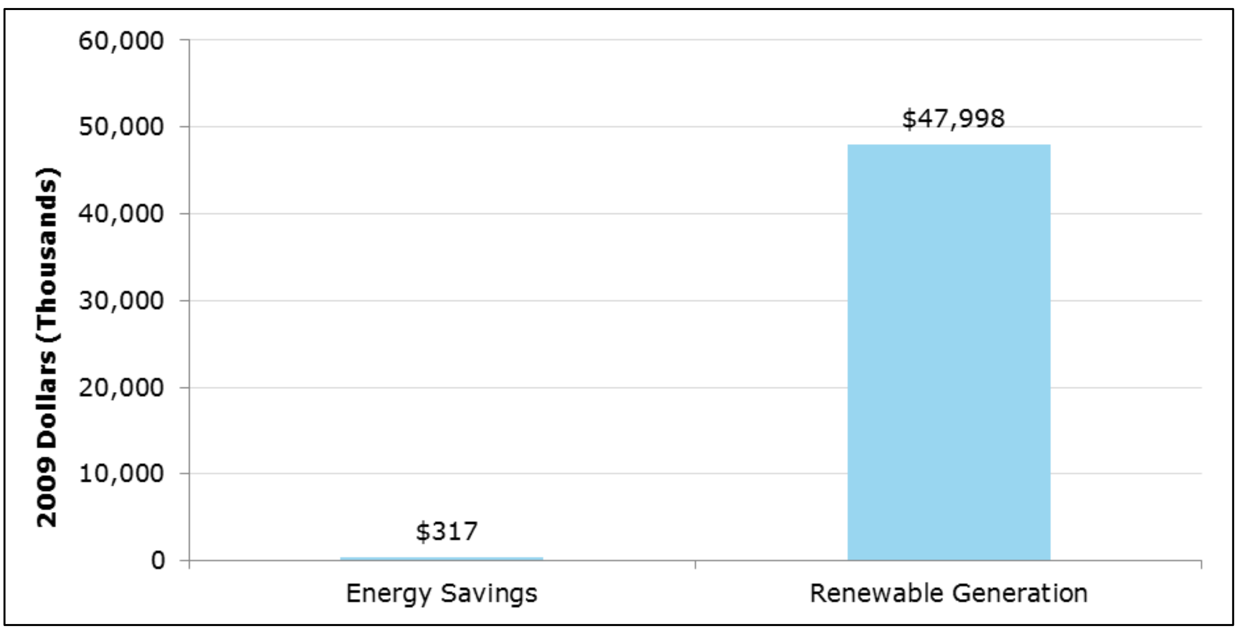

Figure 3-69: Social costs not incurred due to avoided carbon emissions from on-site renewable activities by mode of impact (thousands of 2009 US$)

3.4.5. Lighting

3.4.5.1. Avoided carbon emissions

The lighting BPA avoided 4.4 MMTCE of EECBG-attributable emissions over the 2009–2050 period. Figure 3-70 shows the annual carbon emissions avoided that are attributable to the lighting activities by year.

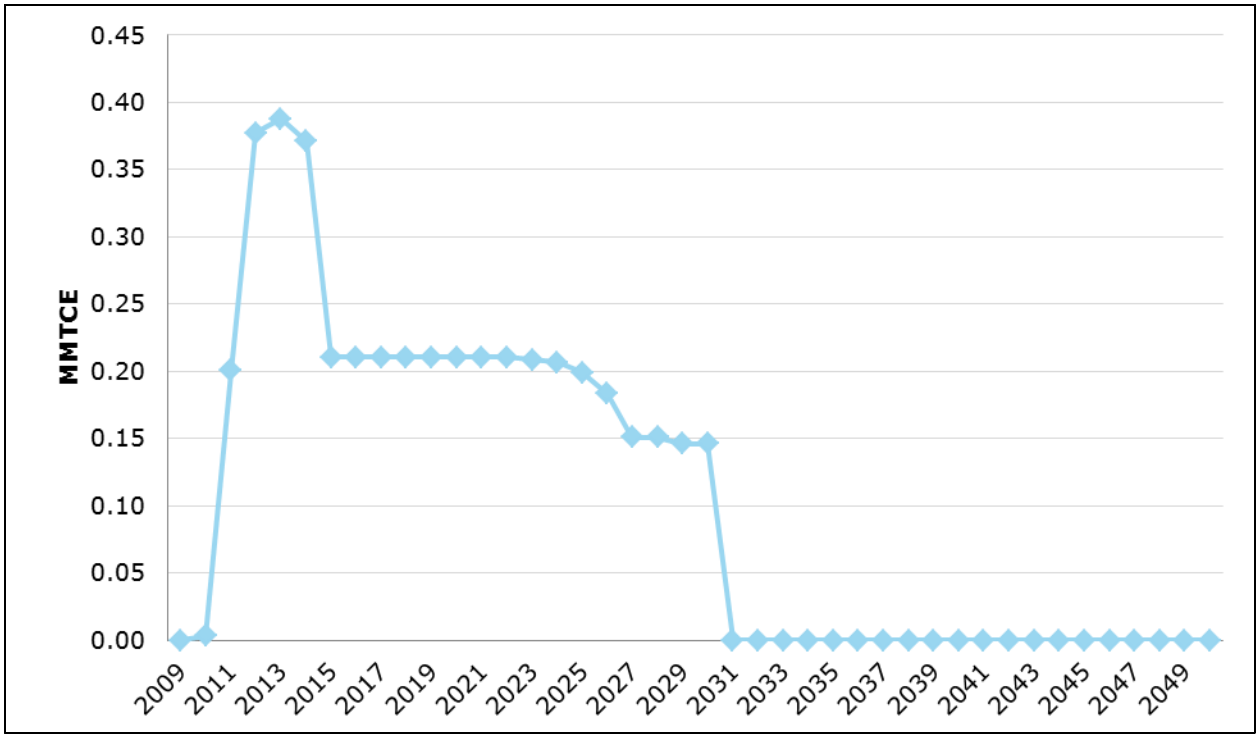

Figure 3-70: Annual carbon emissions avoided due to lighting activities by year (MMTCE)

Residential and public institutional sectors had the greatest avoided carbon emissions from lighting activities (Figure 3-71).

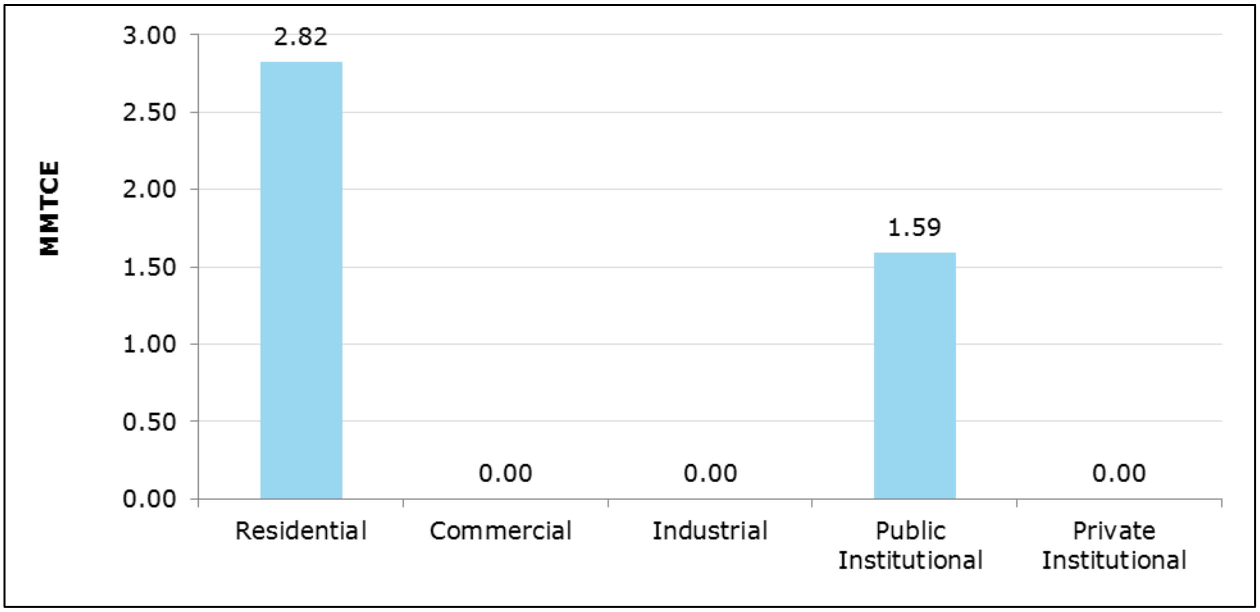

Figure 3-71: Avoided carbon emissions due to lighting activities by sector (MMTCE)

Figure 3-72 shows how total carbon savings from lighting activities are all due to energy savings.

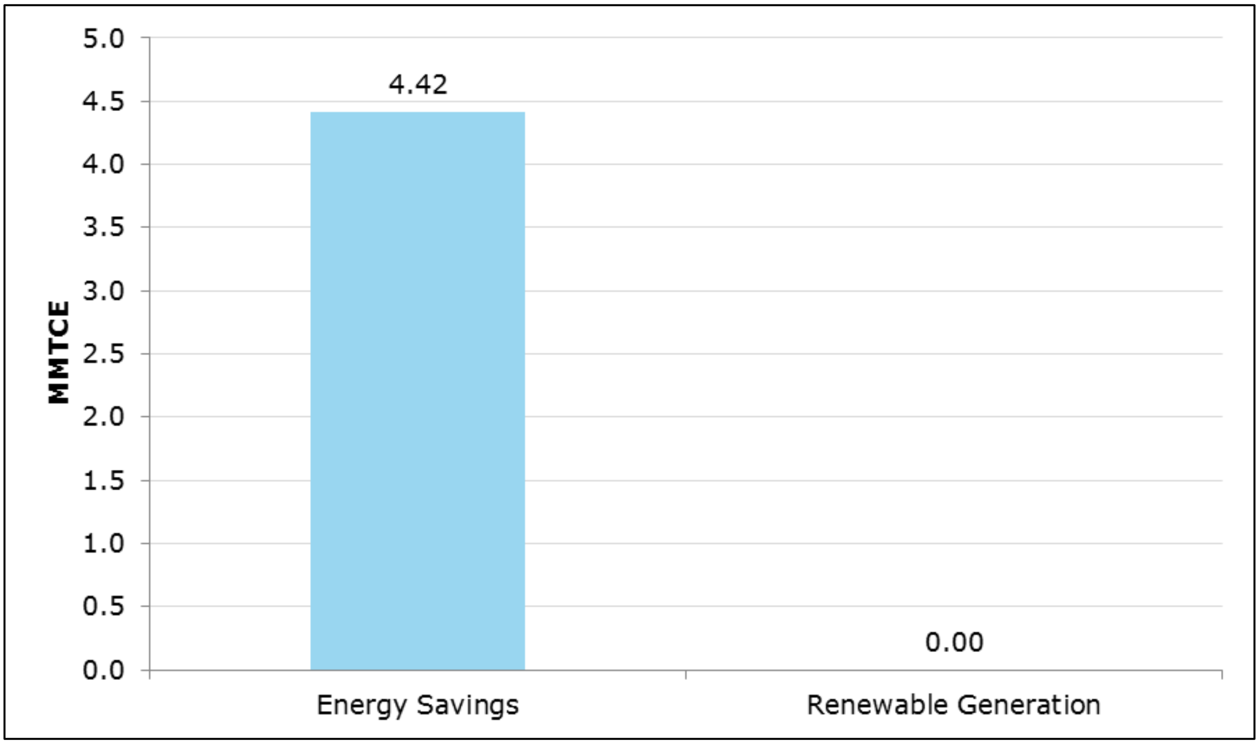

Figure 3-72: Avoided carbon emissions due to lighting activities by mode of impact (MMTCE)

3.4.5.2. Social costs of carbon impacts

The lighting BPA avoided $290 million in social costs according to the methodology described in Appendix J. Figure 3-73 illustrates how those avoided social costs are distributed over time.

