NATIONAL EVALUATION OF THE STATE ENERGY PROGRAM: AN EVALUATION OF SELECT ACTIVITIES CONDUCTED UNDER THE STATE ENERGY PROGRAM

VOLUME I: MAIN REPORT

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List of Acronyms

ARRA	American Recovery and Reinvestment Act of 2009; in this report, ARRA refers specifically to the Department of Energy's State Energy Program ARRA funding
BPAC	Broad Program Area Category
CATI	Computer-Assisted Telephone Interviews
CGE	Computable General Equilibrium
DOE	Department of Energy
EPAct	Energy Policy Act
FOA	Funding Opportunity Announcement
GREET	Greenhouse Gases, Regulated Emissions, and Energy use in Transportation
ICP	Institutional Conservation Program
IDI	In-Depth Interview
I-O	Input-output
MMBtu	Million British thermal units
MMTCE	Million metric tons of carbon equivalent
NASEO	National Association of State Energy Officials
PA	Programmatic activity
PV	Present value
PY	Program year
RAC	Recovery Act Cost
REMI	Regional Economic Models, Inc.
SCT	Standard Calculation Tool
SECP	State Energy Conservation Program
SEO	State Energy Office
SEP	State Energy Program
SOW	Statement of work
WIPO	Weatherization and Intergovernmental Programs Office

1 EXECUTIVE SUMMARY

This document presents findings from an evaluation of the State Energy Program (SEP), a national program operated by the United States (U.S.) Department of Energy (DOE) that provides grants and technical assistance to the states and territories to support a wide variety of energy efficiency and renewable energy activities.

Congress created DOE's State Energy Program in 1996 by merging the State Energy Conservation Program (SECP) and the Institutional Conservation Program (ICP), both of which had been in existence since 1975. The mission of SEP is to provide leadership to maximize the benefits of energy efficiency and renewable energy through communications and outreach activities, technology deployment, and by providing access to new partnerships and resources. Working with DOE, state energy offices address long-term national goals to:

- "Increase energy efficiency in the U.S. energy economy,
- Reduce energy costs,
- Improve the reliability of electricity, fuel, and energy services delivery,
- Develop alternative and renewable energy resources,
- Promote economic growth with improved environmental quality, and
- Reduce reliance on imported oil."[1]

DOE's Weatherization and Intergovernmental Programs Office (WIPO), which manages SEP, commissioned this evaluation. The evaluation's principal objective is to develop independent estimates of key program outcomes and metrics, as shown in **Table ES-1**.

All impacts reported are SEP-attributable impacts, meaning they are the impacts that occurred as a result of SEP funding. The energy impact outcomes, energy savings and renewable generation, are inventoried in source Million British thermal units (MMBtu)[2,3] and are presented by year through 2050 and by sector (residential, commercial, industrial,[4] public institutional and private institutional). The avoided carbon emissions outcome is then calculated by applying carbon emission rates to the verified SEP-attributable energy impacts.[5] A second carbon emissions metric, avoided social costs of carbon, considers the monetary impact associated with carbon emissions as defined in Executive Order 12866.[6]

Two cost effectiveness indicators are reported. The first, SEP Recovery Act Cost (RAC) test, was established by DOE to benchmark annual energy savings cost effectiveness,[7] wherein any ratio above 10 of MMBtu of source energy saved per year, per $1,000 of program expenditures can be considered cost-effective. SEP RAC test results are presented from a building perspective, which evaluates cost

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[1] Program goals are outlined on DOE's Office of Energy Efficiency and Renewable Energy website at http://energy.gov/eere/wipo/about-state-energy-program.

[2] This means that energy savings and renewable generation at a consumer site is converted to the equivalent amount of raw fuel consumed at the fuel source. To account for power plant efficiency and losses resulting from the transmission and distribution line losses, the amount of energy saved at the source is greater than the energy saved at the site.

[3] ENERGY STAR Performance Rating Methodology for Incorporating Source Energy Use, March 2011, http://www.energystar.gov/ia/business/evaluate_performance/site_source.pdf. (accessed: October 1, 2014).

[4] The industrial sector includes manufacturing, mining, construction, agriculture, and, for the purpose of this report, electric and gas utilities.

[5] For renewable generation, avoided carbon emissions are calculated using the energy displaced from renewable generation.

[6] U.S. Interagency Working Group on Social Cost of Carbon, *Technical Support Document:Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*, May 2013. http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf.

[7] "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).

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.[8] The present value ratio compares the present value of participant energy bill savings attributed to SEP against the present value of program expenditures, where 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 is greater than the lifetime value of the energy bill savings resulting from SEP program activity.[9,10]

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 (job-years)[11] created • Total employment impact 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
Bill Savings and Cost-Effectiveness	• Annual and cumulative dollar savings by sector • SEP Recovery Act Cost (RAC) test ratio of annual energy savings or renewable generation to program expenditures at the system and building level • Lifetime present value (PV) ratio of dollar savings to program costs

This evaluation effort covered two separate program periods. The contractor team examined key program outcomes for both the SEP 2008 program year (July 2008 to June 2009) and for the American Reinvestment and Recovery Act (ARRA) period (2009 to 2013). SEP received $3.1 billion of the ARRA funds, which were obligated to states from 2009 to early 2011. SEP funding in Program Year 2008 (PY 2008) was $33 million. This evaluation focused on the future streams of impacts from only the PY 2008 and ARRA-periods, and did not address actions taken in subsequent program years.

There are three key concepts by which the evaluation effort was organized and implemented. They are programmatic activities (PA), Broad Program Area Categories (BPAC), and BPAC subcategories. The study reports findings at the BPAC level.

- **Programmatic Activities (PAs):** PAs in this evaluation are often equivalent to state designated programs, though some state programs are subdivided into two or more PAs for evaluation purposes. PAs are designed and carried out by the states with SEP financial support

8 The substantive distinction between the SEP 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.

9 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. 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.

10 The present value ratio only accounts for SEP expenditures; it does not account for other potential costs, such as costs borne by the participant or other program costs.

11 A job-year is defined as one job in one year, as distinguished from a full-time equivalent, which represents a full-time job over one year.

and involve a number of related activities carried out under a common administrative framework (e.g., energy audits executed, retrofits performed, or grants awarded).

- **Broad Program Area Categories (BPACs):** BPACs are classifications developed by ORNL to categorize PAs for evaluation purposes. PAs in the same BPAC (e.g., Building Retrofits or Clean Energy Policy Support) tend to have similar program delivery mechanisms and similar types of energy saving projects.

- **BPAC Subcategories**: In some cases, grouping PAs for impact evaluation necessitated the use of subcategories within BPACs. BPAC subcategories have similar market sectors or energy savings mechanisms, and thus the PAs in these subcategories can be evaluated with the same impact estimation tools. For example, Non-residential Retrofits and Residential Retrofits are Subcategories within the Building Retrofits BPAC.

The BPACs evaluated in this study are as follows:

- **Clean Energy Policy Support (PY 2008):** The Clean Energy Policy Support BPAC encompasses programmatic activities intended to educate state legislators, administration officials, and regulators on policies to facilitate energy efficiency and renewable energy projects. Examples might include statewide zoning laws, feed-in tariffs, favorable back-up tariffs, and renewable portfolio standards.

- **Building Retrofits (PY 2008 and ARRA-period):** The Building Retrofits BPAC encompasses programmatic activities that provide financial support for building retrofit and equipment replacement projects identified by States. The Building Retrofits BPAC does not include installation of renewable energy equipment and thus has no renewable generation impact. The nature of the activities carried out during PY 2008 and the ARRA period differed substantially, with the dramatic increase in funding under ARRA allowing the states to support larger projects and cover a greater share of total costs.

- **Loans, Grants, and Incentives (PY 2008 and ARRA-period):** The Loans, Grants, and Incentives BPAC encompasses programmatic activities intended to provide financial support for wide variety of energy efficiency and renewable energy projects proposed by recipients across all sectors. The ARRA-period Loans, Grants, and Incentives BPAC contained many renewable energy programs and has both energy savings and renewable generation impacts. The PY 2008 BPAC did not have any renewable generation impacts during the study period. It also differed from its ARRA period

> In contrast with ARRA, PY 2008 PAs were much smaller projects, which had to leverage outside funding to match SEP dollars. Two BPACs, Building Retrofits, and Loans, Grants, and Incentives were evaluated in both PY 2008 and ARRA.
>
> Individual Building Retrofit PAs received substantially less SEP funding and more support from other sources in PY 2008 than under ARRA. PY 2008 also included workshops and training.
>
> For Loans, Grants, and Incentives, PY 2008 included more programmatic activities that focused on carbon reduction, especially in the transportation and alternative fuel areas, where energy savings were lower than those achieved by other types of activities.

counterpart because it included more programmatic activities that focused on carbon reductions, especially in the area of transportation and alternative fuels, where energy savings were lower than those achieved by other types of activities.

- **Technical Assistance (PY 2008):** The Technical Assistance BPAC encompasses programmatic activities that aim to provide hands-on support or other assistance for energy efficiency and renewable energy projects across multiple sectors. These projects are open to commercial, industrial, and agricultural facility owners. Types of projects include technical studies and/or audits leading to efficiency upgrades, or support contracts. The focus of this BPAC was on savings from energy efficiency; however, some renewable generation also occurred as a result of activities in this BPAC.

- **Building Codes and Standards (ARRA-period):** The Building Codes and Standards BPAC encompasses programmatic activities designed to provide technical and administrative support for development of energy-efficient building codes and for training and technical services to strengthen code enforcement. The Building Codes and Standards BPAC did not have any renewable generation impacts.

- **Renewable Energy Market Development (ARRA-period):** Develop or expand existing manufacturing capacity for renewable energy equipment and components and support development of specific renewable energy facilities. This BPAC focuses on support of renewable energy facilities and renewable energy manufacturing. The goal of this BPAC is renewable generation; however, a relatively small amount of energy savings also exist in this BPAC because some renewable technologies (i.e. solar thermal , geothermal, and some biomass) reduce energy use over existing technologies (i.e. electric water heating or natural gas space heating).

1.1 Guidance on interpreting the findings in this report

This study is based on a complex sample design and the data were aggregated to the BPAC level using sample weights created from a multi-phased weighting process. When reviewing the findings, the following should be noted.

- Estimates are derived from a probabilistically selected sample of PAs and are therefore, like all sampling approaches, 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 K of the main report. The sampling error for some statistics (presented in the form of a margin of error in Appendix K) can be large due to the small sample size and high degree of between-PA variability in the data used to derive an estimate.
- Estimates are summarized by BPAC and program year (PY 2008 and ARRA-period). BPAC estimates reflect a target population that omitted smaller PAs (based on a minimum PA funding threshold) and excluded all PAs in specific smaller subcategories (based on total program funding). Therefore, BPAC estimates in this report reflect only the proportion of each BPAC that belong to the study's target population and reflect a high proportion of—but not all—funding associated with a BPAC in any program year.
- 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 PAs.
    - "*" indicates that the estimate exhibits low precision. An estimate is considered to have low precision if its estimated relative standard error is greater than 75% or is based on a sample of fewer than five PAs.
- 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 PAs selected for this study.
- Estimates presented in any table may not sum to the estimates reported in the "Total" row and/or "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 K of the main report.
- Estimates of precision are not presented for the 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 F of the main report.
- Because the BPAC estimates are based on a sample of PAs, the geographic origin of the PAs in the sample frame influences the estimates by BPAC.

1.2 Key findings: PY 2008

In PY 2008, four BPACs were studied: Clean Energy Policy Support; Building Retrofits; Loans, Grants, and Incentives; and Technical Assistance. The cumulative and BPAC-specific impacts for each outcome are presented in this section for the 2008 – 2050 study period.[12] These results can vary substantially across BPACs for many reasons, including program funding levels, program impact objectives (energy savings, renewable generation, or carbon reduction), program delivery mechanism (grant, loan, etc.), the amount of leveraged funding by both the state and the sub-recipient, and a number of other relevant factors.

1.2.1 Energy savings/renewable generation (PY 2008)

Table ES-2 presents cumulative energy savings and renewable generation by sector in source MMBtus for all four BPACs studied for PY 2008. The combined energy impact from PY 2008 activities is 9.7 million source MMBtu for the 2008 to 2050 period.[13]

[12] Annual findings for all outcomes are presented in tables and figures in Chapters 3 and 4 of the main body of this report.

[13] The term "source Btu" refers to the total energy of raw fuel required to produce all heat and electricity used on-site by the ultimate consumer. Source energy includes all production, transmission, and delivery losses for energy that is delivered to a site in the form of heat or electricity rather than as raw fuel. Site to source Btu conversions are based on: http://www.energystar.gov/ia/business/evaluate_performance/site_source.pdf. Date Accessed: October 1, 2014.

Table ES-2: SEP-attributable cumulative energy impacts for PY 2008 activities, by sector (source MMBtu)

	SEP-Attributable Energy Savings 2008-2050	SEP-Attributable Renewable Generation 2008-2050
Residential	644,216	1,078*
Commercial	297,793	220,879*
Industrial	82,005	1,224,318*
Public Institutional	5,876,663	7,780
Private Institutional	1,332,049*	-
Total	**8,232,726**	**1,454,055***

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

As shown in **Table ES-3**, the energy impacts vary by BPAC, with energy savings ranging from 1.2 million source MMBtu for Clean Energy Policy Support to 3.0 million MMBtu for Technical Assistance. Clean Energy Policy Support accounts for nearly all renewable generation impacts.

Table ES-3: SEP-attributable cumulative energy impacts for PY 2008 activities, by BPAC (source MMBtu)

	SEP-Attributable Energy Savings 2008-2050	**SEP-Attributable Renewable Generation 2008-2050**
Clean Energy Policy Support	1,209,203	1,450,175*
Building Retrofits	1,255,910	-
Loans, Grants, and Incentives	2,743,785*	-
Technical Assistance	3,023,828	3,880
Total	**8,232,726**	**1,454,055***

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

1.2.2 Labor impacts (PY 2008)

Labor impacts for the PY 2008 and ARRA-period BPACs are presented in terms of jobs created. 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.[14] 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-4 shows a net total job gain of 2,044 full and part-time jobs for the PY 2008 BPACs studied. This represents approximately $12,347 per job created based on $25.2 million in funding for the evaluated PY 2008 BPACs. The Clean Energy Policy Support BPAC was the source of the largest

[14] See Appendix H of the main report for a high-level description of key REMI model features.

number of positive job impacts—through both the direct short-term jobs as well longer-term jobs and multiplier effects. The Loans, Grants, and Incentives BPAC is the only one that did not show positive job creation from PY 2008. Several factors explain this, but they all center on insufficient bill savings to offset the carrying costs of the programs themselves: (1) this PY 2008 BPAC included alternative fuel development programs which, as intended, reduced carbon emissions impacts but are not typically designed to produce energy bill savings; (2) loan programs during PY 2008 offered interest rates that ranged from below to above market rates, and the higher the interest rate, the more disposable income is eroded from the realized bill savings; and (3) some programs used the loans or incentive funding to bring public sector buildings up to minimum energy efficiency standards, resulting in relatively low energy and bill savings.

Table ES-4: Direct, indirect, and induced jobs created in the U.S. from PY 2008 activities, by BPAC

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Clean Energy Policy Support	418	105	124	95	282	197	1,162	-206	-8	-	2,170
Building Retrofits	23	19	20	19	19	18	100	54	-	-	272
Loans, Grants, and Incentives	25	-29	-33	-36	-40	-46	-377	-431	-7	52	-922
Technical Assistance	205	40	41	39	35	33	145	-9	-4	-	525
Total	**671**	**136**	**153**	**117**	**297**	**202**	**1,029**	**-592**	**-19**	**52**	**2,044**

Note:

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

1.2.3 Avoided carbon emissions and avoided social cost estimates (PY 2008)

Avoided carbon emissions from the PY 2008 BPAC activities are derived from energy savings, energy displaced from renewable generation, and some direct carbon reductions from alternative fuels. Avoided carbon emissions shown in **Table ES-5** total 0.57 million metric tons of carbon equivalent (MMTCE) and are derived mostly from energy savings at 0.44 MMTCE. There are 0.12 MMTCE of avoided carbon emissions from energy displaced from renewable generation and 0.01 MMTCE of direct avoided carbon emissions from alternative fuels.

Table ES-5: Cumulative avoided carbon emissions from PY 2008 activities, by BPAC and program mechanism (MMTCE)

	Avoided Carbon From Energy Savings 2008-2050	Avoided Carbon From Renewable Generation 2008-2050	Avoided Carbon From Alternative Fuels 2008-2050
Clean Energy Policy Support	0.08	0.12	-
Building Retrofits	0.09	-	-
Loans, Grants, and Incentives	0.15	-	0.01
Technical Assistance	0.12	-	-
Total	**0.44**	**0.12**	**0.01**

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.

Similar to energy savings impacts in PY 2008, cumulative avoided carbon emissions are seen to result from all four BPACs, ranging from 0.09 MMTCE for Building Retrofits to 0.21 MMTCE for Clean Energy Policy Support (**Table ES-6**). The majority of avoided carbon emissions occur in the public institutional sector.

Table ES-6: Cumulative avoided carbon emissions from PY 2008 activities, by sector and BPAC (MMTCE)

	Avoided Carbon From Building Retrofits 2008-2050	Avoided Carbon From Clean Energy Policy Support 2008-2050	Avoided Carbon From Loans, Grants, and Incentives 2008-2050	Avoided Carbon From Technical Assistance to Building Owners 2008-2050
Residential	-	0.03	0.01	-
Commercial	-	0.08	-	-
Industrial	-	0.07	-	-
Public Institutional	0.09	0.03	0.14	0.07
Private Institutional	-	-	-	0.05
Transportation	-	-	0.01	-
Total	**0.09**	**0.21**	**0.16**	**0.12**

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.

Avoided social costs from PY 2008 activities total $37.4 million. As shown in **Table ES-7**, energy savings account for the majority of the avoided social costs at $28.3 million. Energy displaced from renewable generation accounts for $8.5 million in avoided social costs and direct carbon accounts for about $602 thousand.

Table ES-7: Cumulative avoided lifetime social costs of carbon from PY 2008 activities, by BPAC and program mechanism (thousands of 2009$)

	Avoided Social Costs From Energy Savings 2008-2050	Avoided Social Costs From Renewable Generation 2008-2050	Avoided Social Costs From Alternative Fuels 2008-2050
Clean Energy Policy Support	$5,015	$8,493	-
Building Retrofits	$5,698	-	-
Loans, Grants, and Incentives	$10,355	-	$602
Technical Assistance	$7,225	$39	-
Total	**$28,294**	**$8,531**	**$602**

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.

The cumulative avoided lifetime social costs of carbon from PY 2008 activities also vary by sector and BPAC as shown in **Table ES-8**. The Building Retrofits BPAC accounts for about $5.7 million in avoided social costs. Clean Energy Policy Support activities are estimated to avoid $13.5 million in social costs, and Loans, Grants, and Incentives avoid about $11.0 million. The Technical Assistance BPAC avoids about $7.3 million in social costs.