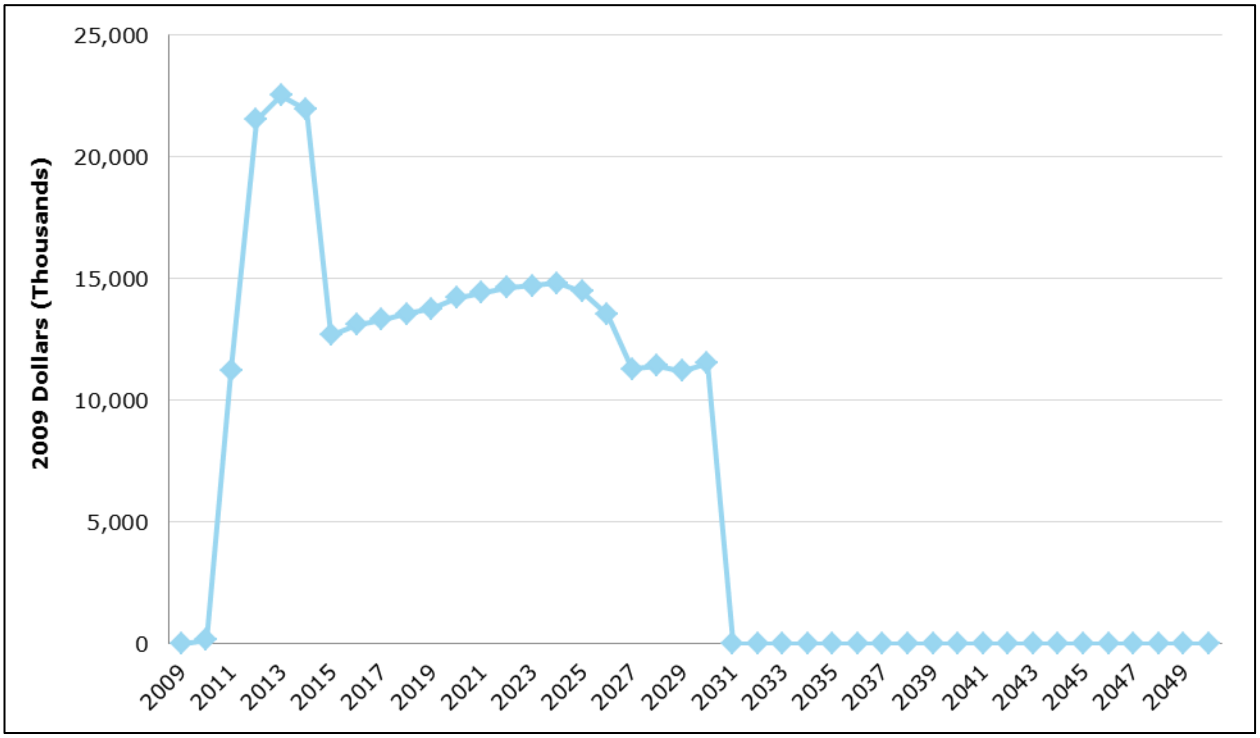

Figure 3-73: Social costs not incurred due to avoided carbon emissions from lighting EECBG activities by year (thousands of 2009 US$)

Figure 3-74 illustrates how those impacts are distributed across various sectors. All of the avoided social costs result from carbon emission savings from lighting activities and are in the residential and public institutional sectors.

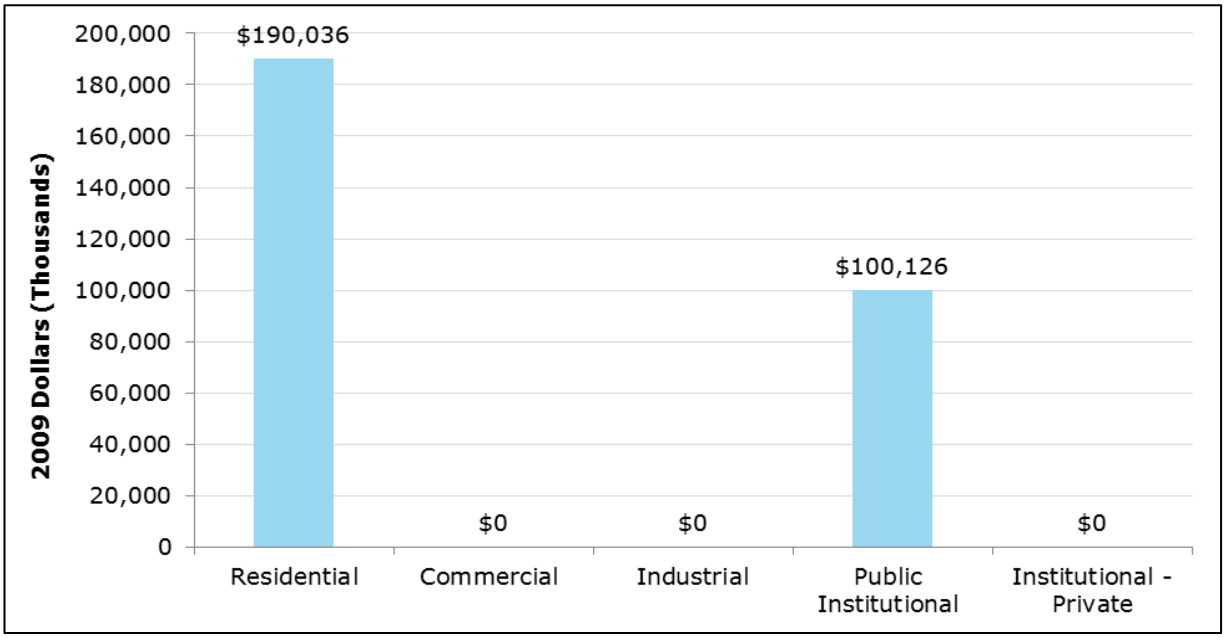

Figure 3-74: Social costs not incurred due to avoided carbon emissions from lighting activities by sector (thousands of 2009 US$)

Figure 3-75 shows that all of the deferred social costs of avoided carbon emissions from lighting activities were due to energy efficiency savings.

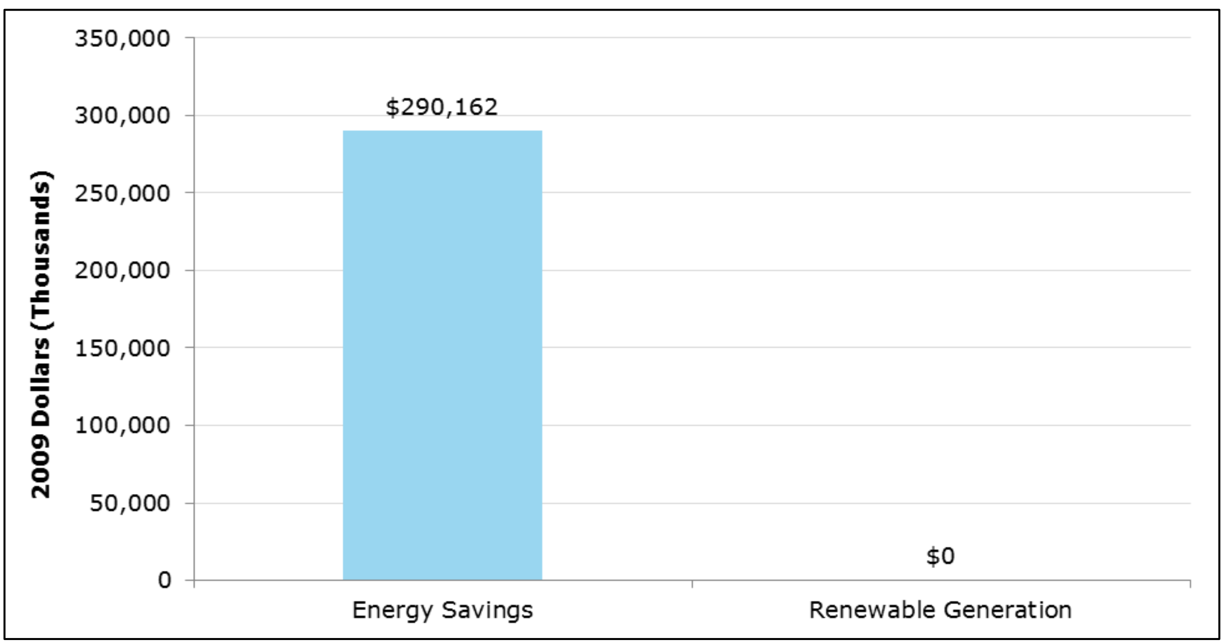

Figure 3-75: Social costs not incurred due to avoided carbon emissions from lighting activities by mode of impact (thousands of 2009 US$)

3.4.6. Energy efficiency and conservation strategy (direct grants)

3.4.6.1. Avoided carbon emissions

The energy efficiency and conservation strategy (direct grant) BPA avoided 0.11 MMTCE of carbon emissions over the 2009–2050 period. Figure 3-76 shows the annual carbon emissions avoided that are attributable to energy efficiency and conservation strategy activities by year.

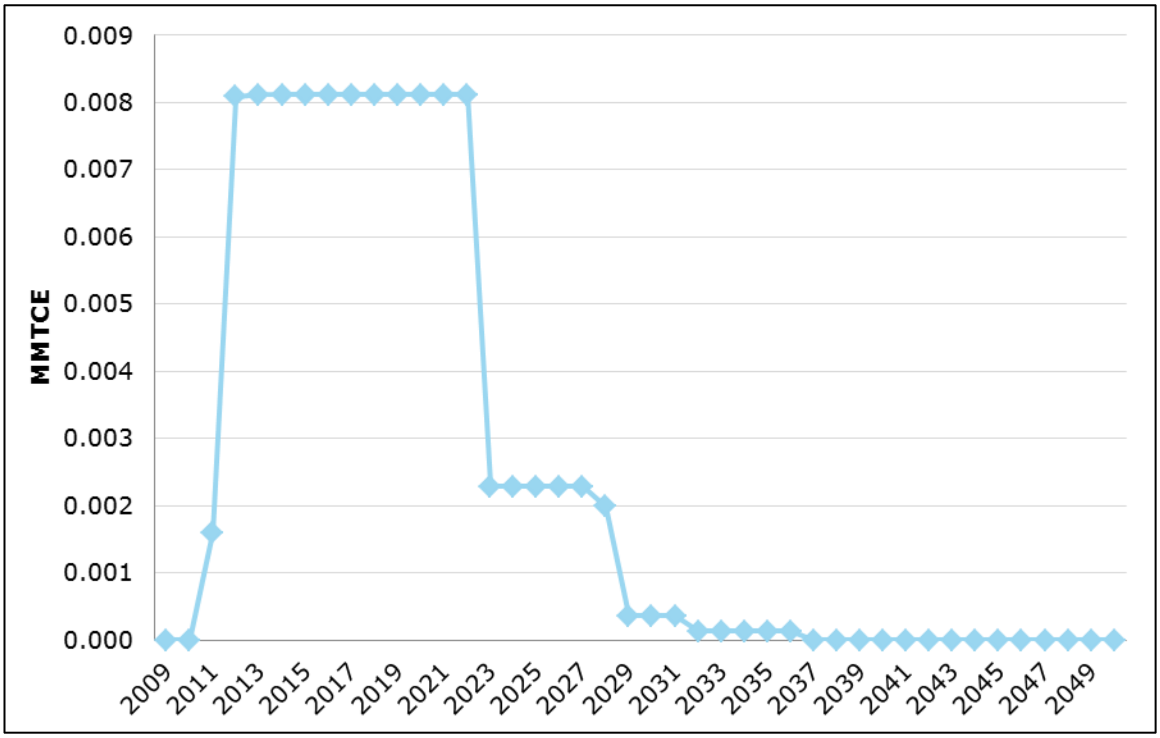

Figure 3-76: Annual carbon emissions avoided due to energy efficiency and conservation strategy (direct grant) activities by year (MMTCE)

Figure 3-77 shows how these carbon impacts are distributed by sector, with the residential sector's savings resulting in the vast majority of the carbon reduction.

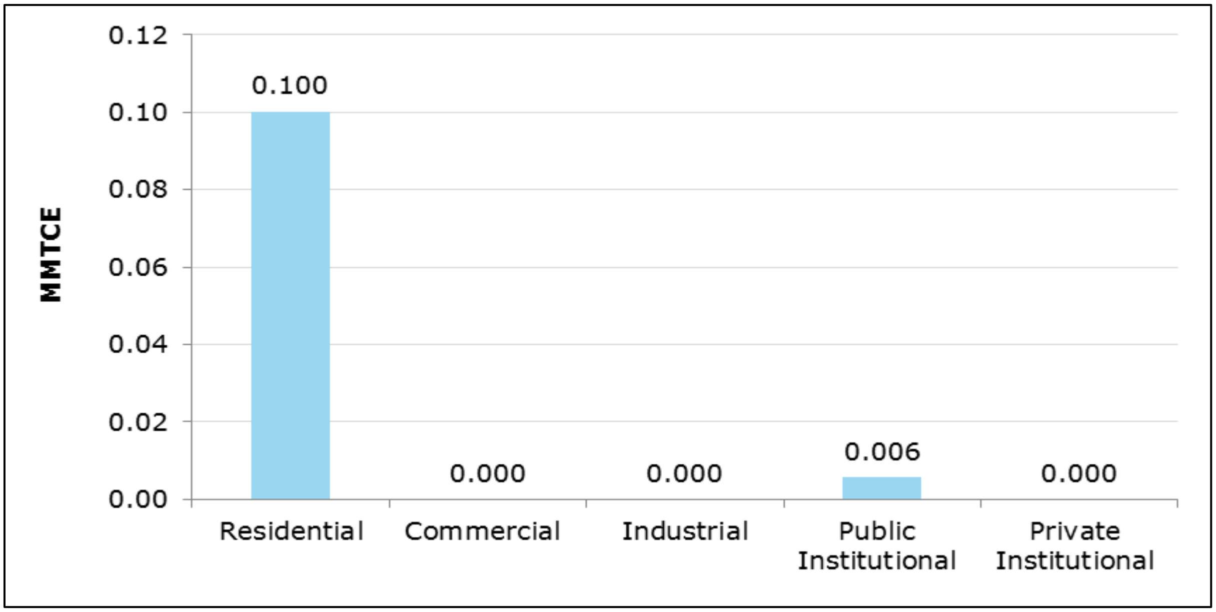

Figure 3-77: Avoided carbon emissions due to energy efficiency and conservation strategy (direct grants) activities by sector (MMTCE)

Energy efficiency and conservation strategy activities mostly avoided carbon emissions through energy savings (Figure 3-78).

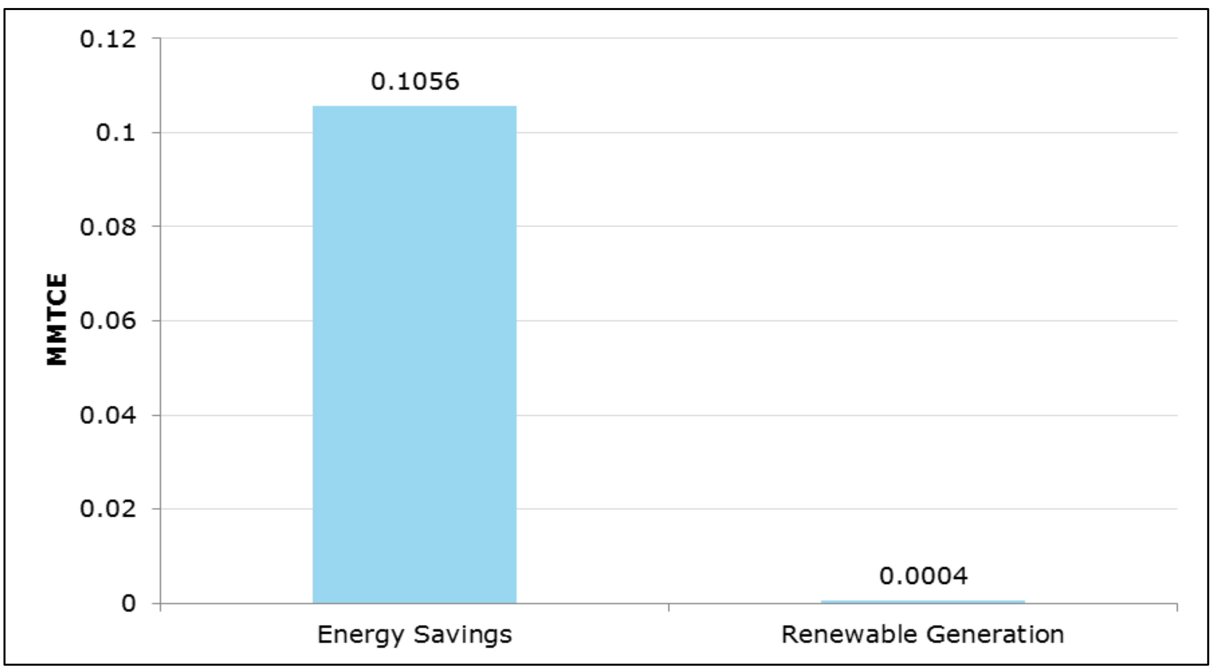

Figure 3-78: Avoided carbon emissions due to energy efficiency and conservation strategy (direct grants) activities by mode of impact (MMTCE)

3.4.6.2. Social costs of carbon impacts

The energy efficiency and conservation strategy (direct grants) BPA avoided $6.8 million in social costs according to the methodology described in Appendix J. Figure 3-79 illustrates how those avoided social costs are distributed over time.

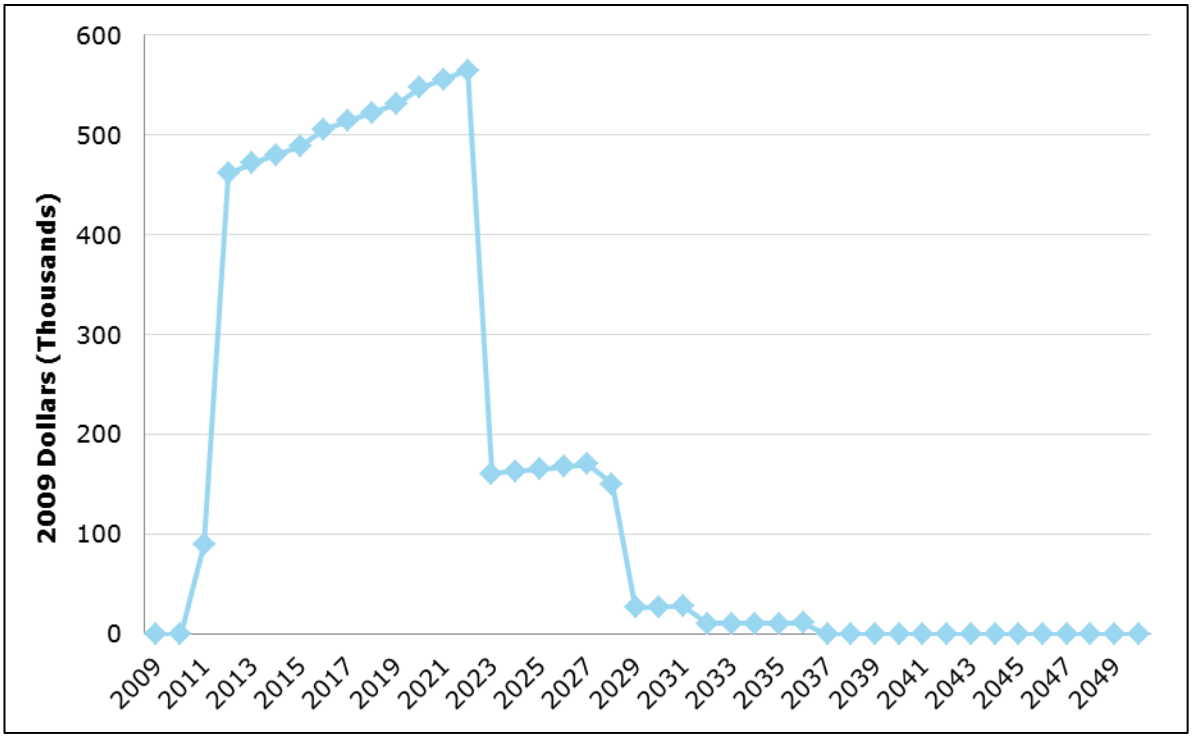

Figure 3-79: Social costs not incurred due to avoided carbon emissions from energy efficiency and conservation strategy (direct grants) activities by year (thousands of 2009 US$)

Figure 3-80 illustrates how those impacts are distributed across various sectors. The figure shows that the vast majority of avoided social costs result from carbon emission savings in the residential sector.