Table ES-8: Cumulative avoided lifetime social costs of carbon from PY 2008 activities, by sector and BPAC (thousands of 2009$)

	Avoided Social Costs From Building Retrofits 2008-2050	Avoided Social Costs From Clean Energy Policy Support 2008-2050	Avoided Social Costs From Loans, Grants, and Incentives 2008-2050	Avoided Social Costs From Technical Assistance to Building Owners 2008-2050
Residential	$237	$1,746	$518	-
Commercial	-	$5,177	-	-
Industrial	-	$4,441	-	$236
Public Institutional	$5,461	$2,144	$9,837	$4,046
Private Institutional	-	-	-	$2,982
Transportation	-	-	$602	-
Total	**$5,698**	**$13,508**	**$10,958**	**$7,264**

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.

1.2.4 Bill savings and cost-effectiveness (PY 2008)

This section presents findings on bill savings and cost-effectiveness indicators for the SEP studied activities funded in PY 2008. Bill savings are presented in 2009 dollars and include bill savings from energy efficiency and on-site renewable generation.

The SEP RAC test was established by DOE to benchmark annual energy savings cost effectiveness,[15] wherein any ratio above 10 of MMBtu of source energy saved per year, per $1,000 of program expenditures can be considered cost-effective. SEP 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.[16]

For the PY 2008 BPACs studied, cumulative bill savings total $94.6 million through the year 2050, as shown in **Table ES-9**. Bill savings distribute across different sectors over time, with the majority going to the public institutional sector from electricity savings, followed by the commercial and the private institutional sectors, with relatively fewer bill savings in the residential and industrial sectors.[17]

The SEP RAC test result for the all studied BPACs at the building and system levels are 20.4 and 21.2 respectively, when including the loan dollars extended to participants. This exceeds the SEP ARRA-established benchmark of 10. Without including the loan dollars, the SEP RAC test result is 31.7 at the building level and 32.9 at the system level. These values are a savings weighted average of all four BPACs studied.

[15] "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.

[16] The substantive distinction between the SEP 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.

[17] Customer bill savings related to on-site generation are included in total bill savings for the Clean Energy Policy Support and Technical Assistance BPACS. All on-site renewable generation evaluated in this study is customer-owned and therefore the savings accrue to the customer.

Table ES-9: SEP RAC test result and bill savings for BPACs studied in PY 2008

Metrics	SEP RAC Test Result (Building)	SEP RAC Test Result (System)	Bill Savings ($Thousands)
Clean Energy Policy Support	26.4	30.7	$33,868
Building Retrofits	25.6	25.6	$10,917
Loans, Grants, and Incentives (with loans)	4.5	4.5	$25,420*
Loans, Grants, and Incentives (without loans)	17.6	17.6	$25,420*
Technical Assistance	48.5	48.6	$24,429
Total (with loans)	**20.4**	**21.2**	**$94,634**
Total (without loans)	**31.7**	**32.9**	**$94,634**

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

Under all three discounting scenarios, each studied PY 2008 BPAC produces positive present value ratios, as shown in **Table ES-10**. For all studied PY 2008 BPACs combined (savings weighted), present value ratios range from 2.5 to 3.4 under different discount rate scenarios when including the loan dollars. When excluding the loan dollars, present value ratios range from 3.8 to 5.3.[18]

Table ES-10: Lifetime present value ratio for PY 2008 Studied BPACs

Discount Rate	0.7%	2.7%	4.7%
Clean Energy Policy Support	6.7	5.6	4.7
Building Retrofit	3.0	2.6	2.3
Loans, Grants, and Incentives (with loans)	1.9	1.4	1.1
Loans, Grants, and Incentives (without loans)	7.3	5.6	4.4
Technical Assistance	4.4	4.0	3.6
Total (with loans)	**3.4**	**2.9**	**2.5**
Total (without loans)	**5.3**	**4.5**	**3.8**

The SEP RAC test results and PV ratios for the same BPACs (i.e., Building Retrofits; Loans, Grants, and Incentives) were found to vary from PY 2008 to the ARRA period. For Building Retrofits, the cost-effectiveness numbers were lower under ARRA than in PY 2008. This can largely be explained by differences in the nature of the programs in the two periods, with the ARRA-funded activities often involving larger projects and covering a greater share of total costs. The state leveraging requirement for PY 2008, which did not apply under ARRA, also contributed to the greater SEP-attributable savings per SEP dollar because that state investment would not have occurred in the absence of SEP. For Loans, Grants, and Incentives, the PY 2008 RAC test results and PV ratios are lower than for the ARRA period because PY 2008 included more programmatic activities that focused on carbon reduction, especially in the transportation and alternative fuel areas, where energy savings were lower than those achieved by other types of activities. Cost-effectiveness is calculated by dividing SEP-attributable savings by SEP funding only.

[18] Customer costs associated with switching electricity service for on-site generation technologies are not considered in the PV ratio.

1.3 Key findings: ARRA-period

This section presents the cumulative and BPAC-specific impacts by key outcome for the four ARRA-period BPACs studied in this evaluation: Building Retrofits; Building Codes and Standards; Loans, Grants, and Incentives; and Renewable Energy Market Development. The cumulative impacts for each outcome are presented for the 2009 – 2050 study period.[19] These results can vary substantially across BPACs for many reasons, including program funding levels, program focus (energy savings, renewable generation, or carbon reduction), program delivery mechanism (grant, loan, etc.), leveraged funding by both the state and the sub-recipient, and a number of other relevant factors.

1.3.1 Energy savings/renewable generation (ARRA-period)

Table ES-11 presents energy savings and renewable generation for all four ARRA-period BPACs combined by sector. The combined energy impact from ARRA-period activities is about 2.8 billion source MMBtu for the 2009 to 2050 period.

Table ES-11: SEP-attributable cumulative energy savings and renewable generation for ARRA-period activities by sector (source MMBtu)

	SEP-Attributable Energy Savings 2009-2050	SEP-Attributable Renewable Generation 2009-2050
Residential	288,668,122	2,543,526
Commercial	82,540,084	1,674,207
Industrial	40,181,766	2,069,385,143
Public Institutional	220,324,442	4,638,131
Private Institutional	56,454,685	1,261,710*
Total	**688,169,099**	**2,079,502,716**

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

As shown in **Table ES-12**, energy impacts vary by BPAC, with Building Codes and Standards and Loans, Grants, and Incentives accounting for a much higher proportion of estimated energy savings than the other BPACs. Renewable Energy Market Development accounts for the vast majority of renewable generation impacts in the ARRA-period.

Table ES-12: SEP-attributable cumulative energy impacts for ARRA-period activities, by BPAC (source MMBtu)

	SEP-Attributable Energy Savings, 2009-2050	SEP-Attributable Renewable Generation, 2009-2050
Building Retrofits	89,173,094	-
Building Codes and Standards	326,239,072	-
Loans, Grants, and Incentives	271,650,484	231,622,460
Renewable Energy Market Development	1,106,448*	1,847,880,257*
Total	**688,169,099**	**2,079,502,716**

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

[19] Annual findings for all outcomes are presented in tables and figures in Chapters 3 and 4 of the main body of this report.

1.3.2 Labor impacts (ARRA-period)

As shown below in **Table ES-13**, while timing of the labor impacts for all four BPACs vary, the cumulative total job impacts amount to more than 135 thousand job-years. This represents approximately $13,858 per job created based on $1.9 billion in funding for the evaluated ARRA period BPACs.

Table ES-13: Direct, indirect, and induced jobs created in the U.S. from the ARRA-period activities, by BPAC

	Direct, Indirect, and Induced Jobs (2009-2050)									
	2009	**2010**	**2011**	**2012**	**2013**	**2014-2020**	**2021-2030**	**2031-2040**	**2041-2050**	**Total**
Building Retrofits	2,487	3,356	4,828	3,374	1,853	7,018	1,914	-418	-	24,413
Building Codes and Standards	74	116	56	61	218	11,639	29,392	6,962	-339	48,178
Loans, Grants, and Incentives	1,626	3,129	4,974	3,750	1,868	2,115	-721	1,072	1,438	19,251
Renewable Energy Market Development	1,955	1,651	4,719	6,480	4,571	21,915	2,262	250	-152	43,651
Total	**6,142**	**8,252**	**14,576**	**13,665**	**8,511**	**42,688**	**32,847**	**7,865**	**947**	**135,493**

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

1.3.3 Avoided carbon emissions and avoided social cost estimates (ARRA-period)

Avoided carbon emissions from ARRA-period BPAC activities total approximately 164.1 MMTCE and are derived from energy displaced from renewable generation and energy savings (**Table ES-14**). The majority of the avoided carbon emissions, 121.8 MMTCE, came from energy displaced from renewable generation, followed by 42.4 MMTCE from energy savings.

Table ES-14: Cumulative avoided carbon emissions from ARRA-period activities, by BPAC and program mechanism (MMTCE)

	Avoided Carbon From Energy Savings 2009-2050	**Avoided Carbon From Renewable Generation 2009-2050**
Building Retrofits	5.88	-
Building Codes and Standards	19.40	-
Loans, Grants, and Incentives	17.04	17.78
Renewable Energy Market Development	0.05	104.00
Total	**42.36**	**121.78**

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.

As shown in **Table ES-15**, cumulative avoided carbon emissions vary widely by BPAC with a majority in the industrial sector from Renewable Energy Market Development, followed by the industrial sector emission reductions from Loans, Grants, and Incentives.

Table ES-15: Cumulative avoided carbon emissions from ARRA-period activities, by sector and BPAC (MMTCE)

	Avoided Carbon From Building Retrofits 2009-2050	Avoided Carbon From Building Codes and Standards, 2009-2050	Avoided Carbon From Loans, Grants, and Incentives 2009-2050	Avoided Carbon From Renewable Energy Market Development 2009-2050
Residential	0.05	10.85	7.78	0.04
Commercial	0.00	3.56	1.54	0.06
Industrial	1.31	0.27	17.53	103.30
Public Institutional	4.30	1.70	7.74	0.61
Private Institutional	0.21	3.02	0.23	0.05
Total	**5.88**	**19.40**	**34.82**	**104.05**

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

As shown in **Table ES-16**, total avoided social costs of carbon are about $11.9 billion. Energy displaced from renewable generation accounts for the majority of the avoided social costs at $8.9 billion and energy savings account for $3.1 billion in avoided social costs.

Table ES-16: Cumulative avoided lifetime social costs of carbon from ARRA-period activities, by BPAC and program mechanism (thousands of 2009$)

	Avoided Social Costs From Energy Savings 2009-2050	Avoided Social Costs From Renewable Generation 2009-2050
Building Retrofits	$368,371	-
Building Codes and Standards	$1,420,916	-
Loans, Grants, and Incentives	$1,264,824	$1,259,601
Renewable Energy Market Development	$3,085	$7,594,414
Total	**$3,057,196**	**$8,854,015**

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

The avoided lifetime social costs of carbon from ARRA-period activities also vary by sector as shown in **Table ES-17.**

Table ES-17: **Cumulative avoided lifetime social costs of carbon from ARRA-period activities, by sector and BPAC (thousands of 2009$)**

	Avoided Carbon From Building Retrofits 2009-2050	Avoided Carbon From Building Codes and Standards 2009-2050	Avoided Carbon From Loans, Grants, and Incentives 2009-2050	Avoided Carbon From Renewable Energy Market Development 2009-2050
Residential	$3,201	$795,906	$568,781	$2,439
Commercial	-	$260,250	$121,705	$3,902
Industrial	$83,725	$20,056	$1,238,521	$7,544,675
Public Institutional	$267,571	$124,159	$579,438	$42,888
Private Institutional	$13,874	$220,544	$15,979	$3,595
Total	**$368,371**	**$1,420,916**	**$2,524,425**	**$7,597,499**

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

1.3.4 Bill savings and cost-effectiveness (ARRA-period)

This section presents findings on bill savings and cost-effectiveness indicators for the ARRA-period SEP activities studied. Bill savings are presented in 2009 dollars and include bill savings from energy efficiency and on-site renewable generation, as well as customer bill savings related to utility scale generation. The same two cost-effectiveness indicators are presented in the main report Section 1.3.4 on PY 2008 impacts.

For the ARRA-period, bill savings total $7.8 billion through year 2050. Bill savings are distributed across different sectors over the entire period of analysis, with most coming from the residential sector, followed by the public institutional sector, then the commercial, industrial and private institutional sectors. The majority of bill savings are related to electricity savings.[20]

The SEP RAC test result for all studied ARRA BPACs combined (using a savings weighted average) is 74.9 from the building perspective when the program loan dollars are included, which exceeds the ARRA-period benchmark of 10 by 649%. It is 75.5 from the system perspective. Individually, each of the four BPACs exceeds the SEP RAC test threshold.

Table ES-18: SEP RAC test result and bill savings for BPACs studied in ARRA-period

Metrics	SEP RAC Test Result (Building)	SEP RAC Test Result (System)	Bill Savings ($Thousands)
Building Retrofits	16.7	16.7	$835,684
Building Codes and Standards	1,562.4	1,562.4	$4,018,704
Loans, Grants, and Incentives (with loans)	20.6	21.5	$2,772,906
Loans, Grants, and Incentives (without loans)	35.1	36.6	$2,772,906
Renewable Energy Market Development	227.1	228.1	$130,165*
Total (with loans)	**74.9**	**75.5**	**$7,757,459**
Total (without loans)	**92.0**	**92.8**	**$7,757,459**

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

Under all three discount scenarios, the combined ARRA-period BPACs produce positive present value ratios. Total present value ratios (savings weighted) range from 2.3 to 3.7 under different discount rate scenarios when loans are included. When loans are excluded, present value ratios range from 2.8 to 4.6.[21] While there was a high amount of renewable generation for this BPAC, much of it was in renewable manufacturing at the utility-scale, which does not result in any measurable bill savings.

[20] Customer bill savings related to on-site generation are included in total bill savings for the Loans, Grants, and Incentives and Renewable Energy Market Development BPACS. All on-site renewable generation evaluated in this study is customer-owned and therefore the savings accrue to the customer.

[21] Customer costs associated with switching electricity service for on-site generation technologies are not considered in the PV ratio.

Table ES-19: Lifetime present value ratio for ARRA-period studied BPACs

Discount Rate	0.7%	2.7%	4.7%
Building Retrofits	1.3	1.2	1.1
Building Codes and Standards	333.8	250.3	191.6
Loans, Grants, and Incentives (with loans)	2.9	2.2	1.7
Loans, Grants, and Incentives (without loans)	4.9	3.7	3.0
Renewable Energy Market Development	0.3	0.2	0.2
Total (with loans)	**3.7**	**2.9**	**2.3**
Total (without loans)	**4.6**	**3.5**	**2.8**

The SEP RAC test results and PV ratios for the same BPACs (i.e., Building Retrofits; Loans, Grants, and Incentives) were found to vary from PY 2008 to the ARRA period. For Building Retrofits, the cost-effectiveness numbers were lower under ARRA than in PY 2008. This can largely be explained by differences in the nature of the programs in the two periods, with the ARRA-funded activities often involving larger projects and covering a greater share of total costs. The state leveraging requirement for PY 2008, which did not apply under ARRA, also contributed to the greater SEP-attributable savings per SEP dollar because that state investment would not have occurred in the absence of SEP. For Loans, Grants, and Incentives, the PY 2008 RAC test results and PV ratios are lower than for the ARRA period because PY 2008 included more programmatic activities that focused on carbon reduction, especially in the transportation and alternative fuel areas, where energy savings were lower than those achieved by other types of activities. Cost-effectiveness is calculated by dividing SEP-attributable savings by SEP funding only.

PY 2008 Loans, Grants, and Incentives programs had a strong focus on carbon reduction, especially in the transportation sector. This resulted in lower energy savings than activities in the ARRA Loans, Grants, and Incentives programs, which focused more on renewable energy projects and energy efficiency retrofits.

1.4 Evaluation approach

The U.S. DOE contracted with an independent evaluation contractor (TecMarket Works) to develop a summary evaluation plan to assess the SEP program. That plan was then peer reviewed by a panel of evaluation experts from across the United States, resulting in an approved summary evaluation plan. The approved summary evaluation plan was then used to develop a detailed evaluation plan to guide the approaches used in this study. The basic steps of the study approach are presented in **Figure ES-1**. Additional detail on the study's methods can be found in Volume II of the main report.

The study began with a PA definition stage, wherein PA tracking data was acquired and managed for initial definition of the population of all programs in the evaluation periods. Collected PA data included funding amounts, program administrator contact information, program milestone accomplishment tracking, and comments submitted to the system by state administrators. For PY 2008, this information was gathered from the DOE WinSAGA management system. For the ARRA-period, information was gathered from the PAGE information system.

Using information gathered from DOE systems, the contractor team then classified all PAs according to defined BPACs and BPAC Subcategories. A random sample was designed to include individual PAs from the most heavily funded BPAC/Subcategory combinations, with a target of including at least eighty percent of SEP funding for both the 2008 and ARRA periods. The achieved coverage rate is presented in Tables **ES-20** and **ES-21**.

The evaluation team then entered the State Energy Office (SEO) data collection phase, wherein data was collected from program administrators. When reaching out to these program administrators, the team assessed evaluability of each PA. PAs were considered ineligible if the funding they received did not meet the minimum funding threshold assigned for this study, or if the PA's verified BPAC or Subcategory was not one of the BPAC/Subcategory combinations being studied as part of this evaluation. Other PAs that did not move to the evaluation stage are those that dropped out due to nonresponse.[22] In this data collection phase, the team determined 29 PAs from PY 2008 to be evaluable and found another 52 from the ARRA-period that could be studied (81 in total).

Programmatic Activities (PAs) Definition	•Universe of PAs derived from DOE's WinSAGA (2008) and PAGE (ARRA) information systems
BPACs and Subcategory Classification	•Classification of PAs into BPACs and Subcategories
Stage 1 Sample Design	•Sample design of PAs based on highest-funded BPAC/Subcategories for each program year •Target coverage of 80% of SEP funding for each of 2008 and ARRA periods
SEO Data Collection	•Final sample result of 29 evaluable PAs from 2008 and 52 evaluable PAs from ARRA •Assessment of evaluability of individual PAs
PA Evaluation	•PA-specific data collection, and data preparation for subsequent analyses •SEP-attributable impact estimation for sampled PAs.
BPAC Estimation	•Estimates of energy savings and renewable generation, avoided carbon emissions, bill savings and cost-effectiveness ratios •Regional Economic Models, Inc. (REMI) model for labor impacts

Figure ES-1: Overview of study approach

[22] In addition to those who did not respond to requests about their programs, nonresponse includes PAs where the person knowledgeable about the program was no longer employed at the SEO or sufficient data to evaluate the program no longer existed. Many states experienced staff turnover resulting in a lower verification rate of PA funding dollars due to the time lag between the 2008 program year and this study effort's data collection.

During the PA evaluation phase of the study, the contractor team collected PA-specific data from funding recipients and other program stakeholders for use in calculation of evaluated outcomes. PA evaluation also included calculation of energy savings and renewable generation impacts over the effective useful life[23] of all efficiency measures and renewable technologies, respectively, for all 81 PAs. The methods used for impact evaluation are described in Section 1.4.1.

The final stage of the evaluation was BPAC expansion, wherein key data parameters for the 81 sampled PAs were extrapolated through a sample weighting process to the BPAC/ Subcategory combinations they represent. Energy savings and renewable generation estimates at the BPAC level were derived directly from expansion of the verified PA level findings. Other evaluated outcomes, including avoided carbon emissions, cost effectiveness, and labor impacts, required additional calculation steps at the BPAC level to generate final impacts. The coverage rate shows the proportion of funding that the estimates cover in comparison to the funding in the universe.[24] The coverage rates from PY 2008 are presented in **Table ES-20**. The same information for the ARRA-period is presented in **Table ES-21**. Sample PA counts and coverage rates are presented for all SEP BPACs, for the evaluated BPACs combined, and for each individual studied BPAC. The amount of funding covered by the evaluation in each BPAC does not equal total funding for the entire BPAC; while PA sampling was largely based on the most heavily funded BPAC/Subcategory combinations, not all BPAC/Subcategory combinations were sampled.

- The "All BPACs" coverage rate is the proportion of evaluated funding compared to the total amount of SEP funding in that study period.
- The "Evaluated BPACs" coverage rate is the proportion of evaluated funding compared to the total amount of funding in the study period for all Subcategories within all studied BPACs.
- The individual BPAC coverage rate is the proportion of evaluated funding compared to the total amount of funding in the program year for all Subcategories within that specific BPAC.

Table ES-20: Stage 1 PA sample and coverage rates (PY 2008)

BPAC	Number of PAs Evaluated	Funding Covered by Evaluation	Estimated Funding in Universe File [3]	Evaluation Coverage Rate
2008 - All BPACs [1]	**29**	**$25,236,572**	**$54,695,119**	**46.1%**
2008 - Evaluated BPACs [2]	**29**	**$25,236,572**	**$33,846,622**	**74.6%**
Individual BPAC Coverage for Evaluated BPACs				
Building Retrofits	7	$3,350,548	$7,481,211	44.8%
Clean Energy Policy Support	9	$4,602,280	$4,991,349	92.2%
Loans, Grants, and Incentives	8	$12,045,327	$15,445,552	78.0%
Technical Assistance to Building Owners	5	$5,238,418	$5,928,510	88.4%

[1] Includes BPACs and subcategories not covered by the evaluation.
[2] Includes subcategories within the evaluated BPACs that were not covered by the evaluation and equals the sum of the individual BPACS studied.
[3] Estimate of universe funding includes some movement of funding dollars between BPACs and Subcategories that was collected during the assessment and evaluation of PAs for this survey.

23 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.

24 Estimate of universe funding includes some movement of funding dollars between BPACs and Subcategories based on updated funding information that was collected during the assessment and evaluation of PAs for this survey.

Table ES-21: Stage 1 PA sample and coverage rates (ARRA-period)

BPAC	Number of PAs Evaluated	Funding Covered by Survey	Estimated Funding on Universe File [3]	Evaluation Coverage Rate
ARRA - All BPACs [1]	**52**	**$1,877,700,716**	**$2,438,970,786**	**77.0%**
ARRA - Evaluated BPACs [2]	**52**	**$1,877,700,716**	**$2,129,356,686**	**88.2%**
Individual BPAC Coverage for Evaluated BPACs				
Building Codes and Standards	7	$10,829,590	$12,197,769	88.8%
Building Retrofits	13	$594,973,231	$678,634,183	87.7%
Loans, Grants, and Incentives	26	$847,736,289	$984,210,550	86.1%
Renewable Energy Market Development	6	$424,161,606	$454,314,184	93.4%

[1] Includes BPACs and subcategories not covered by the survey.
[2] Includes subcategories within the evaluated BPACs that were not covered by the evaluation and equals the sum of the individual BPACs studied.
[3] Estimate of universe funding includes some movement of funding dollars between BPACs and Subcategories that was collected during the assessment and evaluation of PAs for this survey.

The overall coverage rate for the ARRA-period was 77.0%; however, the PY 2008 coverage rate is 46.1%. The coverage rates for evaluated BPACs are fairly high for both the ARRA-period (88.2%) and PY 2008 (74.6%). At the individual BPAC level, coverage rates are also fairly high across the board except for PY 2008 Building Retrofits which is related to the relatively lower coverage rate for PY 2008 overall.

There are several reasons for the relatively lower overall coverage rate in PY 2008. Primarily, coverage is driven by response rates of individual states and the ability to verify scope and funding of individual PAs:

- Nonresponse: In addition to those who did not respond to requests about their programs, nonresponse includes PAs where the person knowledgeable about the program was no longer employed at the SEO or sufficient data to evaluate the program no longer existed. Many states experienced staff turnover resulting in a lower verification rate of PA funding dollars due to the time lag between the 2008 program year and this study effort's data collection.

- Funding changes: Verification of where funding dollars went resulted in funding moving from sampled BPAC/subcategory combinations to other BPAC/subcategory combinations outside of the sample. Consequently, the reduced verified funding data—especially from lack of PY 2008 data in the Building Retrofits BPAC—reduced the overall coverage rate in PY 2008.

- Change in BPACs studied: Due to low response rates and lack of data, the PY 2008 Codes and Standards and Renewable Energy Market Development BPACs were removed from our study design in PY 2008, which also reduced the coverage rate.

1.4.1 Overall impact estimation methods

The five Impact Method Groups shown in **Table ES-22** define standard data collection and impact estimation methods that apply to a particular group of PAs based on the Subcategory of the PAs. The table also lists the rigor level designation applied to each Subcategory.[25]

Table ES-22: Impact method groups

Impact Method Group	Evaluation Rigor Level	Number of PAs in Group	Applicable Subcategory	Impact Calculation Method
Retrofits	High	23	Nonresidential Retrofits	Standard Calculation Tool
	High	7	Residential Retrofits	
Renewables	Medium-High	14	Renewable Energy Projects	Standard Renewable Protocol
	Medium-High	7	Renewable Energy Manufacturing	
Technical Assistance / Training	Medium-High	4	Trainings	Standard Calculation Tool or Secondary Research
	Medium-High	7	Technical Assistance	
Codes and Standards	Medium-High	5	Building Code Development Support	Modified PNNL Tool
Other	Medium-High	5	Alternative Fuels and Transportation	ANL GREET Model
	Medium-High	9	Clean Energy Policy Support	Standard Calculation Tool; Standard Renewable Protocol; or Secondary Research
TOTAL		**81**		

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.

Standard Renewable Protocol: Calculation methods were standardized for each of the following renewable technologies, using publicly available tools and methods: biomass combustion systems,[26,27,28,29] photovoltaic systems,[30] solar water heating,[31] and wind systems[32].

[25] As described in Appendix Section C.2, PAs were classified into a "high" rigor and "medium-high" rigor level during the sample frame development process. These categories partitioned the PAs based on the energy savings verification method that would be used during data collection.

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

Modified PNNL Tool: Codes and Standards PA savings impacts were determined using a custom tool built on key components of a similar tool developed by Pacific Northwest National Laboratory (PNNL).[33,34] The approaches of both models are based on the following basic formula, where EUI is energy use intensity (savings per square foot):

$$\text{Total Savings} = (\text{Old Code EUI} - \text{New Code EUI}) \times (\text{Program Compliance} - \text{Baseline Compliance}) \times \text{Construction Activity}$$

ANL GREET Model: The impacts of Alternative Fuels and Transportation PAs were based on Argonne National Lab's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model, specifically the Fleet Footprint Calculator.[35] The calculations also relied on additional research from NREL and EIA to input baseline assumptions.

1.4.2 SEP-attributable estimation methods

Program evaluation methods commonly estimate the extent to which energy impacts can be attributed to the evaluated program rather than some other influence. The SEP-attributable energy savings were estimated from project-level data using a standard approach across all 81 PAs. Evaluation of attribution involved addressing specific research questions related to market actor response, the influence of other programs on the activity in question, and the influence of SEP on other programs. **Table ES-23** shows how each attribution assessment approach was tailored to each BPAC Subcategory to address the basic research questions.

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

[28] 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.

[29] 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.

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

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

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

[33] PNNL. Commercial Compliance using COMcheck. http://www.energycodes.gov/comcheck

[34] PNNL. Residential Compliance using REScheck. http://www.energycodes.gov/rescheck

[35] *GREET Fleet – Carbon and Petroleum Footprint Calculator*. Argonne National Laboratory. https://greet.es.anl.gov/fleet_footprint_calculator (accessed on March 10, 2013)

Table ES-23: Applications of attribution assessment methods to evaluation of PAs by BPAC Subcategory

Research Question/BPAC Subcategory	Participant Self-reports	Structured Expert Judging	Case Studies
Market Actor Response			
Building Retrofit (Residential and Nonresidential)	⦿		○
Renewable Energy Market Development – Projects	⦿		⦿
Renewable Energy Market Development – Manufacturing	⦿	⦿	⦿
Clean Energy Policy Support	⦿		⦿
Technical Assistance and Training (2 subcategories)	⦿		⦿
Codes & Standards		⦿	⦿
Influence of Other Programs			
Building Retrofit (Residential and Nonresidential)	⦿		○
Renewable Energy Market Development – Projects	⦿		⦿
Renewable Energy Market Development – Manufacturing	○	⦿	⦿
Clean Energy Policy Support			⦿
Technical Assistance and Training (2 subcategories)	⦿		⦿
Codes & Standards		⦿	⦿
SEP Influence on Other Programs			
All BPAC Subcategories	○		⦿

⦿ = Primary Attribution Analysis Approach

○= Secondary Attribution Analysis Approach

2 INTRODUCTION

This document presents findings from an evaluation of the State Energy Program (SEP), a national program operated by the U.S. Department of Energy (DOE) that provides financial assistance and technical support to the states and territories for a wide variety of energy efficiency and renewable energy activities. DOE's Weatherization and Intergovernmental Programs Office (WIPO), which manages the State Energy Program, commissioned this independent evaluation. This evaluation's principal objective is to develop independent estimates of the following key program outcomes:

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

2.1 Program description

Congress created DOE's State Energy Program in 1996 by consolidating the State Energy Conservation Program (SECP) and the Institutional Conservation Program (ICP), both of which had been in existence since 1975. SECP provided states with funding for energy efficiency and renewable energy projects. ICP provided hospitals and schools with a technical analysis of their buildings and identified the potential savings from proposed energy conservation measures.

DOE's Office of Energy Efficiency & Renewable Energy outlines the follow pieces of legislation as foundational to the creation of SEP.[36]

- "The Energy Policy and Conservation Act of 1975 (P.L. 94-163) established programs to foster energy conservation in federal buildings and major U.S. industries and also established the State Energy Conservation Program.
- The Energy Conservation and Production Act of 1976 (P.L. 94–385) took the Energy Policy and Conservation Act of 1975 one step further by including incentives for conservation and renewable energy and providing loan guarantees for energy conservation in public and commercial buildings.
- The Warner Amendment of 1983 (P.L. 95-105) allocated oil overcharge funds—called Petroleum Violation Escrow funds—to state energy programs. In 1986, these funds became substantial when the Exxon and Stripper Well settlements added more than $4 billion into the funds.
- The State Energy Efficiency Programs Improvement Act of 1990 (P.L. 101-440) encouraged states to undertake activities designed to improve efficiency and stimulate investment in and use of alternative energy technologies.
- The Energy Policy Act (EPAct) of 1992 (P.L. 102-486) allowed DOE funding to be used to finance revolving funds for energy efficiency improvements in state and local government buildings. (However, no funding was provided for this activity.) EPAct recognized the crucial role states play in regulating energy industries and promoting new energy technologies and also expanded the policy development and technology deployment role for the states. Many EPAct regulations extended through 2000.

In 2009, the American Recovery and Reinvestment Act provided $3.1 billion for SEP formula grants with no matching fund requirements, allowing the program to provide even more leadership and support to states."

[36] *Weatherization and Intergovernmental Programs Office*. U.S. DOE, Office of Energy Efficiency and Renewable Energy. Accessed October 15, 2014. http://www1.eere.energy.go v/wip/sep_history.html.

The State Energy Program is the cornerstone of a larger partnership between DOE and the states. SEP program goals therefore reflect the partnership's long-term strategic goals (**Section 2.1.1**) and each energy office's current year objectives.

2.1.1 SEP program goals

The mission of SEP is to provide leadership through communications and outreach activities, technology deployment, and by providing access to new partnerships and resources to maximize the benefits of increased energy efficiency and renewable energy. Working with DOE, state energy offices address long-term national goals to:

- "Increase energy efficiency in the U.S. energy economy,
- Reduce energy costs,
- Improve the reliability of electricity, fuel, and energy services delivery,
- Develop alternative and renewable energy resources,
- Promote economic growth with improved environmental quality,
- Reduce reliance on imported oil."37

SEP also helps states prepare for natural disasters and improve the security of the energy infrastructure—programs which are not included in the scope of this evaluation. Specifically, SEP helps states meet federal requirements to:

- Prepare an energy emergency plan, and
- Develop individual state energy plans. Each state shares its plan with DOE, sets short-term objectives, and outlines long-term goals.

2.2 Evaluation approach

This evaluation effort covered two separate program periods. The contractor team examined key program outcomes of both the SEP 2008 program year (July 2008 to June 2009) and for the American Reinvestment and Recovery Act (ARRA) period (2009 to 2013). This decision to include program year 2008 was based on early feedback from stakeholders and program staff at DOE to characterize not only the SEP program during the ARRA-period, but also to examine a period with funding amounts that could approximate post-ARRA levels. This evaluation focused only on the impacts associated with the PY 2008 and ARRA-periods, and did not address activities conducted in subsequent program years.

In February 2009, ARRA was signed into law and allocated $36.7 billion to DOE to fund a range of energy-related initiatives, such as energy efficiency, renewable energy, electric grid modernization, carbon capture and storage, transportation efficiency, increased use of alternative fuels, and environmental management. The primary goals for DOE programs funded by ARRA include rapid job creation, job retention, and a reduction in energy use and the associated greenhouse gas emissions; deadlines for fund expenditures were set to ensure that funds were spent within several years. SEP received $3.1 billion of these funds, which were obligated to states from 2009 to early 2011. By way of contrast, SEP funding in Program Year 2008 (PY 2008) was $33 million.

There are three groups by which the evaluation effort was organized and implemented: programmatic activities (PA), Broad Program Area Categories (BPAC), and BPAC subcategories.

[37] Program goals are outlined on DOE's Office of Energy Efficiency and Renewable Energy website at http://energy.gov/eere/wipo/about-state-energy-program.

2.2.1 Programmatic activities

Programmatic activities (PAs) in this evaluation are often equivalent to state designated programs, though some state programs are subdivided into two or more PAs for evaluation purposes. Programmatic activities are designed and carried out by the states with SEP financial support and involve a number of activities (e.g., energy audits executed, retrofits performed, or grants awarded). While it is not unusual for evaluators to refer to a related set of activities (e.g., multiple energy audits) performed in a single year under a common administrative framework as a "program," such efforts are referred to in this document as "PAs. In some cases, they combine a number of different types of activities designed to advance the program's objectives. For example: energy audits may be combined with financial incentives such as loans or grants to promote energy efficiency measures in targeted buildings. To be eligible for this evaluation, an activity must be included in the State Plan submitted to SEP and be supported in part by SEP funds.

2.2.2 Broad program area categories

BPACs are classifications developed by ORNL to categorize PAs for evaluation purposes. PAs in the same BPAC tend to have similar program delivery mechanisms and similar types of energy savings projects. The Statement of Work (SOW) for this study provided the following BPACs based on past SEP evaluation research and the metric categories provided in the Funding Opportunity Announcement (FOA) for the SEP grants under ARRA. Those original sixteen BPACs specified in the SOW are as follows:

- Retrofits
- Renewable Energy Market Development
- Loans, Grants, and Incentives
- Workshops, Education, and Training
- Building Codes and Standards
- Industrial Retrofit Support
- Clean Energy Policy Support
- Traffic Signals and Controls
- Carpools and Vanpools
- Technical Assistance to Building Owners
- Commercial, Industrial, and Agricultural Audits
- Residential Energy Audits
- Government and Institutional Procurement
- Energy Efficiency Rating and Labeling
- Tax Incentives and Credits
- New Construction and Design

As the first key step, the contractor team members worked collaboratively with key study authors of past SEP evaluation research to develop standards and decision rules for sorting and verifying PAs by BPAC. Since many of the BPAC descriptions provided in the FOA are similar to the SOW, contractor staff reviewed the FOA to ensure that the standards used by the States to classify the programmatic activities were consistent with the FOA's intent. The contractor team then established a set of distinguishing attributes for the BPACs based on the information obtained from SEP researchers and the FOA language to ensure consistency in assignment across the team. The full set of BPACs is described in more detail in Appendix A.

2.2.3 BPAC subcategories

In some cases grouping PAs for impact evaluation necessitated the use of subcategories within BPACs. BPAC subcategories have similar market segments or energy savings mechanisms, and thus the PAs in these subcategories can be evaluated with the same impact estimation tools. For example, Non-residential

Retrofits and Residential Retrofits are Subcategories within the Building Retrofits BPAC. Additionally, DOE directed the contractor team to bundle PAs relating to the Workshops, Education and Training (WET) BPAC into the remaining BPACs, removing the WET-related PAs as a BPAC altogether. The BPAC Subcategories are described in more detail in Appendix A.

2.3 Evaluation objectives

The overall objective of this evaluation is to develop independent, quantitative estimates of key program outcomes for those BPACs and subcategories that represent the largest portion of the PY 2008/ARRA-period funding stream for each period of study. All BPAC-level impacts reported are SEP-attributable impacts, meaning they are the impacts that occurred as a result of SEP funding. The BPACs evaluated in this study, by study period, are as follows:

- Clean Energy Policy Support (PY 2008): The Clean Energy Policy Support BPAC encompasses programmatic activities intended to educate state legislators, administration officials and regulators on policies to facilitate energy efficiency and renewable energy projects. Examples might include statewide zoning laws, feed-in tariffs, favorable back-up tariffs, and renewable portfolio standards.
- Building Retrofits (PY 2008 and ARRA-period): The Building Retrofits BPAC encompasses programmatic activities that provide financial support for building retrofit and equipment replacement projects identified by States. The Building Retrofits BPAC during both study periods did not have any renewable generation impacts.
- Loans, Grants, and Incentives (PY 2008 and ARRA-period): The Loans, Grants, and Incentives BPAC encompasses programmatic activities intended to provide financial support for wide variety of energy efficiency and renewable energy projects proposed by recipients across all sectors. The ARRA-period Loans, Grants, and Incentives BPAC contained many renewable energy programs and has both energy savings and renewable generation impacts. The PY 2008 BPAC did not have any renewable generation impacts during the study period; but it did have transportation projects that focused on avoiding carbon emissions.
- Technical Assistance (PY 2008): The Technical Assistance BPAC encompasses programmatic activities that aim to provide hands-on support or other assistance for energy efficiency and renewable energy projects across multiple sectors. These projects are open to commercial, industrial, and agricultural facility owners. Types of projects include technical studies and/or audits leading to efficiency upgrades or support contracts. The focus of this BPAC was on savings from energy efficiency; however, some renewable generation also occurred as a result of activities in this BPAC.
- Building Codes and Standards (ARRA-period): The Building Codes and Standards BPAC encompasses programmatic activities designed to provide technical and administrative support for development of energy-efficient building codes and for training and technical services to strengthen code enforcement. However, this analysis examines only building codes activities and does not incorporate standards programs because the funding for such programmatic activities fell below the minimums established for evaluability. The Building Codes and Standards BPAC did not have any renewable generation impacts.
- Renewable Energy Market Development (ARRA-period): The Renewable Energy Market Development BPAC encompasses programmatic activities that aim to develop or expand existing manufacturing capacity for renewable energy equipment and components and support development of specific renewable energy facilities. This BPAC focuses on support of renewable energy facilities and renewable energy manufacturing. The goal of this BPAC is renewable generation; however, a relatively small amount of energy savings also exist for this BPAC because some renewable technologies (i.e., solar thermal and geothermal, and some biomass) reduce energy use over existing technologies (i.e., electric water heater, gas heat).