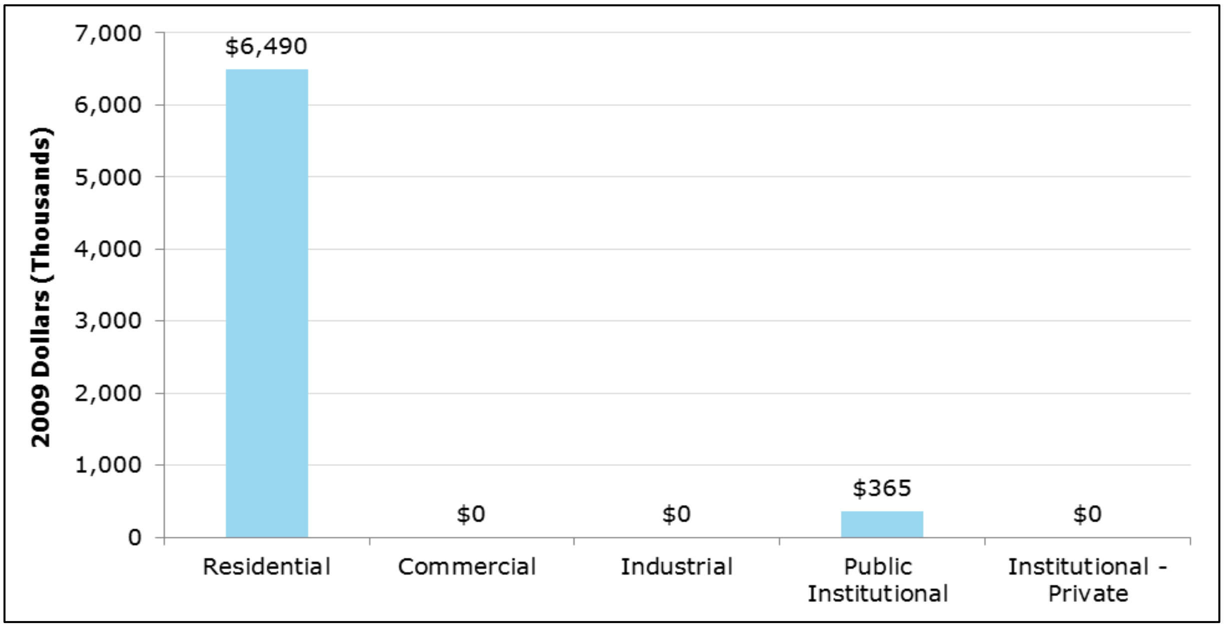

Figure 3-80: Social costs not incurred due to avoided carbon emissions from energy efficiency and conservation strategy (direct grants) activities by sector (thousands of 2009 US$)

The deferred social costs resulting from avoided carbon emissions due to energy efficiency and conservation strategy activities are almost entirely due to energy savings (Figure 3-81).

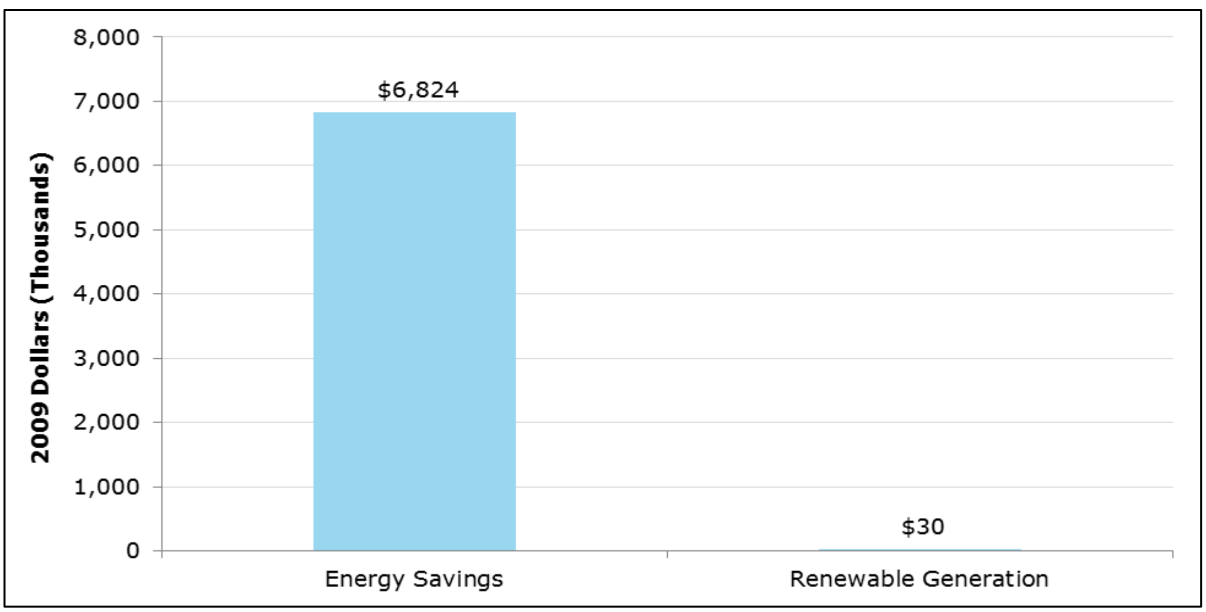

Figure 3-81: Social costs not incurred due to avoided carbon emissions from energy efficiency and conservation strategy (direct grants) activities by mode of impact (thousands of 2009 US$)

3.5. Bill savings and cost-effectiveness

This section presents findings on bill savings and cost-effectiveness indicators for each of the six evaluated BPAs funded through EECBG. Bill savings are presented in 2009 dollars, and include direct customer savings from energy efficiency and on-site renewable generation. For cost-effectiveness, two indicators are presented in this report: the RAC test result comparing annualized source MMBtu saved to program funding and the PV ratio of EECBG-attributable bill savings to EECBG program expenditures. As noted in Section 3.1.4, RAC test results are presented from the building and system perspectives. Similarly, three PV ratios are presented using three discount rate assumptions. The "preferred" rate is an OMB specified rate (2.7%) for evaluating public projects. The two remaining PV ratios are 2 percentage points above and below the preferred rate to provide a sensitivity analysis to the discount rate assumption.

3.5.1. Energy efficiency retrofits

3.5.1.1. Bill savings

For the energy efficiency retrofits BPA, the cumulative (not discounted) bill savings attributable to EECBG from energy savings and renewable generation was $748 million, and was created with estimated program funding of $1.1 billion.

Figure 3-82 displays the bill savings by sector over time. Each point on the graph represents an annual savings value in 2009 dollars. The public institutional sector accounts for nearly all (90%) of the bill savings accumulated from this BPA.

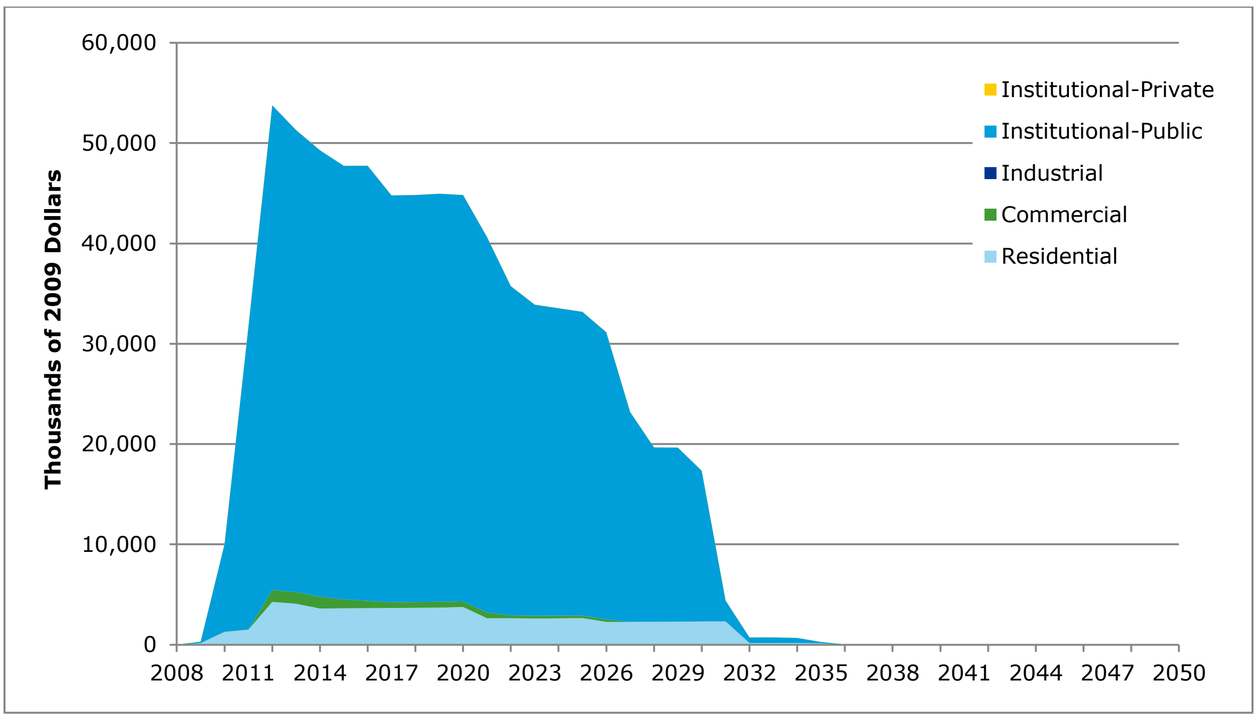

Figure 3-82: Bill savings from energy efficiency retrofit activities by year and sector (thousands of 2009 US$)

Table 3-42 shows a cross tabulation of EECBG-attributable bill savings by fuel and sector. As noted earlier, nearly all bill savings for this BPA appear in the public institutional sector. This savings is driven by reductions in electricity consumption (62%), followed by reductions in diesel fuel (30%). Residential electric and natural gas savings account for the bulk of the remaining savings.