Table 2-1 lists the key metrics estimated for each evaluation outcome examined in this study.

Table 2-1: Key evaluation outcomes and metrics

Outcome	Metric description
Energy Savings	• Annual and cumulative energy savings by fuel, sector and total in source Million British Thermal Units (source MMBtu)
Renewable Generation	• Annual and cumulative renewable generation by fuel, sector and total source MMBtu
Job Creation	• Direct, indirect, and induced jobs (job-years)[38] created • Total employment impact over the life of the program's impacts • Incremental impact by sector
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
Bill Savings and Cost-Effectiveness	• Annual and cumulative dollar savings by sector • SEP Recovery Act Cost (RAC) test ratio of annual energy savings or renewable generation to program expenditures at the system and building level • Lifetime present value (PV) ratio of SEP-attributable dollar savings to SEP expenditures

All impacts reported are SEP-attributable impacts, meaning they are the impacts that occurred as a result of SEP funding. The energy impact outcomes, energy savings and renewable generation, are inventoried in Source MMBtu[39][40] and are presented by year through 2050 and by sector (residential, commercial, industrial[41], public institutional and private institutional). The avoided carbon emissions outcome is then calculated by applying carbon emission rates to the verified SEP-attributable energy impacts. [42] A second carbon emissions metric, avoided social costs of carbon, considers the monetary impact associated with carbon emissions as defined in Executive order 12866.[43]

Two cost effectiveness indicators are reported. The first, SEP Recovery Act Cost (RAC) test, was established by DOE to benchmark annual energy savings cost effectiveness,[44] wherein any ratio above 10 of MMBtu of source energy saved per year, per $1,000 of program expenditures can be considered cost-effective. SEP 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.[45] The present value ratio compares the present value of participant energy bill savings attributed to SEP against the

38 A job-year is defined as one job in one year, as distinguished from a full-time equivalent, which represents a full-time job over one year.

39 This means that energy savings and renewable generation at a consumer site is converted to the equivalent amount of raw fuel consumed at the fuel source. To account for power plant efficiency and losses resulting from the transmission and distribution line losses, the amount of energy saved at the source is greater than the energy saved at the site.

40 ENERGY STAR Performance Rating Methodology for Incorporating Source Energy Use, March 2011. http://www.energystar.gov/ia/business/evaluate_performance/site_source.pdf. (accessed: October 1, 2014).

41 The industrial sector includes manufacturing, mining, construction, agriculture, and, for the purpose of this report, electric and gas utilities.

42 For renewable generation, the avoided carbon emissions are calculated using the energy displaced from renewable generation.

43 U.S. Interagency Working Group on Social Cost of Carbon, *Technical Support Document:Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*, May 2013. http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf.

44 "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.

45 The substantive distinction between the SEP 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.

present value of program expenditures, where 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 is greater than the lifetime value of the energy bill savings resulting from SEP program activity.[46]

Historically, SEP has supported other key outcomes as well. These other outcomes were considered and discussed among the study's sponsors, the contractor team, and stakeholders, but this evaluation effort remains focused on the outcomes above. Electricity demand reductions (kilowatts) are not included in this evaluation because demand reduction is not an SEP program objective, it is specific to electricity and not all fuels, and it is extremely complicated to assess accurately for the purposes of a national evaluation such as SEP.

2.4 Guidance on interpreting the findings in this report

This study is based on a complex sample design and the data were aggregated to the BPAC level using sample weights created from a multi-phased weighting process (summarized in Appendix C). When reviewing the findings presented in the remainder of this report, the following should be noted.

- Estimates are derived from a probabilistically selected sample of PAs and are therefore, like all sampling approaches, 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 K. The sampling error for some statistics (presented in the form of a margin of error in Appendix K) can be large due to the small sample size and high degree of between-PA variability in the data used to derive an estimate.
- Estimates are summarized by BPAC and program year (PY 2008 and ARRA-period). BPAC estimates reflect a target population that omitted smaller PAs (based on a minimum PA funding threshold) and excluded all PAs in specific smaller subcategories (based on total program funding). Therefore, BPAC estimates in this report reflect only the proportion of each BPAC that belong to the study's target population and reflect a high proportion of—but not all—funding associated with a BPAC in any program year.
- 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 PAs.
  - "*" indicates that the estimate exhibits low precision. An estimate is considered to have low precision if its estimated relative standard error is greater than 75% or is based on a sample of fewer than five PAs.
- 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 PAs selected for this study.
- Estimates presented in any table may not sum to the estimates reported in the "Total" row and/or "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 was summarized in Appendix K.

[46] 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.[46] 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.

- Estimates of precision are not presented for the 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 F.
- Because the BPAC estimates are based on a sample of PAs, the geographic origin of the PAs in the sample frame influences the estimates by BPAC.

2.5 Structure of the report

The remainder of this report is organized as follows:

- 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 methodologies from this study are presented in Appendices.
- PY 2008 SEP findings by outcome: For each outcome, the total impacts for PY 2008 are presented, followed by BPAC-specific estimates.
- ARRA-period findings by outcome: Similar to PY 2008, total findings are presented for the ARRA-period, followed by BPAC-specific estimates.
- References: This section lists all references cited in the study.

The appendices are located in three 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. The Appendices found in Volume II are as follows:

Appendix A. Broad Program Area Category and Subcategory Definitions

Appendix B. Summary of Research Planning Activities

Appendix C. Detailed Sampling and Weighting Methodology

Appendix D. Final PA Evaluability Assessment Methodology

Appendix E. Final Data Collection Disposition by Survey Instrument

Appendix F. Detailed BPAC Expansion Methodology

Appendix G . Detailed PA Level Evaluation and Energy Impact Estimation Methodology

Appendix H. Detailed Labor Impact Methodology

Appendix I. Detailed Carbon Impact Methodology

Appendix J. Detailed Bill Savings and Cost-effectiveness Methodology

Volume III contains:

Appendix K. Summary Tables of Detailed Energy Impacts and Customer Bill Savings

Volume IV contains:

Appendix L. All Data Collection Instruments

3 METHODOLOGY

This chapter presents an overview of the evaluation methodology used to achieve the evaluation outcomes described in **Section 2**. This section is organized as follows:

- An overview of the study methods employed
- Classification of PAs
- BPAC components researched
- Sampling selection methodology
- Summary of sample
- PA-level methodologies
- BPAC impact estimation

For a more detailed explanation of the research design and methods, refer to Appendices A-J.

3.1 Overview of study methods

The United States Department of Energy contracted with an independent evaluation contractor (TecMarket Works) to develop a summary evaluation plan to assess the SEP program. That plan was then peer reviewed by a panel of evaluation experts (see Table XYZ for panel members) from across the United States, resulting in an approved summary evaluation plan. The approved summary evaluation plan was then used to develop a detailed evaluation plan to guide the approaches used in this study. The basic steps of the study approach are summarized in **Figure 3-1.** Additional detail on the study's methods can be found in Volume 2. The study began with a PA definition stage, wherein PA tracking data was acquired and managed for initial definition of the population of all programs in the evaluation periods. Collected PA data included funding amounts, program administrator contact information, program milestone accomplishment tracking, and comments submitted to the system by state administrators. For PY 2008, this information was gathered from the DOE WinSAGA management system. For the ARRA-period, information was gathered from the PAGE information system.

Using information gathered from DOE systems, the contractor team then classified all PAs according to defined BPACs and BPAC subcategories. A random sample was designed to include individual PAs from the most heavily-funded BPAC/Subcategory combinations, with a target of including at least eighty percent of SEP funding for both the 2008 and ARRA periods.

The evaluation team then entered the State Energy Office (SEO) data collection phase, wherein data was collected from program administrators. In this phase, the team determined 29 PAs from PY 2008 to be evaluable and found another 52 from the ARRA-period that could be studied (81 in total).During the PA evaluation phase of the study, the contractor team collected PA-specific data from funding recipients and other program stakeholders for use in calculation of evaluated outcomes. PA evaluation also included calculation of energy savings and renewable generation impacts over the effective useful life of all efficiency measures and renewable technologies, respectively, for all 81 PAs.

The final stage of the evaluation was BPAC expansion, wherein key data parameters for the 81 sampled PAs, were extrapolated through a sample weighting process to the BPAC/ Subcategory combinations that they represent. Energy savings and renewable generation estimates at the BPAC level were generated directly from expansion of the verified PA level findings. Other evaluated outcomes, including avoided carbon emissions, cost effectiveness, and labor impacts, required additional calculation steps at the BPAC level to generate final impacts.

Programmatic Activities (PAs)	•Universe of PAs derived from WinSAGA (2008) and PAGE (ARRA) information systems
BPACs and Subcategories	•Classification of PAs into BPACs and Subcategories
Sample Design	•Sample design of PAs based on highest-funded BPAC/Subcategories for each program year
SEO Data Collection	•Final sample disposition of 29 evaluable PAs from 2008 and 52 evaluable PAs from ARRA
PA Evaluation	•PA-specific data collection, and data preparation for subsequent analyses •SEP-attributable impact estimation for sampled PAs.
BPAC Estimation	•Estimates of energy savings and renewable generation, avoided carbon emissions, bill savings and cost-effectiveness ratios •Regional Economic Models, Inc. (REMI) model for labor impacts

Figure 3-1: Overview of study approach

3.2 Source of Population Data

For each study period (PY 2008 and ARRA), DOE provided access to systems used by SEOs to track the SEP programs (called Market Titles) including the associated funding amounts and other relevant attributes. The management system maintained by DOE for PY 2008 was called WinSAGA and the information system maintained by DOE for the ARRA-period was PAGE. When defining the universe of PAs to use in this evaluation, each market title in those systems were designated as individual PAs since they conformed to the functional definition of a PA found in **Section 2.2.1**.[47] In some cases, large market titles covered whose activities covered multiple BPAC/Subcategory groups were split into multiple PAs.

3.3 Sampling Selection Methodology

Given the breadth of the PY 2008 and ARRA-period SEP-funded initiatives, evaluation of these activities required a two-stage sampling approach.

- In the first stage, a sample of individual state-level PAs was selected. These PAs were assessed to determine their eligibility for this evaluation. PAs were considered ineligible if the funding they received did not meet the minimum funding threshold assigned for this study, or if the PA's verified BPAC or Subcategory was not one of the BPAC/Subcategory combinations being studied as part of

[47] The universe file accounted for all funding distributed to states as part of the PY 2008 and ARRA-period programs.

this evaluation. Other PAs that didn’t move to the second stage of sampling are those that dropped out due to nonresponse.[48]

- If a PA was eligible, the next stage of sampling occurred within the PA. This sampling was to select whom to contact to gather specific activities within the PA in order to derive estimates for the principal outcome measures. Sampling done within each PA comprises stage 2 of the design.

The basic steps of the sampling selection methodology are summarized in **Figure 3-2**.

[48] In addition to those who did not respond to requests about their programs, nonresponse includes PAs where the person knowledgeable about the program was no longer employed at the SEO or sufficient data to evaluate the program no longer existed. Many states experienced staff turnover resulting in a lower verification rate of PA funding dollars due to the time lag between the 2008 program year and this study effort’s data collection.

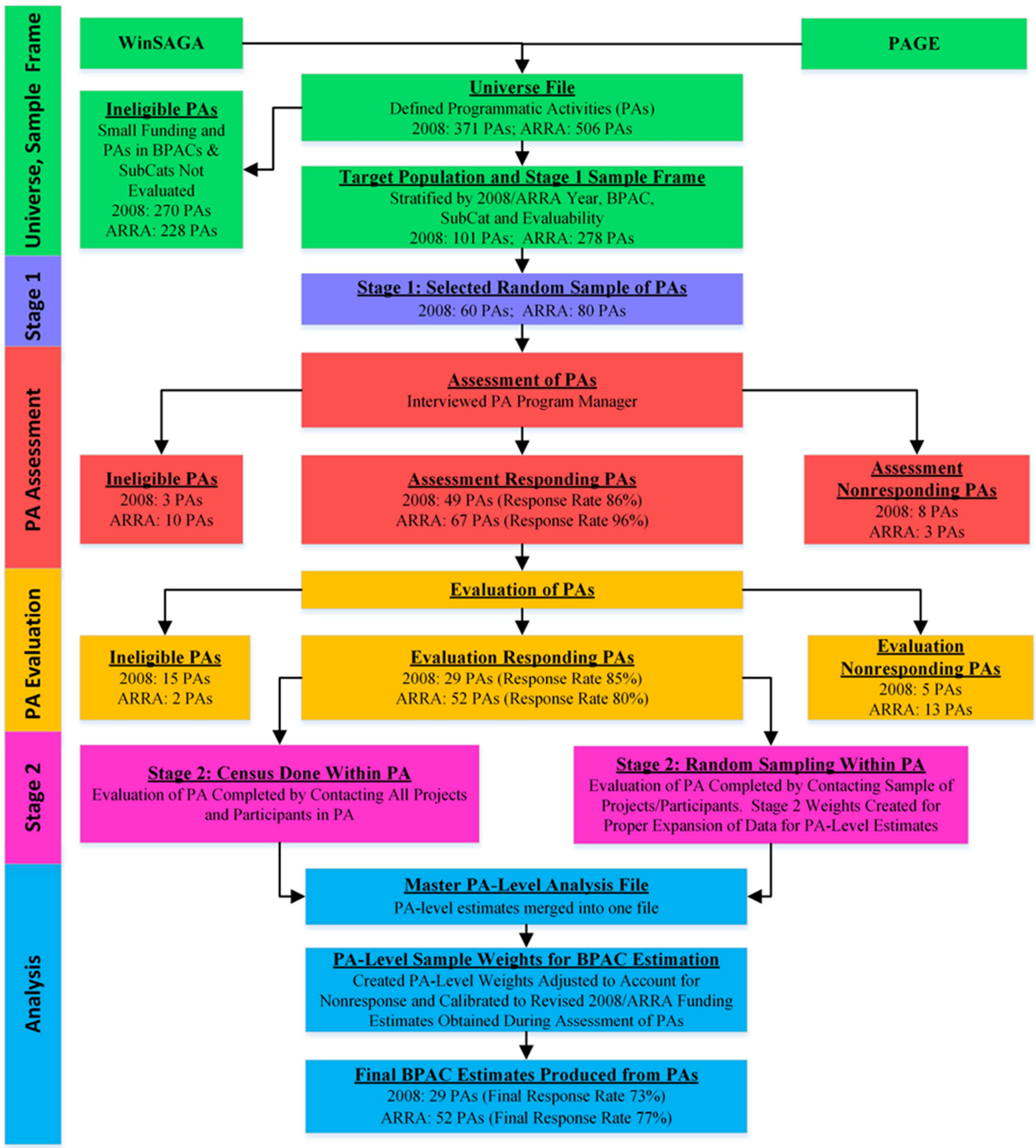

Figure 3-2: Summary of PY 2008/ ARRA-period sample design and analysis process

3.3.1 Determining the universe and sample frame: classification of programmatic activities

This step required a detailed review of the market title data on activities and funding completed to classify them into BPACs and subcategories within BPACs for several purposes:

- To verify that self-reported program categories by each SEO were consistent with working definitions of BPACs and Subcategories (presented in Appendix A);
- To verify the funding levels met the minimum funding targets for the period of study;
- To design an efficient sample stratification49 methodology; and,
- To perform evaluation planning to identify appropriate overall and SEP-attributable impact methodologies.

Completion of this PA classification step included the following tasks:

- Review of WinSAGA and PAGE data;
- Online research of programs and SEO web sites;
- Interviews with DOE Project Officers for each state and Regional Coordinators at the National Association of State Energy Officials (NASEO); and,
- Informal discussions with SEO staff.

Upon completion of this PA classification step, the contractor team identified the target population of PAs to be researched. A detailed summary of universe and sample frame is presented in Appendix C.2.

3.3.2 First stage of sampling: programmatic activities sample selection

Upon DOE's direction, the contractor team focused its evaluation research on the highest funded BPAC/Subcategory combinations. In other cases, BPAC/Subcategory combinations were selected purposely based on policy decisions to include them. For example, the contractor team sampled PAs from the Codes and Standards BPAC and Building Code Development Support Subcategory based on historical information that this BPAC has a potential high impact for relatively less funding than other BPAC/Subcategory combinations.

PAs were sampled within BPAC/ Subcategory combinations. While these combinations represented the large majority of funding within the BPAC, not all Subcategories within the studied BPACs were represented. A detailed summary of the First Stage of Sampling is presented in Appendix C.2.

3.3.3 Results of PA assessment and evaluation: summary of universe, sample, and coverage

The coverage rate shows the proportion of funding that the estimates cover in comparison to the funding in the universe.[50] Stage 1 sample and coverage rates from PY 2008 are presented in **Table 3-1**. The same information for the ARRA-period is presented in **Table 3-2**. Sample PA counts and coverage rates are presented for all SEP BPACs, for the evaluated BPACs combined, and for each individual studied BPAC. The amount of funding covered by the evaluation in each BPAC does not equal total funding for the entire BPAC;

[49] Sample stratification is when the whole population is divided into sub-groups (stratum) and then the sample is pulled from each of those sub-groups, rather than as a whole. This is generally done when we expect that the impacts may vary by sub-group.

[50] Estimate of universe funding includes some movement of funding dollars between BPACs and Subcategories based on updated funding information that was collected during the assessment and evaluation of PAs for this survey.

while PA sampling was largely based on the most heavily funded BPAC/Subcategory combinations, not all BPAC/Subcategory combinations were sampled.

- The "All BPACs" coverage rate is the proportion of evaluated funding compared to the total amount of SEP funding in that study period.
- The "Evaluated BPACs" coverage rate is the proportion of evaluated funding compared to the total amount of funding in the study period for all Subcategories within all studied BPACs.
- The individual BPAC coverage rate is the proportion of evaluated funding compared to the total amount of funding in the program year for all Subcategories within that specific BPAC.

The overall coverage rate for the ARRA-period was 77%; however, the PY 2008 coverage rate is lower at 46.1%. The coverage rates for evaluated BPACs are fairly high for both the ARRA-period (88.2%) and PY 2008 (74.6%). At the individual BPAC level, coverage rates are also fairly high across the board except for PY 2008 Building Retrofits which is related to the relatively lower coverage rate for PY 2008 overall.

Table 3-1: Stage 1 sample and coverage rates (PY 2008)

BPAC	Number of PAs Evaluated	Funding Covered by Evaluation	Estimated Funding in Universe File [3]	Evaluation Coverage Rate
2008 - All BPACs [1]	29	$25,236,572	$54,695,119	46.1%
2008 - Evaluated BPACs [2]	29	$25,236,572	$33,846,622	74.6%
Individual BPAC Coverage for Evaluated BPACs				
Building Retrofits	7	$3,350,548	$7,481,211	44.8%
Clean Energy Policy Support	9	$4,602,280	$4,991,349	92.2%
Loans, Grants, and Incentives	8	$12,045,327	$15,445,552	78.0%
Technical Assistance to Building Owners	5	$5,238,418	$5,928,510	88.4%

[1] Includes BPACs and subcategories not covered by the evaluation.
[2] Includes subcategories within the evaluated BPACs that were not covered by the evaluation and equals the sum of the individual BPACS studied.
[3] Estimate of universe funding includes some movement of funding dollars between BPACs and Subcategories that was collected during the assessment and evaluation of PAs for this survey.

Table 3-2: Stage 1 sample and coverage rates (ARRA-period)

BPAC	Number of PAs Evaluated	Funding Covered by Survey	Estimated Funding on Universe File [3]	Evaluation Coverage Rate
ARRA - All BPACs [1]	52	$1,877,700,716	$2,438,970,786	77.0%
ARRA - Evaluated BPACs [2]	52	$1,877,700,716	$2,129,356,686	88.2%
Individual BPAC Coverage for Evaluated BPACs				
Building Codes and Standards	7	$10,829,590	$12,197,769	88.8%
Building Retrofits	13	$594,973,231	$678,634,183	87.7%
Loans, Grants, and Incentives	26	$847,736,289	$984,210,550	86.1%
Renewable Energy Market Development	6	$424,161,606	$454,314,184	93.4%

[1] Includes BPACs and subcategories not covered by the survey.
[2] Includes subcategories within the evaluated BPACs that were not covered by the evaluation and equals the sum of the individual BPACs studied.
[3] Estimate of universe funding includes some movement of funding dollars between BPACs and Subcategories that was collected during the assessment and evaluation of PAs for this survey.

There are several reasons for the relatively lower overall coverage rate in PY 2008. Primarily, coverage is driven by response rates of individual states and the ability to verify scope and funding of individual PAs:

- Nonresponse: In addition to those who did not respond to requests about their programs, nonresponse includes PAs where the person knowledgeable about the program was no longer employed at the SEO or sufficient data to evaluate the program no longer existed. Many states experienced staff turnover resulting in a lower verification rate of PA funding dollars due to the time lag between the 2008 program year and this study effort's data collection.

- Funding changes: Verification of where funding dollars went resulted in funding moving from sampled BPAC/subcategory combinations to other BPAC/subcategory combinations outside of the sample. Consequently, the reduced verified funding data—especially from lack of PY 2008 data in the Building Retrofits BPAC—reduced the overall coverage rate in PY 2008.
- Change in BPACs studied: Due to low response rates and lack of data, the PY 2008 Codes and Standards and Renewable Energy Market Development BPACs were removed from our study design in PY 2008, which also reduced the coverage rate.

3.3.4 Second stage of sampling: within programmatic activity sample selection

Nearly all of the 81 PAs in this study required sample weighting, primarily to account for nonresponse. Some of the PAs required additional probability-based sampling within the PA to efficiently estimate the desired PA-level parameters. To conduct individual PA evaluations and analyses, a sampling approach was specified for each individual PA using standard survey sampling procedures in order to develop precise, statistically defensible, unbiased estimates of the outcomes of interest for each PA. Most of the sampled PAs had a relatively small number of projects/participants associated with it. In these situations, all projects/participants were contacted so no random sampling was done within the PA. In general, participant nonresponse still occurred in these PAs with a smaller number of projects/participants; in these cases appropriate within-PA sample weights were constructed in order to adequately account for any nonresponse in the estimation process.

In summary, the ultimate objective in stage 2 was to develop estimates of the outcome measures of interest for the PA using scientifically and statistically defensible techniques that were employed to maximize the precision of the within-PA estimates, minimize burden to respondents, and minimize costs associated with collecting the data. A complete description of stage 2 sampling methods is provided in Appendix C.4.

3.4 PA-level methodologies

This section summarizes the contractor team's approach to assessing each PA's evaluability, estimating overall and SEP-attributable impacts, and estimating other key outcomes, such as jobs created, avoided carbon emissions, and energy bill savings.

3.4.1 Evaluability assessment and planning

The contractor team assessed evaluability for all responding PAs and also verified funding and accuracy of BPAC/Subcategory classification during the initial SEO and program manager interviews. In total, the contractor team assessed the evaluability of 143 PAs in order to reach the targeted 81 PAs. To be included in the target of 81 PAs for analysis, a responding PA had to not only be eligible based on various criteria (e.g., minimum funding level and active program status), but also have verified funding, a verified BPAC/Subcategory classification, and sufficient data records for further data collection and analyses. The PA evaluability assessment, data collection, and analysis process is further explained in Appendices D, E, and G.

Upon completion of the evaluability assessment, an evaluation plan was developed for each PA based on the individual program design and the available program data. The evaluation plans for all PAs included the following elements:

- Identify funding amounts per BPAC/Subcategory and subactivity within the PA.
- Program logic models, wherein program inputs, activities, outputs, and outcomes were described to provide clarity on how a program functioned.
- Definition of available program tracking data and intended use, as well as planned methods for resolving data gaps through additional data collection.
- Data collection plan based on impact method group and guidance from the SEP evaluation detailed study plan.
- Stage 2 sample design for participant Computer Assisted Telephone Interviews (CATI) and/or in-depth interviews (IDIs).
- SEP Attribution data collection plan, including Stage 2 sample design for vendor IDIs and interviews of other market actors, as necessary.
- Pre-evaluation review of other program influences.

In addition to the general evaluation plan elements, evaluation plans for high-rigor PAs[51] also included plans for the collection of on-site verification data. On-site visit counts were allocated across retrofit PAs based on funding size. Building site selection for on-site visits within a PA was based on the tracking data quality, distribution of project funding sizes, distribution of expected energy savings across projects, and other determinants, in order to utilize on-site data quotas to most significantly improve the quality of verified impact estimates.

3.4.2 PA-level data collection (stage 2 data collections)

During Stage 2 data collection, the contractor team attempted to reach 8,596 sampled contacts for telephone data collection efforts at the PA level. The contractor team completed 1,422 surveys out of the 8,596 sampled contacts. Additionally, for select building retrofit evaluations, the contractor team conducted on-site verification of measures installed at 56 residential participants' homes and 95 nonresidential participants' sites. A summary by program year and BPAC is presented below (**Table 3-3**) of sample size, the targeted completes of all surveys within the BPAC, ineligibles, non-respondents, and response rate. See Appendix E for detailed response rates by individual survey instrument.

The sample represents the number of contacts sampled from the total population. Completes, ineligibles, and non-respondents are actual dispositions of contacts in the sample and these three columns add up to the sample column. The completes are those who completed the survey, as opposed to those who were found ineligible after being contacted (ineligibles)[52], or those who either refused or could not be reached during survey fielding (non-respondents). The final column provides the final response rate, which is the completes divided by the sample minus the ineligibles Even when the target was not achieved due to high level of nonresponse, we were still able to conduct the analysis for each PA.

[51] As described in Appendix Section C.2, PAs were classified into a "high" rigor and "medium-high" rigor level during the sample frame development process. These categories partitioned the PAs based on the energy savings verification method that would be used during data collection.

[52] An ineligible record include sample points with non-working phone numbers, wrong phone numbers, or when the eligible respondent is no longer available, perhaps because they have moved in the case of residential surveys, or they no longer work there in the case of non-residential surveys.

Table 3-3: Stage 2 sample disposition and response rates

BPAC	Study Period	Number of Projects/Participants				Response Rate
		Sample	Completes	Ineligibles	Non-respondents	
Building Retrofits	PY 2008	509	45	215	249	15%
Clean Energy Policy Support	PY 2008	63	46	0	17	73%
Loans, Grants, and Incentives	PY 2008	233	61	59	113	35%
Technical Assistance	PY 2008	242	43	29	170	20%
Building Retrofits	ARRA	637	357	74	207	63%
Loans, Grants, and Incentives	ARRA	6,230	698	5,115	417	63%
Renewable Energy Market Development	ARRA	248	95	54	97	49%
Codes and Standards	ARRA	415	77	60	278	22%

3.4.3 Overall PA-level energy savings/renewable generation estimation methodologies

The five Impact Method Groups shown in **Table 3-4** define standard data collection and impact estimation methods that apply to a particular group of PAs based on the Subcategory of the PAs. These groups are based on the main activities in each PA and determine the main method used for calculating the impacts of those PAs. The table also lists the rigor level designation applied to each Subcategory.[53]

[53] As described in Section C.2, PAs were classified into a "high" rigor and "medium-high" rigor level during the Stage 1 sample frame development process. These categories partitioned the PAs based on the energy savings verification method that would be used during data collection.

Table 3-4: Impact method groups

Impact Method Group	Evaluation Rigor Level	Number of PAs in Group	Applicable Subcategory	Impact Calculation Method
Retrofits	High	23	Nonresidential Retrofits	Standard Calculation Tool (G.4)
	High	7	Residential Retrofits	
Renewables	Medium-High	14	Renewable Energy Projects	Standard Renewable Protocol (G.5)
	Medium-High	7	Renewable Energy Manufacturing	
Technical Assistance / Training	Medium-High	4	Trainings	Standard Calculation Tool (G.4) or Secondary Research
	Medium-High	7	Technical Assistance	
Codes and Standards	Medium-High	5	Building Code Development Support	Modified PNNL Tool (G.7)
Other	Medium-High	5	Alternative Fuels and Transportation	ANL GREET Model (G.6)
	Medium	9	Clean Energy Policy Support	Standard Calculation Tool (G.4) Standard Renewable Protocol (G.5), or Secondary Research
TOTAL		**81**		

Each of the impact calculation methods shown above are outlined in Appendix Sections G.4 through G.8. Section G.9 outlines the method used to calculate revolving loan impacts, which occurred for PAs across several of the Impact Method Groups. For projects financed by revolving loan funds, the attribution methodology follows building retrofit and renewable technology methods. After estimating SEP-attributable impacts from the first round of financing, the contractor team estimated 20 years of revolved SEP attributable impacts based on verified lending practices of the loan fund (e.g., annual loan offerings, typical loan terms, etc.), the pattern of lifetime savings from the first round, and scaled the revolved impacts to the estimated amount of available loan funds from accumulated principal and interest payments from each round of lending.

3.4.4 SEP-attributable PA impact estimation methodologies

Program evaluation methods commonly estimate the extent to which energy impacts can be attributed to the evaluated program rather than some other influence. The SEP-attributable energy savings were estimated from project-level data using a standard methodology across all 81 PAs. The standard attribution methodology is based on addressing the following three fundamental research questions for each evaluated PA.

- **What would the market actors targeted by the sample PA have done in regard to adopting the PA-supported technology or service in the absence of the program?** This question provides the framework for assessing the attribution of observed changes in key outcomes to the effects of the program. Market actors include energy users as well as firms and individuals in the supply chain for energy using equipment, renewable energy generating equipment, and design, installation, and maintenance services.

- **In instances when two or more programs, including the SEP PA, target the same outcomes in the same domain,**[54] **to what extent are observed outcomes attributable to one program or another?** In many states, energy utility ratepayer funded programs with significantly greater resources targeted some of the same outcomes, particularly in the pre- ARRA- period. Additionally, to leverage its resources, SEP PAs often coordinate explicitly with programs offered by other sponsors which provide additional resources for efficiency and renewable measure adoption. This question takes into account the potential influence of programs and policies other than the ones under evaluation on the outcomes of interest, such as the change in the pace of adoption of the targeted technology.
- **To what extent have SEP PAs influenced the allocation and deployment of resources by other program sponsors in the relevant domains?** A number of studies of SEP activities[55,56] have found that sponsors of ratepayer-funded programs collaborated closely with state energy offices to leverage their own resources, especially with the influx of ARRA funding. This means that, "in the absence of the program," the array of resources available to market actors in the PA would have been reduced not only by the absence of the SEP PA activities, but by a reduction in the level of resources available from other program sponsors. Thus, it was necessary to formulate and test hypotheses regarding the influence of SEP PA activities on the programming decisions of other sponsors in the domain.

Each fundamental attribution research question is listed in **Table 3-5** with the preferred (primary, secondary, and tertiary) attribution assessment method for use with each BPAC Subcategory studied.

Table 3-5: Applications of attribution assessment methods to evaluation of PAs by BPAC subcategories

Research Question/BPAC Subcategory	Participant Self-reports	Structured Expert Judging	Case Studies
Market Actor Response			
Building Retrofit (Residential and Nonresidential)	◉		○
Renewable Energy Market Development – Projects	◉		◉
Renewable Energy Market Development – Manufacturing	◉	◉	◉
Clean Energy Policy Support	◉		◉
Technical Assistance and Training (2 subcategories)	◉		◉
Codes & Standards		◉	◉
Influence of Other Programs			
Building Retrofit (Residential and Nonresidential)	◉		○
Renewable Energy Market Development – Projects	◉		◉
Renewable Energy Market Development – Manufacturing	○	◉	◉
Clean Energy Policy Support			◉
Technical Assistance and Training (2 subcategories)	◉		◉
Codes & Standards		◉	◉
SEP Influence on Other Programs			
All BPAC Subcategories	○		◉

◉ = Primary Attribution Analysis Approach

○= Secondary Attribution Analysis Approach

[54] By "domain" we mean the groups of market actors, regulators, government bodies, and other institutions, and their network of interactions in which the program operates and that it attempts to influence.

[55] TecMarket Works. *The State Energy Program: Building Energy Efficiency and Renewable Energy Capacity in the States*. Oak Ridge National Laboratory, Oak Ridge, Tenn, 2010.

[56] Goldman, Charles A. et al. *Interactions between Energy Efficiency Programs funded under the Recovery Act and Ratepayer-funded Energy Efficiency Programs.* Lawrence Berkeley National Laboratory, Berkeley, Calif., March 2011.

3.4.5 PA-level labor impacts, avoided carbon emissions, bill savings, and cost-effectiveness estimation

The study approach estimated other key outcomes such as labor, avoided carbon emissions, energy bill savings, and cost-effectiveness at the BPAC level rather than the PA level because the BPAC impact estimation process required intermediate calculation steps to apply state-level retail energy unit costs and state-level carbon emissions factors. These models and algorithms are discussed in further detail in Appendices H, I, and J. Estimating labor impacts at the BPAC level required an additional modeling process with the Regional Economic Models, Inc. (REMI) model, described in Appendix H.

To generate these non-energy outcomes at the BPAC level, the contractor team produced the following PA-level data inputs:

- **Energy savings and renewable generation impacts allocated to five sectors: residential, commercial, industrial, public institutional, and private institutional.** After BPAC expansion, these sector-level energy impacts became inputs for estimating bill savings at the state-level which, in turn, is an input for estimating labor impacts and various cost-effectiveness metrics.
- **Administrative costs and incentives that were collected from WinSAGA and PAGE, and verified by the SEOs.** The BPAC estimates of administrative costs and incentives were inputs into the labor impact estimation process.
- **Incremental costs—or the costs paid by the program participant or service recipient to get the efficient technology —and the associated proportions of incremental cost that went to equipment versus labor.** These cost estimates, after BPAC expansion, were inputs into the labor impact estimation process. The methodology and assumptions for estimating PA-level incremental costs is described in Appendix H.
- **Loan amortization schedules, and the associated repeated energy savings and renewable generation impacts of revolving loans over an assumed 20 year period.** The methodology and assumptions for estimating PA-level revolving loan impacts is described in Appendix H.

3.5 BPAC impact estimation

The scope of this evaluation focused on those BPACs and subcategories that represent the largest portion of the PY 2008/ ARRA-period funding stream for each period of study. The estimates in this report were computed using the fully calibrated and non-response adjusted sample weights discussed in Appendix C.5 for the selected subcategories in the eight BPACs evaluated in this study. They do not represent all market titles that were classified in these eight BPACs for the entire population of PAs nor do they represent non-evaluated BPACs. A discussion of the universe file,[57] the study's target population, and BPAC funding coverage associated with this evaluation is provided in Appendix C.

3.5.1 Energy impacts

As stated earlier, the expansion process for estimating energy and bill savings differs from the other impacts: labor, avoided carbon emissions, and cost-effectiveness. Energy savings were expanded directly to a national level, while the PA-level inputs for the latter impacts were first expanded regionally to create intermediate estimates that required further region-specific calculations to present the indicators presented in **Table 2-1**. Because the final BPAC estimates are based on a sample of PAs, the geographic origin of the PAs influences the estimates by BPAC. Consequently, BPAC estimates represent the states in which PAs existed in the sample frame for that particular BPAC for carbon, labor, or bill savings. For example,

[57] The universe file accounted for all funding distributed to states as part of the PY 2008 and ARRA-period programs.

- Carbon estimates are based on state carbon emission factors and driven by allocations of BPAC energy savings and renewable generation by state and U.S. territory.[58,59] Final BPAC estimates of this outcome are presented for all states and U.S. territories. A second carbon emissions metric, avoided social costs of carbon, considers the monetary impact associated with carbon emissions as defined in Executive Order 12866.[60]
- Labor estimates are based on (i) customer-sector net project expenses (after any rebates), (ii) short-term orders related to required equipment and installation services, (iii) short-term program administration expenditures, and (iv) customer bill savings net of any applicable loan repayment. SEP-attributable energy bill savings reflect an allocation of BPAC energy savings and renewable generation valued using average state-level retail rates which are then aggregated into eight sub-national regions (not including rates for the U.S. Territories).[61] Final BPAC estimates on labor exclude U.S. Territories and thus are presented at the U.S. state level only.
- For cost-effectiveness analyses, the dollar savings are based on average state-level retail rates and include the U.S. territories. Final BPAC estimates of this outcome are presented at the U.S.-level only.

Specific BPAC impact estimation methodologies for the labor, carbon, and cost-effectiveness outcomes are summarized below. The models and algorithms are discussed in further detail in Appendices H, I, and J.

3.5.2 Labor impacts

The Regional Economic Models, Inc. (REMI) economic forecasting model used for this study is a dynamic computable general equilibrium model with an input-output transaction model at its core.[62] The REMI model was designated for this evaluation because it can capture lasting net energy reduction (in particular, energy bill savings) 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 a specific industry (designated with a NAICS[63] code) experiences energy (and the associated bill) savings, it becomes a reduction in the cost-of-doing-business. The REMI model includes region-specific and industry-specific output elasticities to respond to these cost changes. This is the basis for assessing market share growth based on being more competitive once adopting some efficient device or system, which supports job growth. Therefore, part of the impacts by BPAC includes these dynamic responses which can work both ways—either in terms of job creation or losses—depending on whether the BPAC evaluated outcomes are negative or positive.