Table 3-42 EECBG-attributable bill savings from energy efficiency retrofit activities by fuel and sector (thousands of 2009 US$)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional
Electricity	$26,499	$6,410	$169*	$424,407	-
Natural Gas	$21,807	$2,437	-	$27,042	-
Oil	$744*	-	-	$2,988*	-
Propane	-	-	-	-	-
Kerosene	-	-	-	-	-
Wood	$5,559*	-	-	-	-
Diesel	-	-	-	$230,124*	-
Ethanol	-	-	-	-	-
Gasoline	-	-	-	-	-
Other	-	-	-	-	-
Total	**$54,610**	**$8,848**	**$169***	**$684,561**	**-**

"-" 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.

3.5.1.2. Cost-effectiveness

This section presents cost-effectiveness indicators for EECBG-funded activities. The two major indicators of cost-effectiveness (RAC test and PV ratio) along with the two perspectives are defined in the introduction to Section 2.5.5 and discussed in more detail in Appendix K. Table 3-43 shows the RAC test ratio for a single year from two perspectives: the building and the system. The result of the RAC test for this BPA is 5.18, which is below the benchmark of 10 by approximately 49%.

Table 3-43: RAC test ratio for energy efficiency retrofit activities

Perspective	Benchmark	RAC
Building	10.0	**5.18**
System	10.0	**5.20**

As stated earlier in this section, program funding totaled $1.1 billion and created $748 million in EECBG-attributable bill savings from 2009 to 2040. In present value terms, this is program funding of $1.0 billion and bill savings of $579 million. Table 3-44 shows ratios of PV savings to funding at various discount rates. Ratios were calculated at discount rates 2% above and below the specified discount rate of 2.7%. All three PV ratios for this BPA are less than 1.0, reflecting the fact that the present value bill savings for the life of the installed projects in all sectors combined was less than the present value of total program funding.

Table 3-44: PV ratio for energy efficiency retrofit activities

Discount Rate	0.70%	2.70%	4.70%
Ratio of PV bill savings to PV BPA funding	0.66	0.56	0.49

3.5.2. Financial incentives

3.5.2.1. Bill savings

For the financial incentives BPA, the cumulative bill (not discounted) savings attributable to EECBG from energy savings and renewable generation was $2.7 billion, and was created with estimated program funding of $500 million.

Figure 3-83 displays the bill savings by sector over time. Each point on the graph represents close to an annual savings value in 2009 dollars. The bill savings from the residential sector represents 93% of the bill savings accumulated from this BPA. The institutional-public sector accounts for most of the remainder (7%), with less than one-half percent associated with the commercial sector.

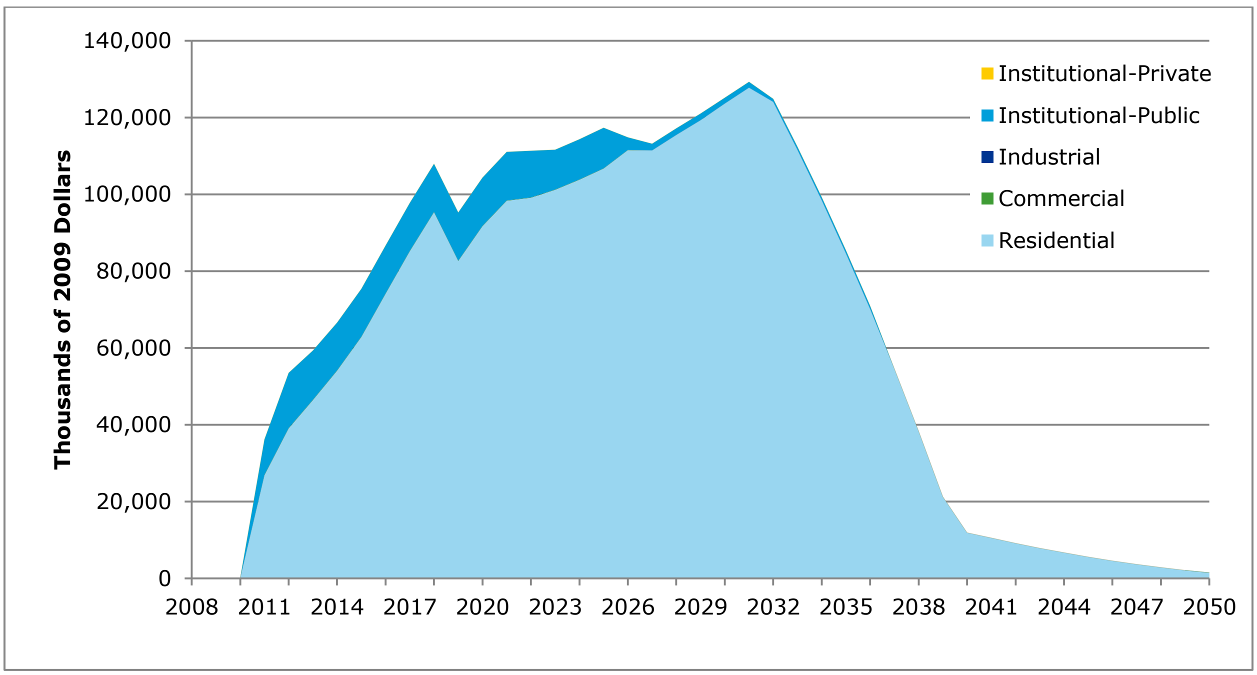

Figure 3-83: Bill savings from financial incentive activities by year and sector (thousands of 2009 US$)

Table 3-45 shows a cross tabulation of EECBG-attributable bill savings by fuel and sector. Nearly all bill savings for this BPA appear in the residential sector. This savings is driven by reductions in electricity consumption (89%) and natural gas (11%).

Table 3-45: EECBG-attributable bill savings from financial incentive activities by fuel and sector (thousands of 2009 US$)

	Residential	Commercial	Industrial	Institutional-Public	Institutional-Private
Electricity	$2,345,455*	$1,587*	-	$93,237	-
Natural Gas	$199,537	$204*	-	$101,625	-
Oil	-	-	-	-	-
Propane	-	-	-	-	-
Kerosene	-	-	-	-	-
Wood	-	-	-	-	-
Diesel	-	-	-	-	-
Ethanol	-	-	-	-	-
Gasoline	-	-	-	$769*	-
Other	-	-	-	-	-
Total	**$2,544,992**	**$1,791***	**-**	**$195,630**	**-**

"-" 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.

3.5.2.2. Cost-effectiveness

This section presents cost-effectiveness indicators for EECBG-funded activities. The two major indicators of cost-effectiveness (RAC test and PV ratio) are defined in the introduction to Section 2.5.5 and discussed in more detail in Appendix K. Table 3-46 shows the RAC test ratio for from the building and system perspectives. For this BPA we provide two calculations for each perspective. One calculation considers initial loan disbursements as program expenditures. The other considers initial loan disbursements not as expenditures, but as assets that are paid back. This treatment of loans is discussed in section 2.5.5.

The result of the RAC test for this BPA is 9.76, which falls below the benchmark of 10 by approximately 3%. This result is produced by including all program funding in the calculation (i.e. program operations and the dollar amount of initial loans). If the RAC test is conducted without counting the value of initial loan principal (because these loans are paid back), the RAC result is substantially higher, as shown below.

Table 3-46: RAC test ratio for financial incentive activities

Perspective	Benchmark	RAC
Building	10.0	**9.76** (loan principal included)
System	10.0	**9.92** (loan principal included)

Perspective	Benchmark	RAC
Building	10.0	**14.97** (loan principal excluded)
System	10.0	**15.20** (loan principal excluded)

As stated earlier in this section, program funding totaled $500.8 million and created $2.6 billion in EECBG-attributable bill savings from 2009 to 2040. In present value terms, this is program funding of $477.0 million and bill savings of $1.8 billion. Table 3-47 shows ratios of PV bill savings to funding at various discount rates. Ratios are calculated at discount rates 2% above and below the specified discount rate of 2.7%. All three PV ratios for this BPA are greater than 1.00, reflecting the fact that the present value bill savings for the life of the installed projects was greater than the present value of total program funding. As with RAC test results, PV ratios are reported both with and without the cost of initial loan principal.

Table 3-47: PV Ratio for financial incentive activities

Discount rate	0.70%	2.70%	4.70%
Ratio of PV bill savings to PV activity funding (loan principal included)	4.95	3.77	2.95
Ratio of PV bill savings to PV activity funding (loan principal excluded)	7.61	5.79	4.51

3.5.3. Buildings and facilities

3.5.3.1. Bill savings

For the buildings and facilities BPA, the cumulative (not discounted) bill savings attributable to EECBG from energy savings and renewable generation was $260 million, and was created with estimated program funding of $211 million.

Figure 3-84 displays the bill savings by sector over time. Each point on the graph represents an annual savings value in 2009 dollars. The bill savings from the public institutional sector represent nearly all (99%) of the bill savings accumulated from this BPA.

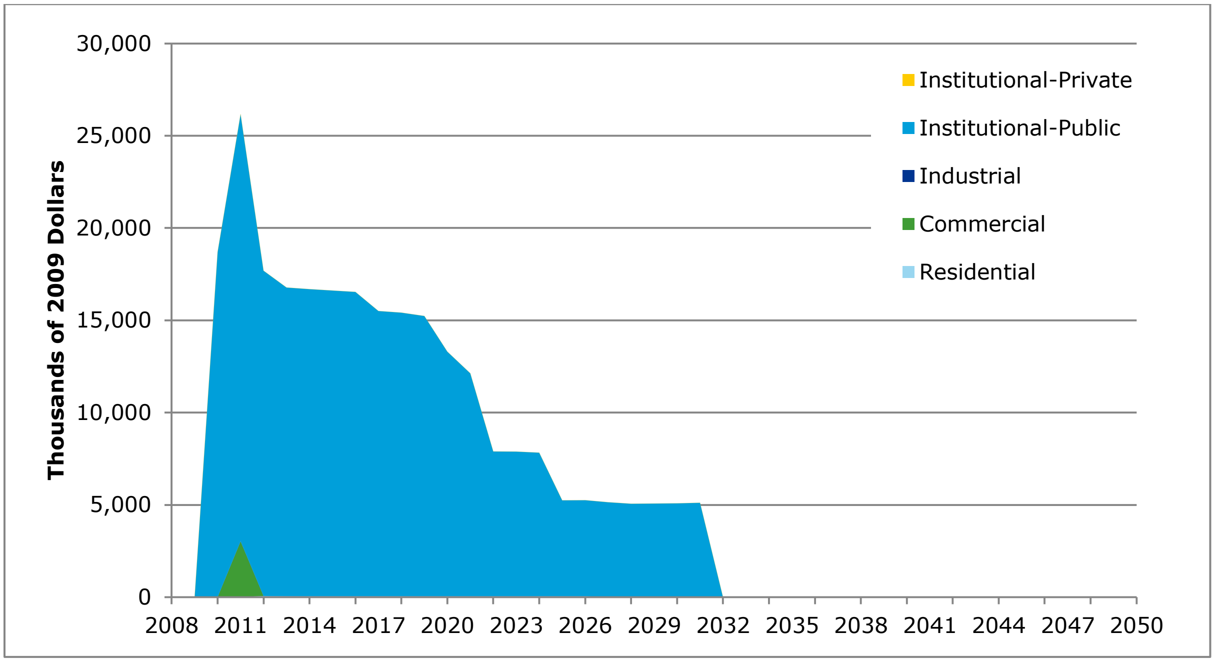

Figure 3-84: Bill savings from building and facilities activities by year and sector (thousands of 2009 US$)

Table 3-48 shows a cross tabulation of EECBG-attributable bill savings by fuel and sector. Nearly all bill savings for this BPA appear in the public institutional sector, with residential and commercial savings accounting for the remainder. The public institutional sector's savings is driven by reductions in electricity consumption (99%) followed by reductions in natural gas (1%). Residential and commercial electric savings account for the remainder.