Job impacts occur in response to initial program-related spending within any BPAC (i.e., 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 also some portion of the manufactured equipment that is U.S. made. In the long-term, job impacts also emanate from newly installed systems provided the investment was cost-effective, and those energy efficiency investments deliver energy savings over the life

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58 U.S. state emissions come from E.H. Pechan & Associates, Inc., *The Emissions & Generation Resource Integrated Database for 2010 (eGRID2010) Technical Support Document*, U.S. Environmental Protection Agency, Office of Atmospheric Programs, Clean Air Markets Division, December 2010.

59 U.S. territory emissions come from U.S. Environmental Protection Agency, *GHG Reporting Program Data Sets*, May, 2014. http://www.epa.gov/ghgreporting/ghgdata/reportingdatasets.html. 2010 net electricity generation comes from U.S. Energy Information Administration, *International Energy Statistics*, May 2014. http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=2&aid=12&cid=AQ,GQ,RQ,IQ,US,VQ,&syid=2010&eyid=2010&unit=BKWH.

60 U.S. Interagency Working Group on Social Cost of Carbon, *Technical Support Document:Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*, May 2013. http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf.

61 The REMI model includes eight sub-national regions that reflect the major BEA regions. Each is a multi-state aggregated economy, and does not include U.S. Territories.

62 See Appendix H for a high-level description of key REMI model features.

63 NAICS stands for the North American Industry Classification System. It is a standard code developed by the U.S. Office of Management and Budget and is used to classify business establishments.

of the equipment. For large scale renewable assets that are added as part of SEP activities, data on the difference in the annual operating expenditures of a wind farm compared to a combined cycle plant were not available. These purchasing shifts from conventional generation to renewables are not accounted for in the macroeconomic impact model. Instead, a price benefit for reductions in fuel costs was estimated for each customer sector (as long as the region experienced investments in utility-scale renewable generating assets using SEP funds) which then was included in the 'bill savings' effect. Therefore part of the bill savings result from the customer needing fewer MWhs (or MMBtus) and part of it reflects a lower price per unit consumed as a result of more renewable generation on the grid. This lower price is an income loss to the utility sector. At the same time, persistent future bill savings through energy efficiency or on-site renewable generation for customers implies lower demand for the electric and gas utilities as well as for the supply chain that delivers propane and heating oil.[64]

Over time, there are additional transactions that emerge and multiply from each program's direct job effect. 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 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.

Another mechanism at work in producing this job impact analysis is a set of adjustments which bring the macro-economy back to equilibrium. The adjustments occur among organizations in an industry, 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).

Note that the job impacts to be shown in specific sections of this report are presented at the U.S.-level. The REMI model used was a multi-regional impact forecasting system[65] of the eight major BEA[66] regions. BPAC related information was provided for each region (when a region showed participation in a specific SEP-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 characterized with relative costs (such as labor, housing, capital, energy, taxation, the general cost-of-living, etc..), 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 a ramp up of bill savings (or a large investment of up-front project deployment), and that region already exhibited relatively higher cost characteristics than its neighbor region(s), 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

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64 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.

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

66 These a multi-state aggregate regions defined by the Bureau of Economic Analysis within the U.S. Department of Commerce

characteristics of specific BPAC program 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.

3.5.3 Carbon impacts

Carbon impacts at the BPAC level were calculated by applying the appropriate emission rates to the verified SEP-attributable energy impacts from each BPAC, including displacement from renewable generation. State-level emission rates were applied to electricity savings and conventional electricity displacement from renewable sources since the mix of fuels used to generate electricity varies regionally. 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. The appropriate emission rates were applied to the SEP-attributable energy savings from energy efficiency or energy displaced from renewable generation and aggregated to the BPAC level. A subset of programmatic activities, alternative transportation and some biomass-related PAs, had direct carbon impacts that did not correlate with energy savings or generation in the same way energy efficiency savings do. In these instances, the carbon savings were calculated separately using PA-specific data. Emissions from energy efficiency, energy displaced from renewable generation, and direct carbon impacts were then aggregated to determine the total carbon impact for each BPAC.

This evaluation also considered the monetary impact associated with carbon emissions. The team monetized the carbon impacts associated with SEP-funded programs by using the social cost of carbon (SCC) from the following source for the listed years:

- 2010-2050: Technical Support Document- Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis- Under Executive Order 12866.[67]
- 2008-2009: EERE Standard Impact Evaluation Method - Evaluating Realized Impacts of DOE/EERE R&D Programs.[68,69]

3.5.4 Bill savings and cost-effectiveness

Bill savings are presented in 2009 dollars, and include bill savings from energy efficiency and on-site renewable generation, as well as customer bill savings related to utility-scale generation. For bill savings estimates and cost-effectiveness analyses, the dollar savings are based on average state-level retail rates and include the U.S. territories.

For cost-effectiveness, two indicators are presented in this report: the SEP Recovery Act Cost (RAC) test and the ratio of present value of participant bill savings to present value of program dollars spent. A more detailed discussion of both is provided in Appendix J.

The SEP RAC test result is expressed in SEP-attributable MMBtu of source energy saved or generated per year, per $1,000 of SEP expenditures. A program can be considered cost-effective for any ratio above the

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67 U.S. Interagency Working Group on Social Cost of Carbon, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, May 2013. http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf.

68 Ruegg, Rosalie et al. EERE Standard Impact Evaluation Method: Evaluating Realized Impacts of DOE/EERE R&D Programs, August 2014. http://www1.eere.energy.gov/analysis/pdfs/evaluating_realized_rd_mpacts_9-22-14.pdf

69 The technical support document only provides social cost of carbon values for 2010-2050. Historical SCC values were generated in the 2014 EERE Standard Impact Evaluation Method.

benchmark of 10 set by DOE. Even though the SEP RAC test was developed for ARRA-period programs, it is also used here for PY 2008.

SEP 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 SEP 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.

The present value ratio compares participant bill savings attributed to SEP against SEP expenditures. When the ratio is equal to 1.0, the bill savings attributable to PY 2008 are equal to the program's expenditures. A ratio greater than 1.0 means the lifetime value of the SEP-attributable bill savings is greater than total SEP spending. A negative ratio means that SEP spending is greater than any SEP-attributable energy bill savings resulting from SEP program activity.

Finally, 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 and reported in OMB circular A-94.[70] We also provide results using a range of values from 0.7 percent to 4.7 percent to assess the sensitivity of these results.

[70] Office of Management and Budget. 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.

4 PY 2008 SEP FINDINGS BY OUTCOME

The following sections will present the cumulative and BPAC-specific impacts by key outcome for the four PY 2008 BPACs studied in this evaluation: Clean Energy Policy Support; Building Retrofits; Loans, Grants, and Incentives; and Technical Assistance. The four outcomes presented are as follows, with the Appendices that provide additional methodological detail indicated in parentheses:

- Energy savings/renewable generation (Appendices F and G)
- Labor impacts (Appendix H)
- Avoided carbon emissions and avoided social cost estimates (Appendix I)
- Bill savings and cost-effectiveness (Appendix J)

The impacts are calculated by year through 2050 and by sector (residential, commercial, industrial[71], public institutional and private institutional). All outcomes presented in this chapter (and elsewhere in the body of the report) are attributable to support received from the State Energy Program, meaning they are the impacts that occurred as a result of SEP funding. These "SEP-attributable" impacts are analogous to the "net" impacts discussed in many other evaluations. Overall energy savings and renewable generation, associated with the totality of support provided by SEP and other funding sources, are presented in Appendix K. Those "overall" impacts are analogous to the "gross" impacts discussed in other studies.

> In contrast with ARRA, PY 2008 PAs were much smaller projects, which had to leverage outside funding to match SEP dollars. Two BPACs, Building Retrofits, and Loans, Grants, and Incentives were evaluated in both PY 2008 and ARRA.
>
> Individual Building Retrofit PAs received substantially less SEP funding and more support from other sources in PY 2008 than under ARRA. PY 2008 also included workshops and training.
>
> For Loans, Grants, and Incentives, PY 2008 included more programmatic activities that focused on carbon reduction, especially in the transportation and alternative fuel areas, where energy savings were lower than those achieved by other types of activities.

4.1 Summary of impacts (PY 2008)

4.1.1 Energy savings and renewable generation (PY 2008)

This section addresses energy savings and renewable generation impacts for all four of the PY 2008 BPACs studied in this evaluation. 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. The combined energy impact of the PY 2008 BPACs studied, displayed in **Table 4-1**, is about 9.7 million source MMBtu for the 2008 to 2050 period: 8.2 million MMBtu from energy savings and 1.5 million MMBtu from renewable generation. Energy savings varied by BPAC, from 1.2 million source MMBtu from Clean Energy Policy Support to 3.0 million MMBtu from Technical Assistance. Clean Energy Policy Support accounts for nearly all renewable generation impacts.

[71] The industrial sector includes manufacturing, mining, construction, agriculture, and, for the purpose of this report, electric and gas utilities.

Table 4-1: SEP-attributable cumulative energy impacts for PY 2008 activities, by BPAC (source MMBtu)

	SEP-Attributable Energy Savings 2008-2050	SEP-Attributable Renewable Generation 2008-2050
Clean Energy Policy Support	1,209,203	1,450,175*
Building Retrofits	1,255,910	-
Loans, Grants, and Incentives	2,743,785*	-
Technical Assistance	3,023,828	3,880
Total	**8,232,726**	**1,454,055***

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

4.1.1.1 Energy impacts for all fuel types and sectors combined (PY 2008)

The PY 2008 BPACs studied resulted in cumulative SEP-attributable energy savings of 8.2 million source MMBtu over the 2008 to 2050 study period. **Figure 4-1** shows the SEP-attributable impacts over time. Energy impacts peak in 2012, followed by a steady decline through 2050, the end of the evaluation's study period. The majority of the later impacts occur as a result of revolving loan programs.

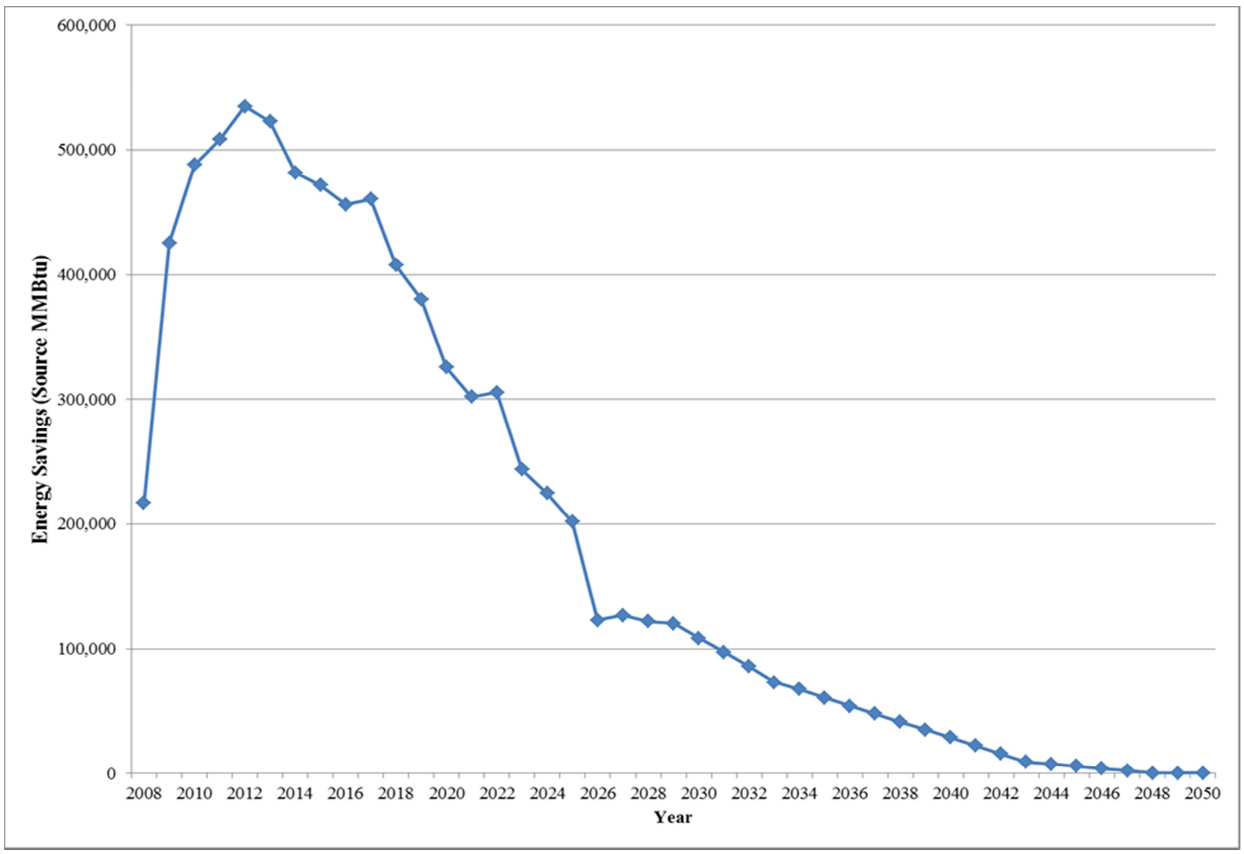

Figure 4-1: SEP-attributable cumulative energy savings for PY 2008 activities in source MMBtu by year

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

The PY 2008 BPACs resulted in an estimated 1.5 million source MMBtu of SEP-attributable renewable generation from 2008 to 2050. **Figure 4-2** shows the impacts during the period of study. Impacts peak in 2012 and 2013 and then drop off gradually until 2035 when they become slightly negative through 2044. In 2044 modeled impacts return to zero as all technologies installed reach the end of their effective useful lives[72]. The negative impacts between 2037 and 2044 are related to two factors:

- The continuation of negative impacts for the 2008 to 2044 period from policies funded by SEP that were reflected in the sample that caused planned renewable energy resources in the pipeline to not be built based on the cost of regulatory compliance from those policies. The overall stream of estimates includes projects with positive impacts and projects with negative impacts. The cumulative impacts are positive, but the negative impacts, which are overshadowed by the positive impacts through 2037, outlast them by a few years, resulting in negative cumulative impacts in the final years.
- The negative renewable generation impacts exist prior to 2037, but other renewable technologies with positive impacts outweigh the negative impacts. As those technologies with positive impacts reach the end of their expected useful life, the negative savings appear more prominently.

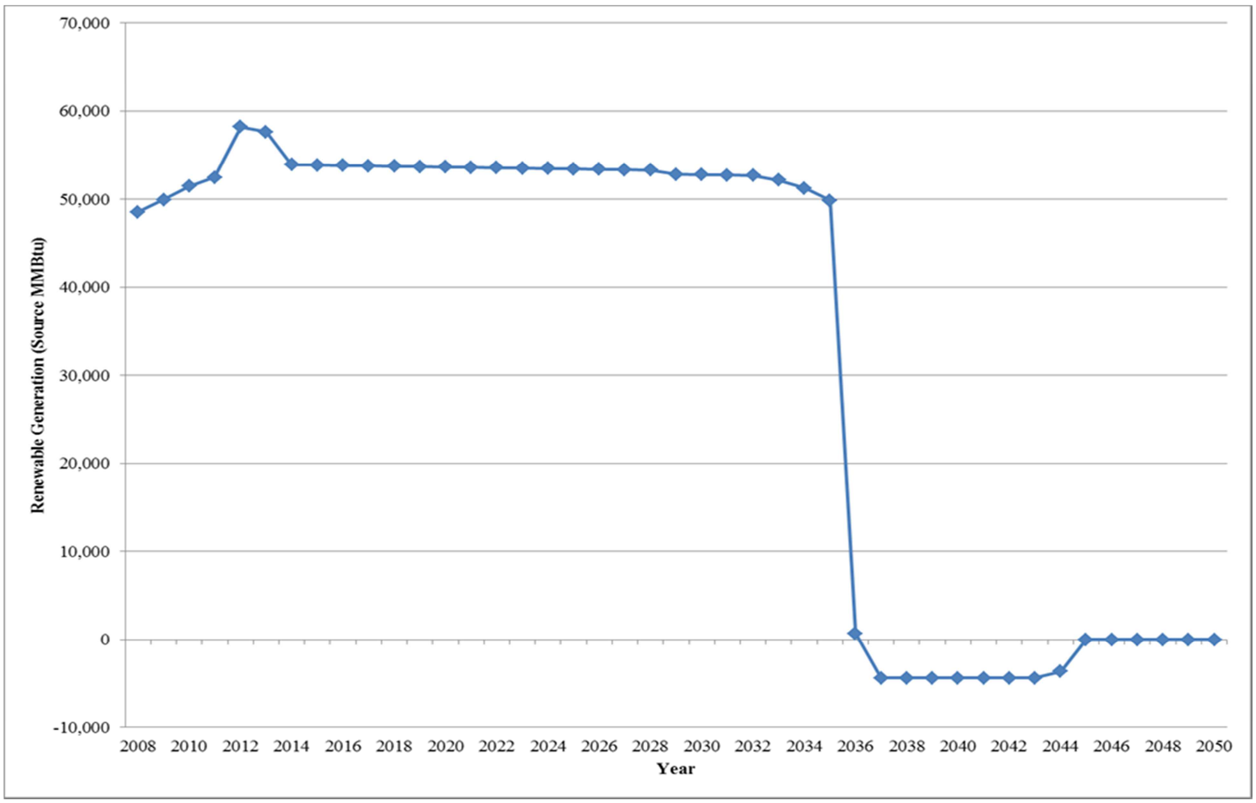

Figure 4-2: SEP-Attributable cumulative renewable generation for PY 2008 activities in source MMBtu by year

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

[72] 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.

4.1.1.2 Energy impacts by fuel type (PY 2008)

Table 4-2 and **Table 4-3** show the cumulative SEP-attributable energy savings and renewable generation over time by fuel type in Source MMBtu for the PY 2008 BPACs. **Table 4-2** shows SEP-attributable energy savings of around 6.3 million source MMBtu of electricity and 1.9 million source MMBtu of natural gas between 2008 and 2050. The PY 2008 BPACs also resulted in SEP-attributable energy savings for gasoline, propane, oil, and wood, among other fuel types.

Table 4-3 shows that the electric renewable generation amounted to around 104,000 source MMBtu during the study period. Generation of digester gas amounted to about 1.4 million source MMBtu.