Table 3-48: EECBG-attributable bill savings from building and facilities activities by fuel and sector (thousands of 2009 US$)

	Residential	Commercial	Industrial	Institutional-Public	Institutional-Private
Electricity	$736*	$3,014*	-	$254,881	-
Natural Gas	-	$13*	-	$1,733	-
Oil	-	-	-	-	-
Propane	-	-	-	-	-
Kerosene	-	-	-	-	-
Wood	-	-	-	-	-
Diesel	-	-	-	-	-
Ethanol	-	-	-	-	-
Gasoline	-	-	-	-	-
Other	-	-	-	-	-
Total	**$736***	**$3,027***	**-**	**$256,614**	**-**

"-" 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.

3.5.3.2. Cost-effectiveness

This section presents cost effectiveness indicators for EECBG-funded activities. The two major indicators of cost-effectiveness (RAC test and PV ratio) are defined in Section 2.5.5 and discussed in more detail in Appendix K. Table 3-49 shows the RAC ratio from both the building and system perspectives. Both perspectives show the same value because no on-site generation was installed through this BPA.

The result of the RAC test result for this BPA is 13.7, which exceeds the benchmark of 10 by approximately 37%.

Table 3-49: RAC test ratio for building and facilities activities

Perspective	Benchmark	RAC
Building	10.0	**13.70**
System	10.0	**13.70**

As stated earlier in this section, program funding totaled $211 million and created $260 million in EECBG-attributable bill savings from 2009 to 2040. In present value terms, this represents program funding of $200 million and bill savings of $210 million. Table 3-50 shows the PV ratios of bill savings to funding at various discount rates. Ratios were calculated at discount rates 2% above and below the specified discount rate of 2.7%. The PV ratio for this BPA is greater than 1.0 when the specified discount rate is used, reflecting the fact that the present value of bill savings for the life of the installed projects exceeds the present value of total program funding.

Table 3-50: PV ratio for building and facilities activities

Discount Rate	0.70%	2.70%	4.70%
Ratio of PV bill savings to PV activity funding	1.18	1.05	0.94

3.5.4. On-site renewables

3.5.4.1. Bill savings

For the on-site renewables BPA, the cumulative (not discounted) bill savings attributable to EECBG from renewable generation was $124 million, and was created with estimated program funding of $158 million.

Figure 3-85 displays the bill savings by sector over time. Each point on the graph represents an annual savings value in 2009 dollars. The bill savings from the public institutional sector represents nearly all (99.6%) of the bill savings accumulated from this BPA.

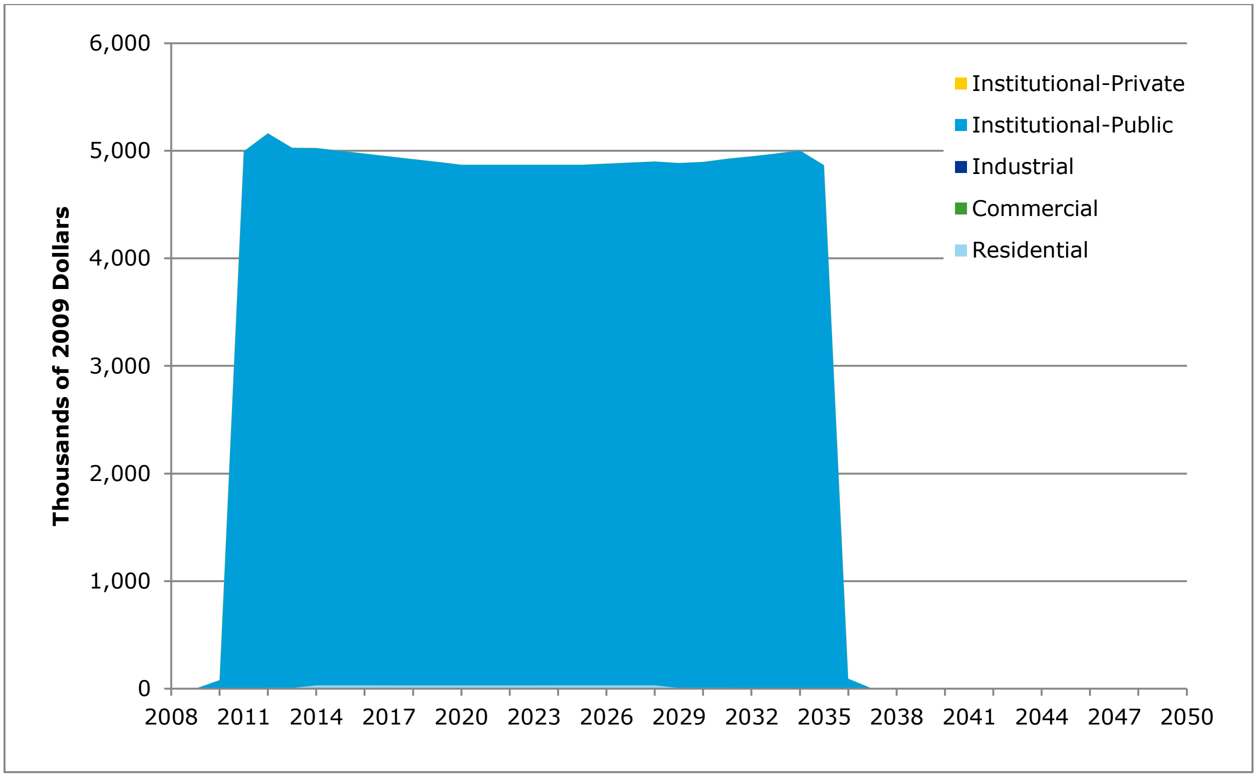

Figure 3-85: Bill savings from on-site renewable activities by year and sector (thousands of 2009 US$)

Table 3-51 shows a cross tabulation of EECBG-attributable bill savings by fuel and sector. Nearly all bill savings for this BPA (99.6%) appear in the public institutional sector, with the remainder accounted for by residential electric savings. Savings in the public institutional sector are driven entirely by reductions in electricity consumption.

Table 3-51: EECBG-attributable bill savings from on-site renewable activities by fuel and sector (thousands of 2009 US$)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional
Electricity	$503	-	-	$123,047	-
Natural Gas	-	-	-	-	-
Oil	-	-	-	-	-
Propane	-	-	-	-	-
Kerosene	-	-	-	-	-
Wood	-	-	-	-	-
Diesel	-	-	-	-	-
Ethanol	-	-	-	-	-
Gasoline	-	-	-	-	-
Other	-	-	-	-	-
Total	$503	-	-	$123,047	-

"-" 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.

3.5.4.2. Cost-effectiveness

This section presents cost-effectiveness indicators for EECBG-funded activities. The two major indicators of cost-effectiveness (RAC test and PV ratio) are defined in Section 2.5.5 and discussed in more detail in Appendix K. Table 3-52 shows the RAC test ratio for a single year from two perspectives: the building and the system.

The result of the RAC test for this BPA is 0.90 and is below the benchmark of 10 by approximately 91%.

Table 3-52: RAC test ratio for on-site renewable activities

Perspective	Benchmark	RAC
Building	10.0	**0.90**
System	10.0	**2.92**

As stated earlier in this section, program funding totaled $158 million and created $124 million in bill savings from 2009 to 2040. In present value terms, this is program funding of $152 million and bill savings of $86 million. Table 3-53 shows ratios of PV savings to funding at various discount rates. All three PV ratios for this BPA are less than 1.00, reflecting the fact that the present value bill savings for the life of the installed projects in all sectors combined were less than present value of total program funding.

Table 3-53: PV ratio for on-site renewable activities

Discount rate	0.70%	2.70%	4.70%
Ratio of PV bill savings to PV activity funding	0.72	0.57	0.47

3.5.5. Lighting

3.5.5.1. Bill savings

For the lighting BPA, the cumulative (not discounted) bill savings attributable to EECBG from energy savings and renewable generation was $1.3 billion, and was created with estimated program funding of $193.3 million.

Figure 3-86 displays the bill savings by sector over time. Each point on the graph represents an annual savings value in 2009 dollars. The bill savings from the residential sector represent the majority (81%) of the bill savings and the public institutional sector accounts for the rest (19%).

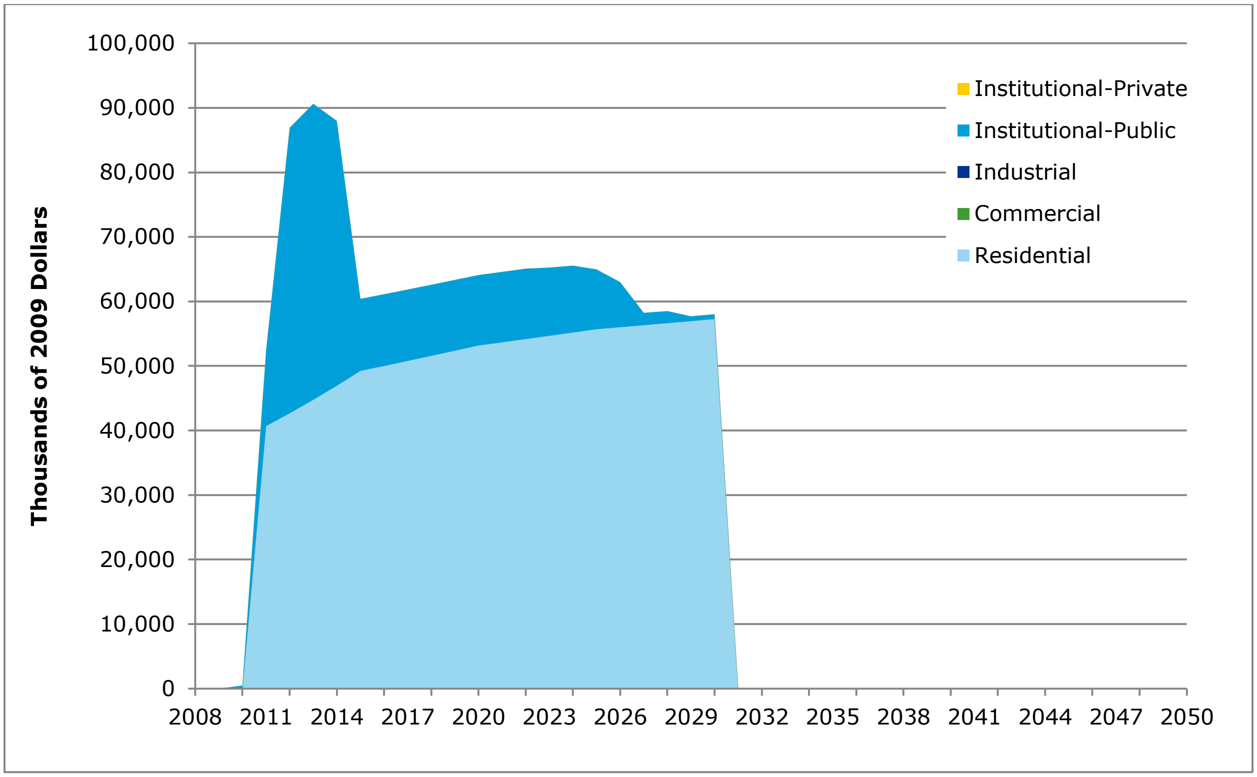

Figure 3-86: Bill savings from lighting activities by year and sector (thousands of 2009 US$)