Table 4-2: SEP-attributable cumulative energy savings for PY 2008 activities over time by fuel type (source MMBtu)

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	138,711	325,508	383,518	393,652	418,729	409,829	2,337,566	1,406,987	410,839*	29,217*	6,254,556
Natural Gas	77,328	98,581	103,035	113,190	114,789	111,705	641,076	470,013	180,612*	38,843*	1,949,171
Oil	-	-	2*	3*	5*	5*	35*	30*	-	-	81*
Propane	-	291	291	291	291	291	1,998	815	-	-	4,268
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	1*	3*	3*	22*	22*	-	-	51*
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	2,790	2,790	2,790	2,790	2,612	2,389	7,143	-	-	-	23,306
Other	-	60	97	94	100	100	637	205*	-	-	1,292
Total	**218,829**	**427,231**	**489,734**	**510,022**	**536,528**	**524,321**	**2,988,47**	**1,878,072**	**591,451***	**68,060***	**8,232,726**

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

Table 4-3: SEP-attributable cumulative renewable generation for PY 2008 activities by fuel type over time (source MMBtu)

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	325*	1,723	3,254*	4,295*	9,987*	9,410*	39,192*	51,314*	1,004*	-16,692*	103,814*
Methane	-	-	-	-	-	-	-	-	-	-	-
Landfill Gas	-	-	-	-	-	-	-	-	-	-	-
Digester Gas	48,223*	48,223*	48,223*	48,223*	48,223*	48,223*	337,560*	482,229*	241,114*	-	1,350,241*
Biodiesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**48,548***	**49,946***	**51,477***	**52,518***	**58,210***	**57,633***	**376,752***	**533,543***	**242,119***	**-16,692***	**1,454,055***

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

4.1.1.3 Energy impacts by sector (PY 2008)

Figure 4-3 displays the SEP-attributable energy savings by sector during the 2008 through 2050 study period. As shown, the greatest amount of energy savings occurred in the public institutional sector.

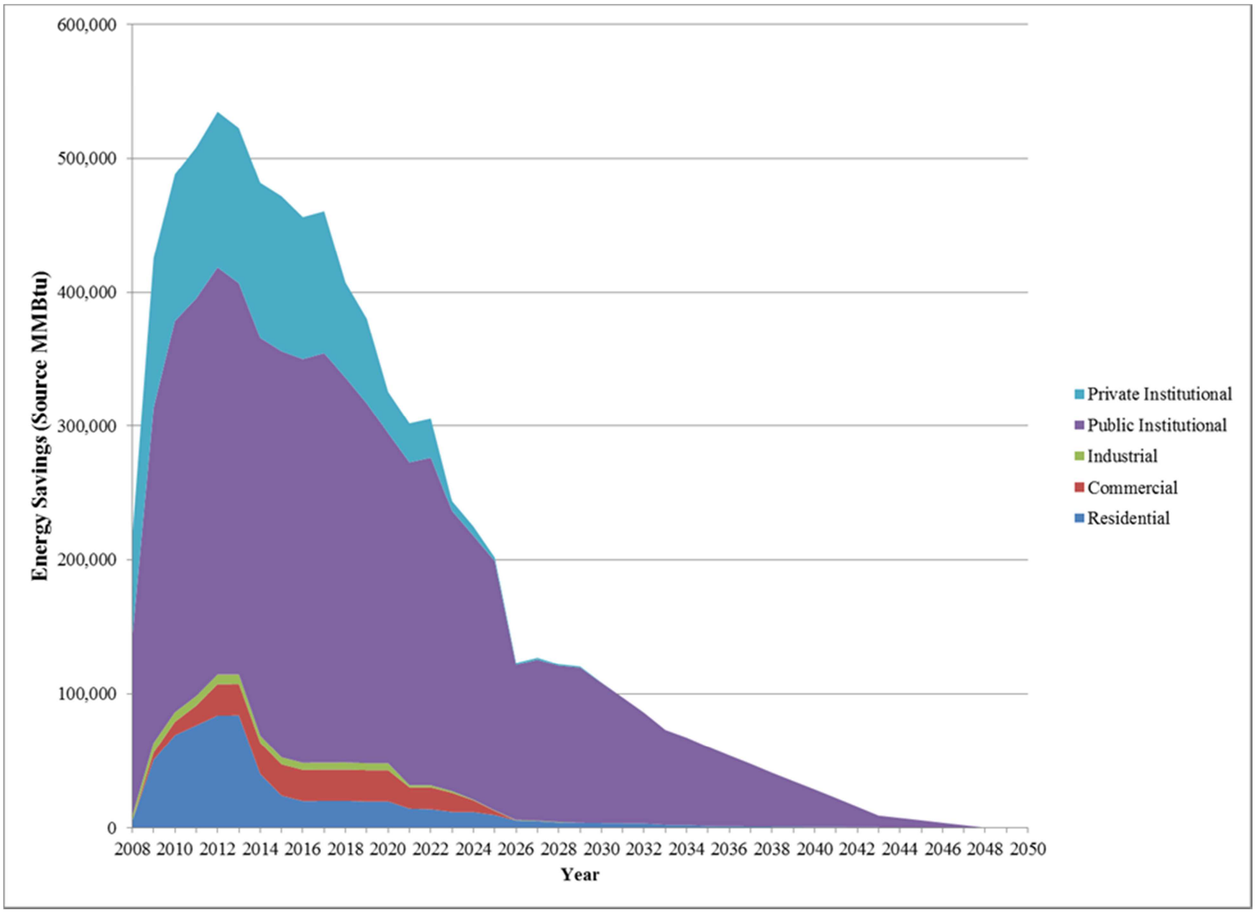

Figure 4-3: SEP-attributable cumulative energy savings for PY 2008 activities by sector by year (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-4 shows the cumulative SEP-attributable energy savings by sector in source MMBtu for the 2008 through 2050 period. The public institutional sector experienced savings of around 5.9 million source MMBtu, followed by the private institutional sector, which saved of about 1.3 million source MMBtu and the residential sector which saved around 644 thousand source MMBtu.

Table 4-4: SEP-attributable cumulative energy savings for PY 2008 activities by sector (source MMBtu)

	SEP-Attributable Energy Savings 2008-2050
Residential	644,216
Commercial	297,793
Industrial	82,005
Public Institutional	5,876,663
Private Institutional	1,332,049*
Total	**8,232,726**

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

Figure 4-4 displays the cumulative SEP-attributable renewable generation by sector over time. The majority of the renewable generation occurred in the industrial sector followed by the commercial sector. The impacts turn negative in 2037 as explained in **Section 4.1.1.1**.

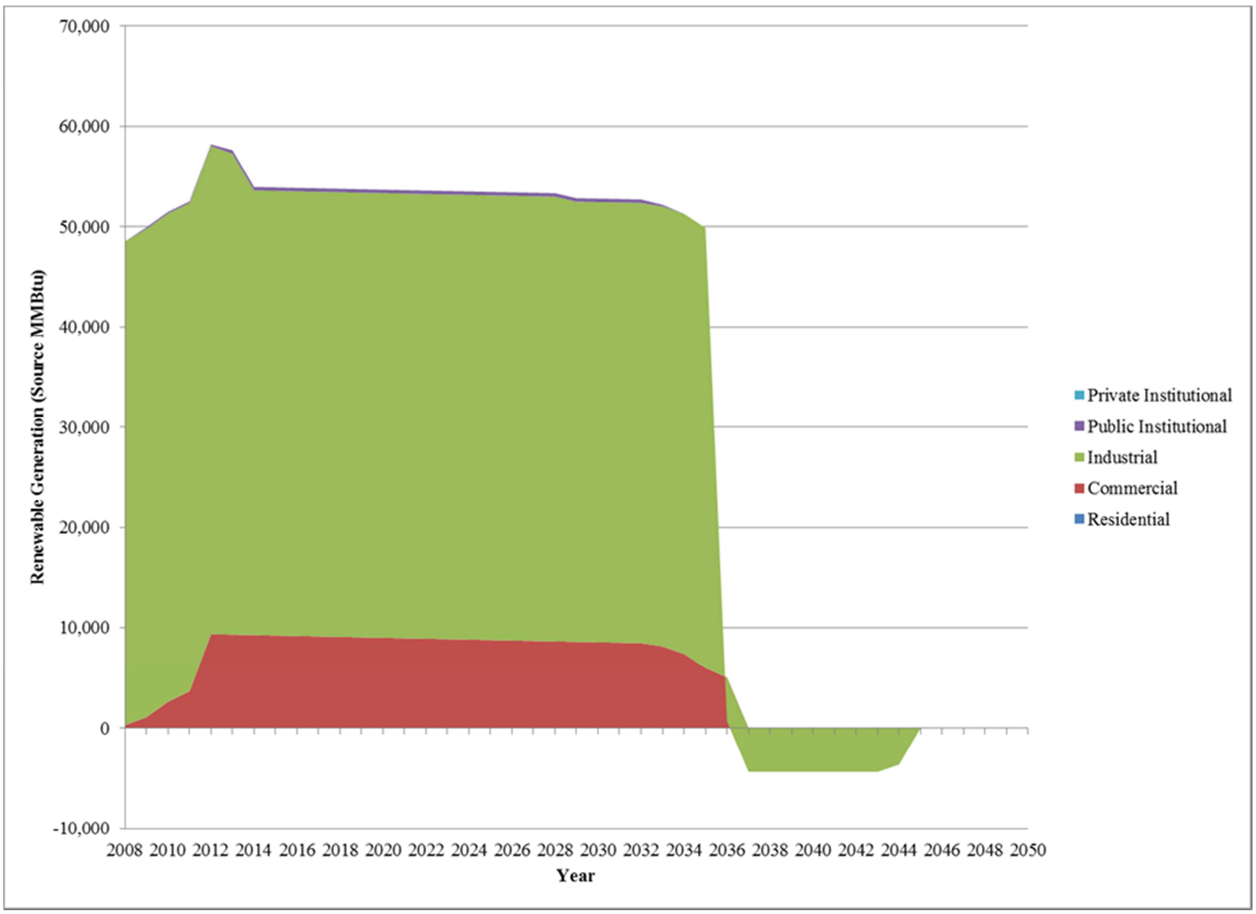

Figure 4-4: SEP-attributable cumulative renewable generation for PY 2008 activities by sector over time (source MMBtu)
A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-5 shows the cumulative SEP-attributable renewable generation during the 2008 through 2050 study period by sector in source MMBtu. The industrial sector had around 1.2 million source MMBtu of renewable generation. The commercial sector had about 221 thousand source MMBtu of renewable generation. The public institutional and residential sectors had eight thousand and one thousand source MMBtu of renewable generation respectively.

Table 4-5: SEP-attributable cumulative renewable generation for PY 2008 activities by sector (source MMBtu)

	SEP-Attributable Renewable Generation 2008-2050
Residential	1,078*
Commercial	220,879*
Industrial	1,224,318*
Public Institutional	7,780
Private Institutional	-
Total	**1,454,055***

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

4.1.2 Labor impacts (PY 2008)

This section presents findings on labor impacts from the PY 2008 BPACs in terms of job creation.

4.1.2.1 PY 2008 employment impact (national roll-up)

The resulting job impacts for the four studied PY 2008 BPACs are shown in **Table 4-6**. The results through 2050 are some 2,044 job-years, and approximately $12,347 per job created based on $25.2 million in funding for the evaluated PY 2008 BPACs. There are some unique aspects by BPAC from the evaluation derived information that form the basis of the jobs analysis in the REMI model.

- **Clean Energy Policy Support**: Bill savings end by 2036 in the commercial sector; other sectors are exhausted prior to that. All participating sectors –other than residential- were frequently over-compensated for their outlay towards project-related costs. The industrial sector also canceled some investment in clean energy projects in 2013 and 2014, which curtailed installation contracts and some U.S. manufacturing orders reducing labor impacts for this BPAC.
- **Building Retrofits**: Only the residential and public institutional sectors had programs in this BPAC. The majority of the bill savings are within the public institutional sector and these persist until 2025. The residential sector incurs no project-related costs, their electricity and natural gas savings are small but do persist to either 2036 or 2050. In this BPAC, there are minimal contracts for installation labor or U.S. manufactured equipment orders required which has a moderating impact on labor.
- **Technical Assistance to (Nonresidential) Building Owners**: The nature of this BPAC requires little-to-no participant costs or orders for U.S. equipment or requirements for U.S. installation contractors. As such, there are minimal opportunities for competitiveness gains given the small scale of industrial savings ($0.6 million cumulative), no participation from the commercial sector, and bills savings to health care and educational (private) institutions. Because 60 percent of this BPAC's bill savings accrued to the public institutional sector, the multiplier effects in this BPAC overall are muted because multiplier effects are inherently limited in this sector compared to other sectors. .
- **Loans, grants, and Incentives:** Program spending is focused on the public institutional sector ($11.7 million of initial project costs after rebates), the industrial sector ($2.7 million after rebates), with limited participation from the residential sector ($0.2 million after rebates). When considering the stream of expected bill savings (net of total loan repayment costs),

negative labor impacts emerge sectors starting in 2009 (and remain so through 2038 for the public institutional and industrial sectors and 2048 for the residential sector). The revolving loan fund aspect of this BPAC also includes some administrative spending through 2048.

Table 4-6: Direct, indirect, and induced jobs created in the U.S. from the studied PY 2008 period SEP activities

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Clean Energy Policy Support	418	105	124	95	282	197	1,162	-206	-8	-	2,170
Building Retrofits	23	19	20	19	19	18	100	54	-	-	272
Loans, Grants, and Incentives	25	-29	-33	-36	-40	-46	-377	-431	-7	52	-922
Technical Assistance	205	40	41	39	35	33	145	-9	-4	-	525
Total	**671**	**136**	**153**	**117**	**297**	**202**	**1,029**	**-592**	**-19**	**52**	**2,044**

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

As shown in **Figure 4-5**, total job impacts from PY 2008 begin in 2008 at 671, turn negative in 2018, and then become positive again in 2037. As stated previously, this is driven by job losses in the Loans, Grants, and Incentives BPAC. Several factors explain the negative job impacts, but they all center on insufficient bill savings to offset the carrying costs of the programs themselves: (1) this PY 2008 BPAC included alternative fuel programs that, as intended, reduced carbon emissions impacts but did not result in substantial energy bill savings; (2) loan programs during PY 2008 offered interest rates that ranged from below market to above market, and the higher the interest rate the more disposable income is eroded from any realized bill savings; and (3) some programs used the loans or incentive funding to bring public sector buildings up to minimum energy efficiency standards, resulting in relatively low energy and bill savings.

The PY 2008 results fluctuate by year as program spending ramps up, then tapers off. This is because the dynamic adjusting REMI model examines demand for labor, capital, public spending, wages, and trade across all regions of the U.S. macroeconomy. Increases in demand (and resulting jobs) are followed by readjustment periods during which labor and capital markets make their way back to equilibrium.

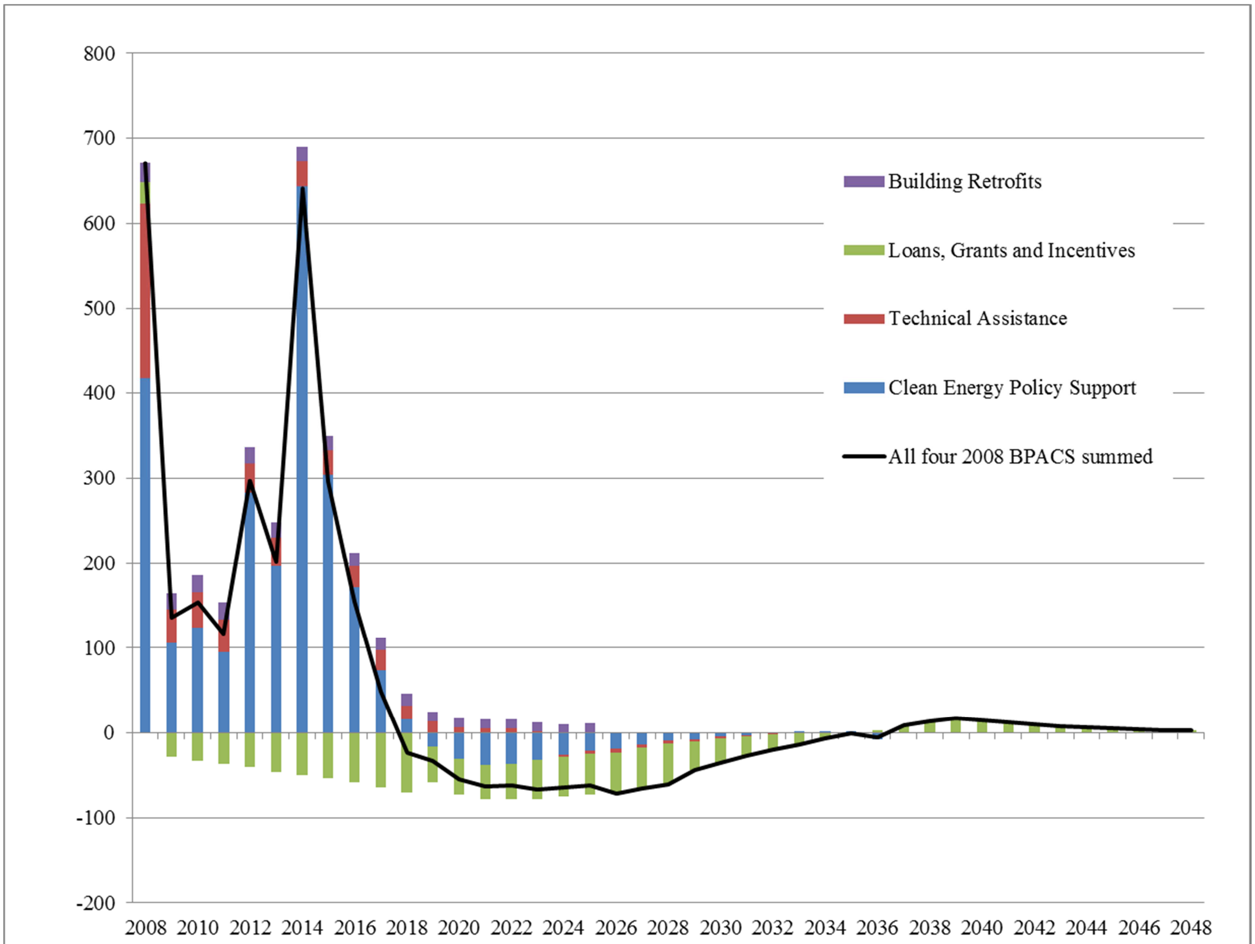

Figure 4-5: Direct, indirect, and induced job changes created in the U.S. from the PY 2008 SEP activities

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.
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In 2008, the jobs (retained or created) spanned many NAICs activities. This is attributable to (a) project deployment and administration activities (hence the pronounced job impacts for State/Local Government, Construction, Professional/Scientific/Technical Services, and Manufacturing), (b) instances of immediate bill savings that become consumer expenditures, or Commercial and Industrial customers transform into increased levels of production, and (c) multiplier effects. By 2022, the most pronounced job change occurs in the Construction sector (27 jobs forfeited) as shown in **Figure 4-6**. This is associated with the Clean Energy Policy Support BPAC for which job generating effects occur between 2008 and 2015 and the REMI model captures a capital stock adjustment process after a period of increased investment. The Construction sector is largely driven by investment demand changes and household income growth.