Table 3-54 shows a cross tabulation of EECBG-attributable bill savings by fuel and sector. Nearly all bill savings for this BPA appear in the residential sector. This savings is driven by reductions in gasoline consumption (79%), followed by reductions in electricity (21%). This BPA implemented traffic signal changes that saved fuel for motorists and electricity for the city.

Table 3-54: EECBG-attributable bill savings from lighting activities by fuel and sector (thousands of 2009 US$)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional
Electricity	-	-	-	$273,628	-
Natural Gas	-	-	-	-	-
Oil	-	-	-	-	-
Propane	-	-	-	-	-
Kerosene	-	-	-	-	-
Wood	-	-	-	-	-
Diesel	-	-	-	-	-
Ethanol	-	-	-	-	-
Gasoline	$1,039,082*	-	-	-	-
Other	-	-	-	-	-
Total	**$1,039,082***			**$273,628**	**-**

"-" 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.

3.5.5.2. Cost-effectiveness

This section presents cost-effectiveness indicators for EECBG-funded activities. The two major indicators of cost-effectiveness (RAC test and PV ratio) are defined in Section 2.5.5 and discussed in more detail in Appendix K. Table 3-56 shows the RAC test ratio for a single year. Both perspectives are shown, but no on-site generation was installed through this BPA.

The result of the RAC test for this BPA is 39.2 and was above the benchmark of 10 by approximately 292%.

Table 3-55: RAC test ratio for lighting activities

Perspective	Benchmark	RAC
Building	10.0	**39.17**
System	10.0	**39.17**

As stated earlier in this section, program funding totaled $193.3 billion and created $1.3 billion in EECBG-attributable bill savings from 2009 to 2040. In present value terms, this is program funding of $184 million and bill savings of $989 million. Table 3-56 shows PV ratios of savings to funding at various discount rates. Ratios were calculated at discount rates 2% above and below the specified discount rate of 2.7%. All three PV ratios for this BPA are greater than 1.0, reflecting the fact that the present value bill savings for the life of the installed projects in all sectors combined were 4 to 6 times greater than the present value of total program funding.

Table 3-56: PV ratio for lighting activities

Discount rate	0.70%	2.70%	4.70%
Ratio of PV bill savings to PV activity funding	6.37	5.38	4.60

3.5.6. Energy efficiency and conservation strategy (direct grants)

3.5.6.1. Bill savings

For the energy efficiency and conservation strategy BPA, the cumulative (not discounted) bill savings attributable to EECBG from energy savings and renewable generation was $21 million, and was created with estimated program funding of $63 million.

Figure 3-87 displays the bill savings by sector over time. Each point on the graph represents an annual savings value in 2009 dollars. The bill savings from the residential sector represent nearly all (95%) of the bill savings accumulated from this BPA.

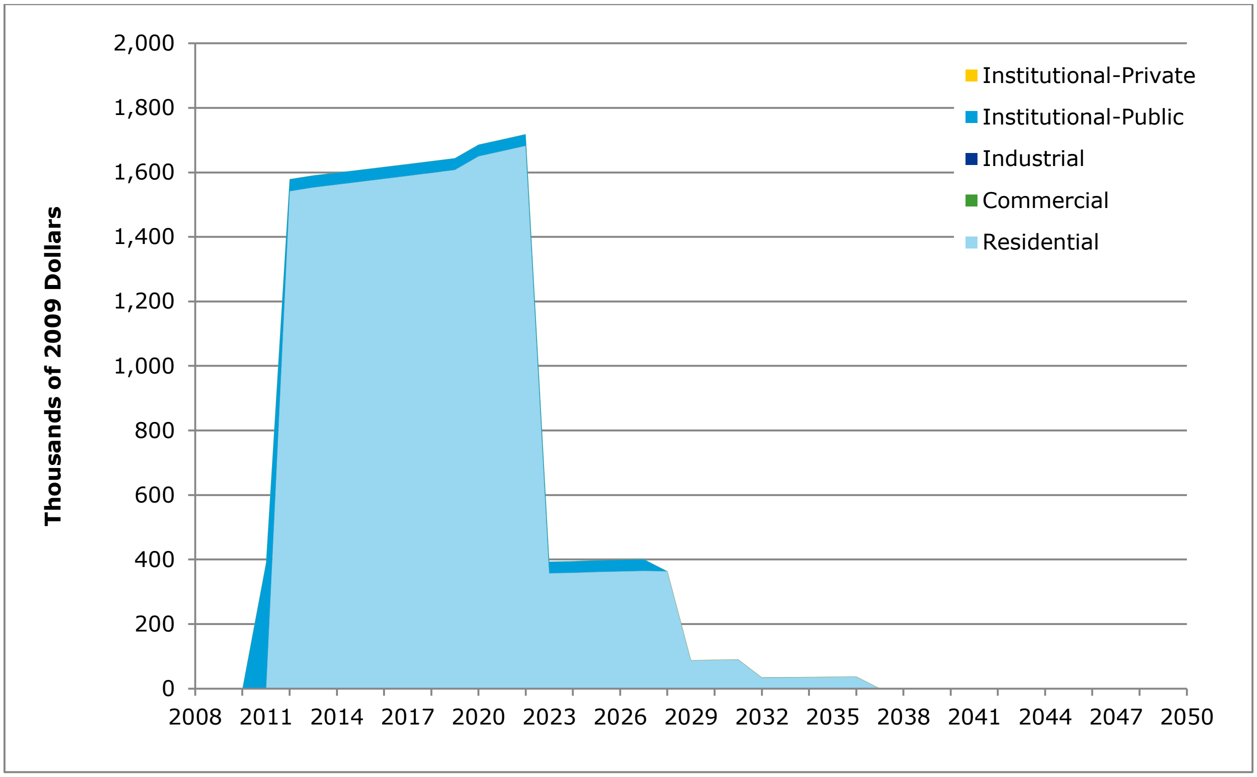

Figure 3-87: Bill savings from energy efficiency and conservation strategy (direct grants) activities by year and sector (thousands of 2009 US$)

Table 3-57 shows a cross tabulation of EECBG-attributable bill savings by fuel and sector. Nearly all bill savings for this BPA appear in the residential sector (95%). This savings is driven by reductions in natural gas (70%) and electricity consumption (30%). Public institutional electric savings accounts for 5% of the total savings.

Table 3-57: EECBG-attributable bill savings from energy efficiency and conservation strategy (direct grants) activities by fuel and sector (thousands of 2009 US$)

	Residential	Commercial	Industrial	Institutional-Public	Institutional-Private
Electricity	$5,482*	-	-	$969*	-
Natural Gas	$14,741*	-	-	-	-
Oil	-	-	-	-	-
Propane	-	-	-	-	-
Kerosene	-	-	-	-	-
Wood	-	-	-	-	-
Diesel	-	-	-	-	-
Ethanol	-	-	-	-	-
Gasoline	-	-	-	-	-
Other	-	-	-	-	-
Total	**$20,223***	**-**	**-**	**$969***	**-**

"-" 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.

3.5.6.2. Cost-effectiveness

This section presents cost-effectiveness indicators for EECBG-funded activities. The two major indicators of cost-effectiveness (RAC test and PV ratio) are defined in Section 2.5.5 and discussed in more detail in Appendix K. Table 3-58 shows the RAC test ratio for a single year from two perspectives: the building and the system.

The result of the RAC test for this BPA was 2.9 and was below the benchmark of 10 by approximately 71%.

Table 3-58: Single-year RAC test ratio for energy efficiency and conservation strategy (direct grants) activities

Perspective	Benchmark	RAC
Building	10.0	**2.86**
System	10.0	**2.87**

As stated earlier in this section, program funding totaled $63 million and created $21 million in EECBG-attributable bill savings from 2009 to 2040. In present value terms, this is program funding of $63 million and bill savings of $17 million.

Table 3-59 shows PV ratios of bill savings to funding at various discount rates. Ratios were calculated at discount rates 2% above and below the specified discount rate of 2.7%. All three PV ratios for this BPA are less than 1.0, reflecting the fact that the present value bill savings for the life of the installed projects in all sectors combined were less than the present value of total program funding.

Table 3-59: PV ratio for energy efficiency and conservation strategy (direct grants) activities

Discount rate	0.70%	2.70%	4.70%
Ratio of PV bill savings to PV activity funding	0.31	0.27	0.23

4. ORGANIZATIONAL/OPERATIONAL FACTORS INFLUENCING PROGRAM PERFORMANCE

The objective of the performance analysis was to determine if there were organizational or operational aspects of the EECBG project that could be found to have a statistical relationship to the energy savings achieved per grant dollar spent. An understanding of the 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 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. Since the point of the study was to isolate the impact of operational and organizational factors on performance 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?

4.1. Methodology

An exploratory statistical analysis was conducted to explore whether we could identify key factors that explain the relative level of savings per grant dollar and if so, to report the strength of that relationship.

A regression model was used to explore the relationship between the dependent variable of interest (i.e., the ratio of EECBG-attributable energy savings to grant dollars) and the potential explanatory or independent variables, both endogenous and exogenous to the program.

Endogenous variables are those that are directly related to program participation, such as the level of support received from various entities, whether the project/activity involved an audit of some type, the types of assistance received in implementing the program, whether it was a direct or indirect grant, and the program category or BPA in which the activity was classified.

Exogenous variables were also of interest – These included variables or conditions external to the program, such as weather during the grant period (captured as heating and cooling degree days), energy costs and the unemployment rate in the state where the activity took place. The characteristics of the state in terms of the presence of energy efficiency policies, regulations and utility programs was also of interest as potentially having an impact on the effectiveness of grant activities.

Regression modeling can examine a large number of variables that are associated with each observation in a dataset. In this case, each observation in the model is an EECBG grant activity.

Each grant activity has a calculated energy savings impact per grant dollar spent that has been determined through the evaluation to have been attributable to the EECBG grant program. This value is the dependent variable that we are trying to explain through examination of various independent variables.

The model started with 169 total observations or records of EECBG activities for which we developed a ratio of energy savings per dollar spent. In addition to this dependent variable, each observation included a large number of potential explanatory variables such as the type of BPA with which the activity is associated, whether an audit was done to help identify energy savings opportunities, whether other financial support was obtained, and whether the grant activity was supported by the community in which it was carried out. These variables were identified a literature search of program best practices and a review of findings from previous evaluations undertaken to reveal what others have found regarding operational and organizational variables and their impact on project performance.   A list of potential variables was developed from this literature review and then augmented, reviewed and ranked by the evaluation team. Details regarding the literature review and variable selection process are provided in Appendix L.

Once the final set of variables of interest was developed, questions were designed for gathering the necessary data through a CATI telephone survey of grant managers. Though originally designed as a separate survey, the final evaluation approach incorporated the performance factors questions into the impact evaluation survey. This was done primarily to limit interviewer fatigue while still capture data on a majority of the variables of interest.

In cases where respondents did not answer relevant questions or it was unclear how to interpret a missing value, we ended up with activities that had incomplete information for the full set of variables to be tested. Removing these incomplete observations reduced the number of activities that could be tested in the model from 169 (for which we had ratios of energy savings per dollar) to some lower number, with the exact figure determined by the set of dependent variables contained in the model. Depending on how many independent variables were included in the model, the number of activities that could be analyzed ranged from a high of 148 to a low of 80.

The list of independent variables also included a few exogenous variables taken from secondary sources.   For two of those variables (retail rates of electricity and average electricity consumption), a high number of missing values prevented including of the variable in the final regression model.

The modeling was preceded by an extensive data preparation step to select, clean, and transform or recode, as required, all the variables that were used in the regression model. Two regression models were developed and are reported in this section:

- Multivariate regression model with BPAs included
- Univariate regression model

4.2. Overview of Findings

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. More specific findings are:

- When included in a multivariate regression model, the BPA categories of "financial incentives" and "lighting" have a relatively high positive impact on the ratio of net savings to funding. "Buildings and facilities" and "energy efficiency retrofits" have a moderate impact on the outcome variable. An overall fit of the regression model of 64% is achieved (meaning that the variables included in the model explained 64% of the energy savings per dollar spent) with 148 observations (grant activities in the data set) and 13 independent variables considered.
- When each of the variables was modeled independently in a set of univariate regressions, we note that no single variable explained more than 15% (R-sq=.15) of the variability of the dependent variable. The R-square in this case is an indicator of the amount of variability in the dependent variable explained by just the one factor under consideration. Similar to the multivariate regression model, the top three variables with explanatory value (positive or negative) were BPA categories. It should be noted that a few variables other than the BPA category do emerge as significant, but their impact on program performance tends to be smaller than the impact of BPA category.

4.3. Limitations of the Study

There are several possible reasons why this study did not find more organizational and operational factors with a significant relationship to program performance. The top three are summarized here:

Low Sample Size - The evaluation produced energy savings results for 169 grant activities, the population of records available for the performance factors analysis. Of these 169 activities, complete data on organizational factors (primarily from the survey) was available for 148 activities. This constituted the final number of activities or records for inclusion in the performance analysis. In order to identify additional significant factors a sample of 500 or more activities would have been necessary, depending on the factors under consideration.

High Variability in Dependent Variable - There was extremely high variability in the dependent variable which is the ratio of program impact (energy savings) to funding. The highest value is over 200,000 times larger than the lowest value of the dependent variable used in this analysis. This variability is likely related to the fact that the grant activities studied are spread across all six BPAs involving both direct installation of measures (where high levels of energy savings would be expected) as well as indirect activities that are associated with low levels of savings (due to being focused primarily on education or training, for example). Therefore the range of energy savings achieved per dollar spent had a high level of variability, confounding the detection of other non-savings related variables. Had the study been restricted to a large number of activities sampled within one BPA, where the type of projects were more homogeneous, variability may well have been lower, and organizational and operational factor related to performance might have been more easily detected.

Missing Values in Independent Variables – The study team considered a wide range of potential operational and organizational factors that might influence program performance, informed by a literature review that resulted in the design of a series of survey questions posed to grant managers. The original study design included a separate survey exclusively for the purpose of gathering performance-related data for this analysis. Subsequent changes to the evaluation design, necessitated by a lack of impact related data on the grants, shifted the data collection approach to a two-staged survey process, with a telephone survey (Computer Aided Telephone Interviews or CATI) and an on-line survey. The CATI survey accommodated a smaller number of operational and organizational-related questions, while the on-line survey was devoted exclusively to collecting data necessary for impact evaluation. The CATI survey resulted in a significant number of missing values to the questions posed. The combination of a high number of missing values for the smaller number of variables sought limited the data available for the performance factors analysis.

4.4. Detailed Results

4.4.1. Multivariate regression model with BPAs included

Five iterations of the regression model with BPA categories included as independent variables were performed before arriving at a satisfactory result, where the number of explanatory variables is well balanced with the number of observations (EECBG activities) remaining in the model. The resulting model, where the final set of observations or activities included complete data for all the independent variables of interest, contained 148 observations or activities where the dependent variable of performance (defined as energy savings per dollar spent) is explained by 13 variables.

The following table summarizes the independent variables or performance factors that appear to have had a significant effect on the dependent variable – the amount of energy savings achieved per grant dollar - in the final regression model.

Table 4-1: Summary of Results of Operational Factors Regression Analysis

	Relative Impact	Variable/Definition	Interpretation
1	**High +**	Financial incentives BPA	Activities that included some type of financing or financial incentive appear to have a strong positive impact on performance, the highest level of explanation of all variables considered
2	**High +**	Lighting BPA	Similarly, those activities in the category of exterior or street lighting had a positive relationship to grant performance
3	**Medium +**	Buildings and Facilities BPA	This BPA categorization had a moderate positive relationship to grant performance
4	**Medium +**	Energy Efficient Retrofits BPA	This BPA categorization had a moderate positive relationship to grant performance
5	**Low +**	EE Conservation Strategy BPA	A marginal but positive impact on grant performance
6	**Low +**	Direct grant	Whether an activity was from a direct rather than an indirect grant appears to have had a low but positive impact on grant performance
7	**Low +**	Assistance entering into performance contract	A marginal but positive impact on grant performance
8	**Low +**	High ACEEE energy efficiency score	A marginal but positive impact on grant performance
9	**Negligible**	Technical training received	This variable appears to have a negligible impact on grant performance
10	**Negligible**	Technical energy audit conducted	This variable appears to have a negligible impact on grant performance
11	**Negligible -**	Financial or technical support programs from other sponsors (utilities, etc.)	This variable appears to have a negligible negative impact on grant performance
12	**Negligible -**	Audit or tech assistance in identifying opportunities	This variable appears to have a negligible negative impact on grant performance
13	**Negligible -**	High level of community support	This variable appears to have a negligible negative impact on grant performance

Table 4-2 displays the parameter estimates of the final regression model.

The key conclusions are:

- The categories of BPA in which the grant activities were assigned rise to the top as the most significant variables or predictors of performance. Within these, financial incentives and lighting have a relatively high positive impact on the ratio of net savings to funding.

- The next two BPA categories, buildings and facilities and energy efficiency retrofits, have a moderate impact on the outcome variable.

- The remaining variables that appear to have a positive but low impact on energy savings per dollar spent are the BPA energy efficiency conservation strategy, purchase of renewable technology, direct grant type, assistance entering into a performance contract, and ACEEE's energy efficiency score average.

Table 4-2: Parameter estimates of the final regression model (BPAs included)

	Estimated Regression Coefficients					Each 1-unit increase in X multiplies the expected value of Y by e^β
Variable	**Label**	**Estimate**	**Standard Error**	**t Value**	**Pr > |t|**	**Exp(beta) -1**
INTERCEPT[78]		3.37	0.17	19.86	<.0001	
FININCBPA	BPA = Financial Incentive	2.43	0.21	11.32	<.0001	10.3
LIGHTINGBPA	BPA = Lighting	2.26	0.23	9.99	<.0001	8.5
BLDGFACBPA	BPA=Buildings and Facilities	1.96	0.14	13.83	<.0001	6.1
EERETROBPA	BPA=EE Retrofits	1.85	0.20	9.19	<.0001	5.4
EECONSERVEBPA	BPA =EE Conservation Strategy	0.70	0.05	15.43	<.0001	1.0
DIRECT	Direct/Indirect	0.58	0.28	2.10	0.04	0.8
VB1_5	Assistance in entering into performance contracts	0.55	0.09	6.09	<.0001	0.7
ACEEE	ACEEE state EE score 2009-2011 average	0.52	0.18	2.80	0.01	0.7
VB1_9	Technical training	0.30	0.19	1.63	0.11	0.4
AUDIT	Compound binary indicator where audit=1 if any of bp6a--bp6h is a 1, audit= 0 otherwise	0.25	0.19	1.31	0.19	0.3
OP1	Use of financial or technical support programs offered by other sponsors, such as local utilities, industry associations, or government agencies	-0.34	0.19	-1.83	0.07	-0.3
VB1_6	Energy audit or other technical assistance in identifying & characterizing opportunities	-0.36	0.19	-1.90	0.06	-0.3
NVB6C	High level of support from the community	-0.67	0.18	-3.80	0.00	-0.5

[78] The intercept of the model serves to give the model a better fit, rather than forcing the regression line to go through the origin (when x and y-axes are both 0). It is especially important to keep the intercept when it is significant, as it is in this case.

4.4.2. Additional model results

A set of univariate models was constructed to assess the potential explanatory value of each variable independent of the others. Several variables emerged as having statistically significant relationships with program performance, but no single variable explained more than 15% (R-square=.15) of the variability of the dependent variable. The R-square in this case is an indicator of the amount of variability in the dependent variable explained by just the one factor under consideration. Similar to the multivariate regression model, the top three variables with explanatory value were BPA categories. We also found that the number of cooling degree days, the use of energy audits, and a high level of support from local utilities were positively related to program performance and that each of those factors, by itself, explained between 7 and 8% of the total variance in the dependent variable.

The full tables of statistical results for all regressions are provided in Appendix L.

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