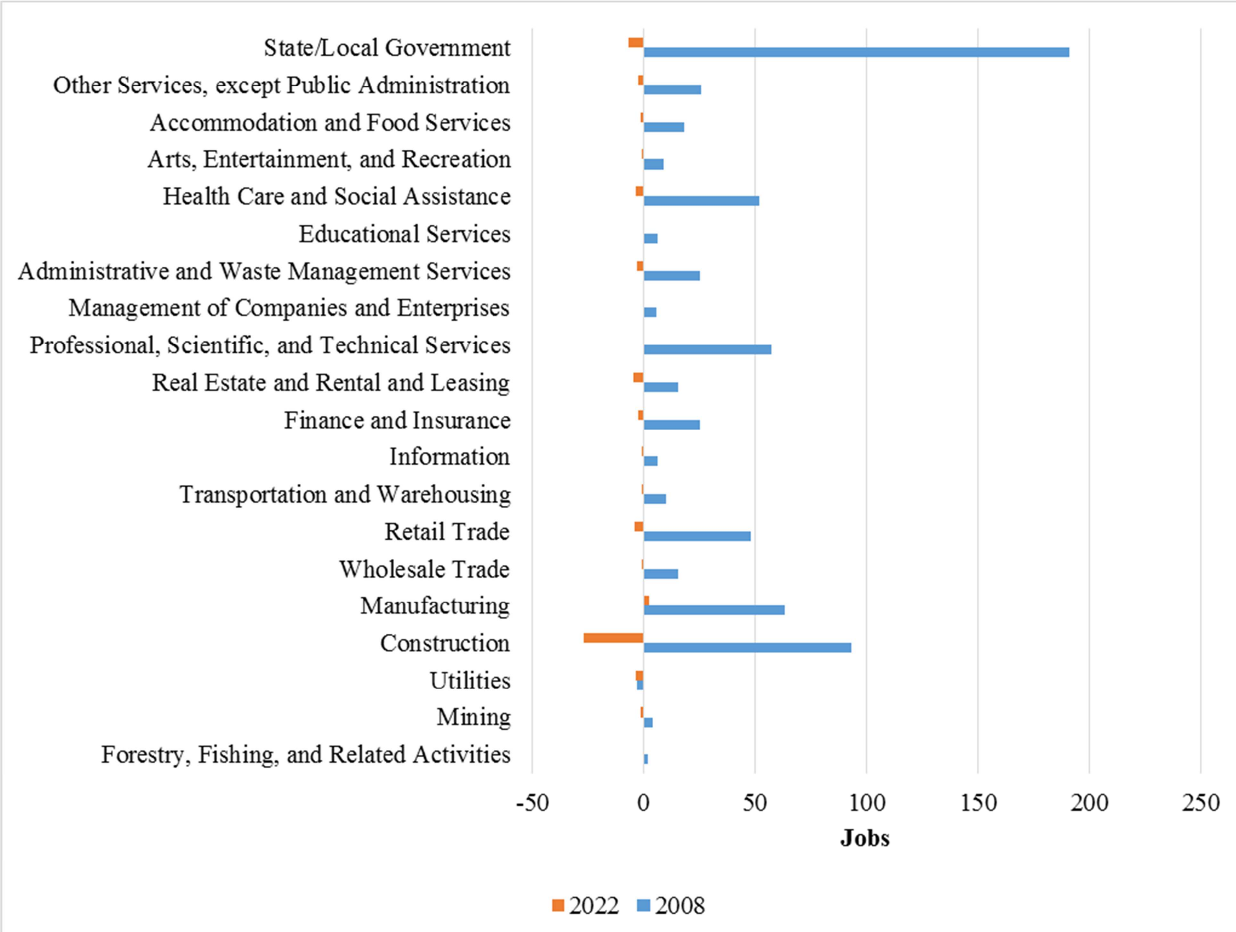

Figure 4-6: Job impact of PY 2008 SEP activities, by NAICS sector

The negative direct job impacts in 2013 and 2014 are attributable to the Clean Energy Policy Support BPAC which lost investment by some industrial customers related to regulatory compliance costs for clean energy projects which forestalled installation and U.S. manufactured orders that would have otherwise occurred (see **Section 4.1.1** Energy Savings and Renewable Generation for PY 2008).

Table 4-7: Direct jobs from PY 2008 SEP spending

Year	2008	2009	2010	2011	2012	2013	2014	Job-years
Clean Energy Policy Support	133	13	29	25	37	-203	-209	-175
Building Retrofits	48	-	-	-	-	-	-	48
Loans, Grants, and Incentives	53	5	5	5	5	5	6	84
Technical Assistance	67	-	-	-	-	-	-	67
Total	301	18	33	30	42	-197	-203	24

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

4.1.3 Avoided carbon emissions and avoided social cost estimates (PY 2008)

This section addresses avoided carbon emissions and the avoided social costs of carbon for all four of the PY 2008 BPACs studied in this evaluation. The avoided emissions impacts are all reported in million metric tons of carbon equivalent (MMTCE). The avoided social costs are reported in 2009 dollars. Table 4-8 displays the avoided carbon in MMTCE by BPAC. The majority of avoided carbon emissions come from energy savings (0.44 MMTCE) compared with energy displaced from renewable generation (0.12 MMTCE) and alternative fuels (0.01 MMTCE).

Table 4-8: Cumulative avoided carbon emissions from PY 2008 activities, by BPAC and program mechanism (MMTCE)

	Avoided Carbon From Energy Savings 2008-2050	Avoided Carbon From Renewable Generation 2008-2050	Avoided Carbon From Alternative Fuels 2008-2050
Clean Energy Policy Support	0.08	0.12	-
Building Retrofits	0.09	-	-
Loans, Grants, and Incentives	0.15	-	0.01
Technical Assistance	0.12	-	-
Total	**0.44**	**0.12**	**0.01**

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.

Avoided social costs from PY 2008 activities total $37.4 million. Energy savings account for the majority of the avoided social costs at $28.3 million. Energy displaced from renewable generation accounts for $8.5 million in avoided social costs and direct carbon from alternative fuels accounts for about $602 thousand.

Table 4-9: Cumulative avoided lifetime social costs of carbon from PY 2008 activities, by BPAC and program mechanism (thousands of 2009$)

	Avoided Social Costs From Energy Savings 2008-2050	Avoided Social Costs From Renewable Generation 2008-2050	Avoided Social Costs From Alternative Fuels 2008-2050
Clean Energy Policy Support	$5,015	$8,493	-
Building Retrofits	$5,698	-	-
Loans, Grants, and Incentives	$10,355	-	$602
Technical Assistance	$7,225	$39	-
Total	**$28,294**	**$8,531**	**$602**

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.

4.1.3.1 Avoided carbon emissions (PY 2008)

Avoided carbon emissions from the PY 2008 BPACs are derived from energy savings, energy displaced from renewable generation, and some direct carbon reduction from lower carbon alternative fuels in transportation programs. As shown in **Figure 4-7**, avoided carbon emissions from PY 2008 BPAC activities total 0.57 MMTCE, and are derived mostly from energy savings at 0.44 MMTCE. There are 0.12 MMTCE of avoided carbon emissions from energy displaced from renewable generation and 0.01 MMTCE of direct avoided carbon emissions from alternative fuels.

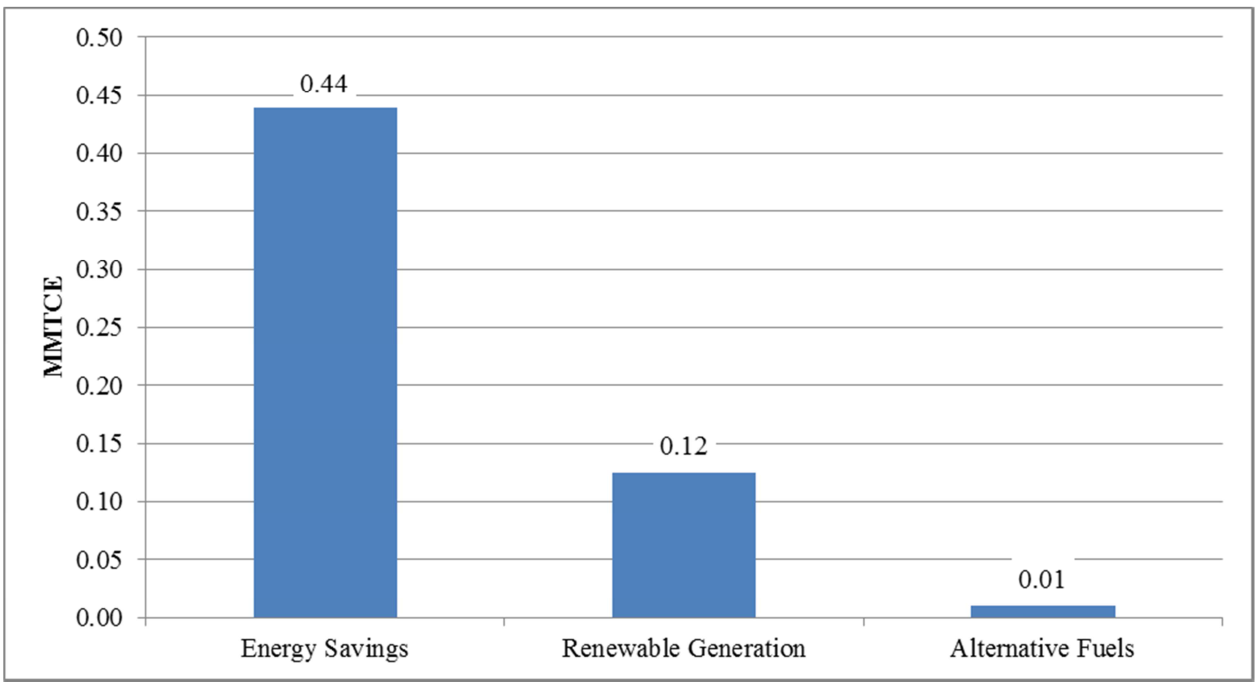

Figure 4-7: Cumulative PY 2008 avoided carbon emissions by program mechanism (MMTCE)
A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-8 shows SEP-attributable avoided carbon emissions over time from PY 2008 programmatic activities in MMTCE. Avoided carbon emissions rise quickly from 2008, reach a peak in 2012, and steadily descend to 2050. Avoided carbon emissions persist through 2050, the end of the study's program evaluation. The majority of the later impacts occur as a result of revolving loan programs.

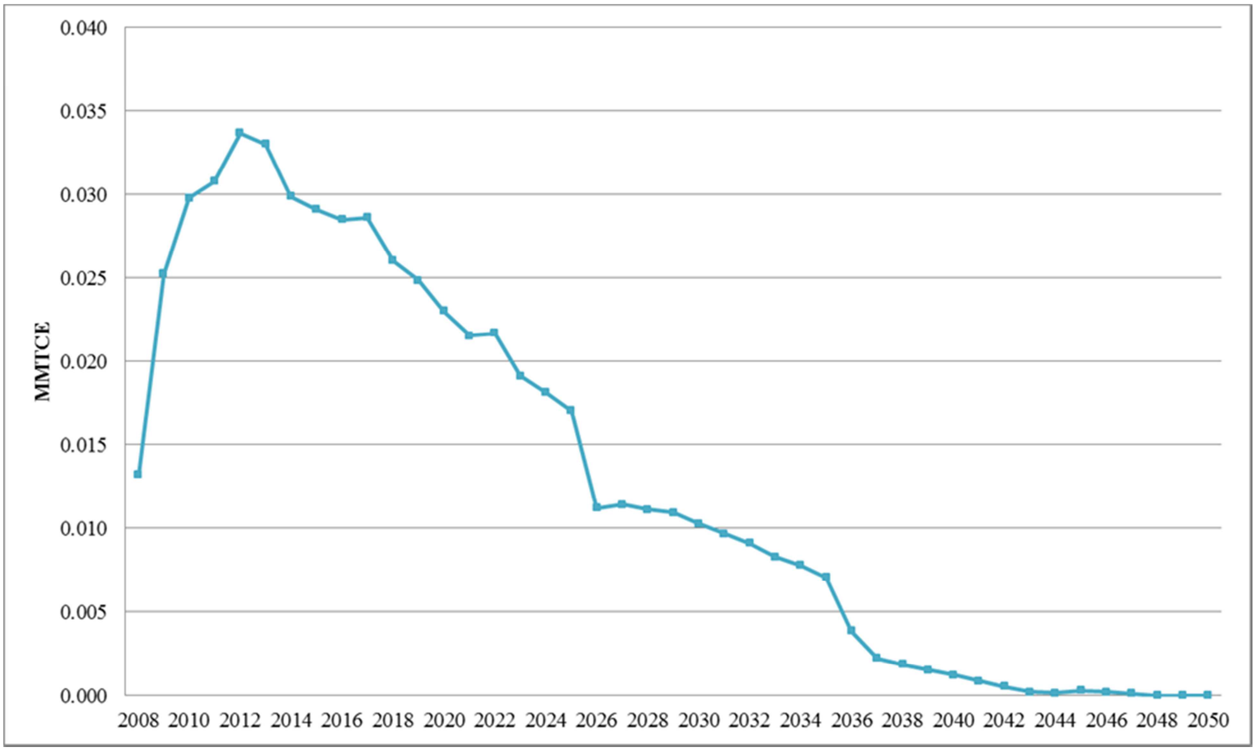

Figure 4-8: Cumulative avoided carbon emissions over time from PY 2008 activities (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided carbon emissions over the lifetime of energy impacts, by sector, are presented in **Figure 4-9**. The public institutional sector accounts for the largest amount of avoided MMTCE (0.33 MMTCE). The other sectors all have similar amounts of avoided MMTCE (0.04-0.08). The transportation sector has 0.01 avoided MMTCE from alternative fuels.

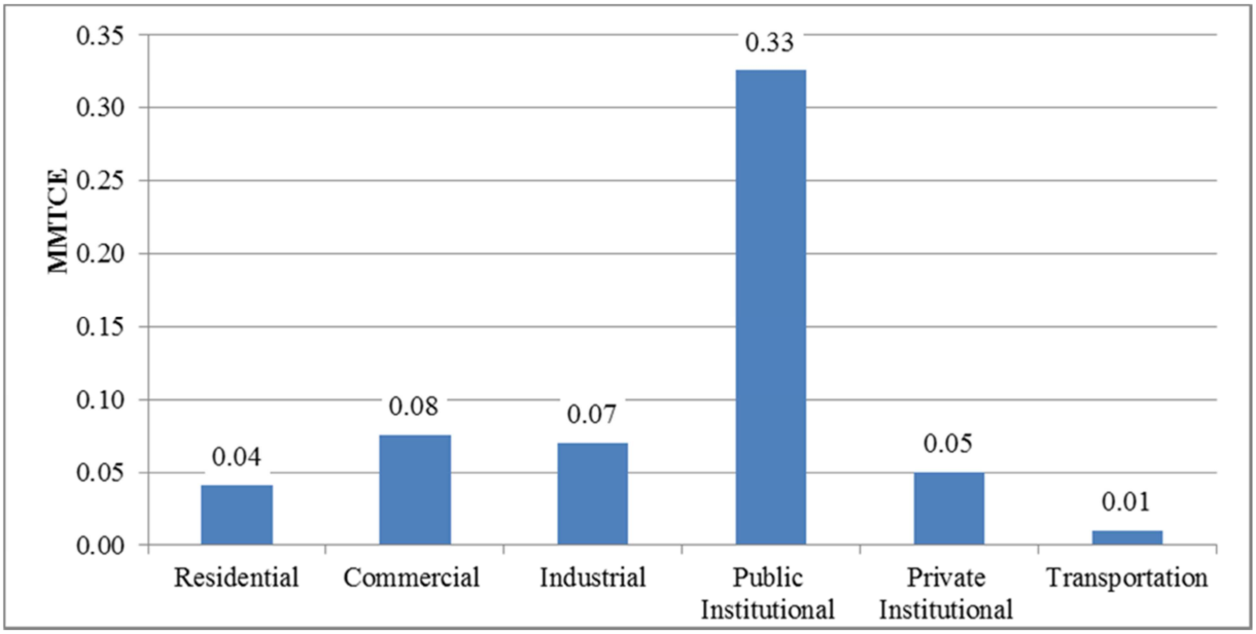

Figure 4-9: Cumulative avoided lifetime carbon emissions by sector from PY 2008 activities (MMTCE)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

4.1.3.2 Avoided social costs of carbon (PY 2008)

As shown below in **Figure 4-10**, avoided social costs total over $37.4 million. Energy savings account for the majority of the avoided social costs at $28.3 million. Energy displaced from renewable generation accounted for $8.5 million in avoided social costs and alternative fuels accounted for about $602 thousand.

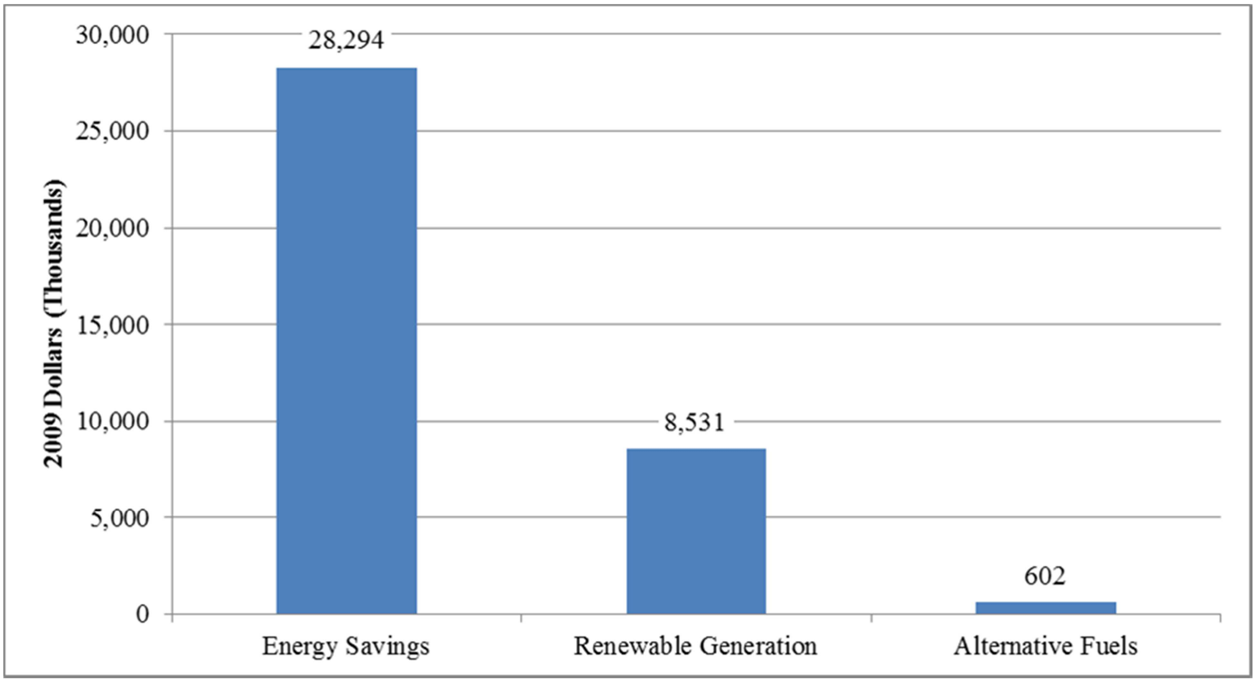

Figure 4-10: PY 2008 cumulative avoided social costs of carbon emissions by program mechanism (Thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided social costs of carbon over time are presented in **Figure 4-11** for the four PY 2008 BPACs. Similar to the pattern of avoided carbon emissions, the associated avoided social costs rise quickly through 2012, followed by a steady decline through 2050. Some associated avoided social costs of carbon persist through 2050.

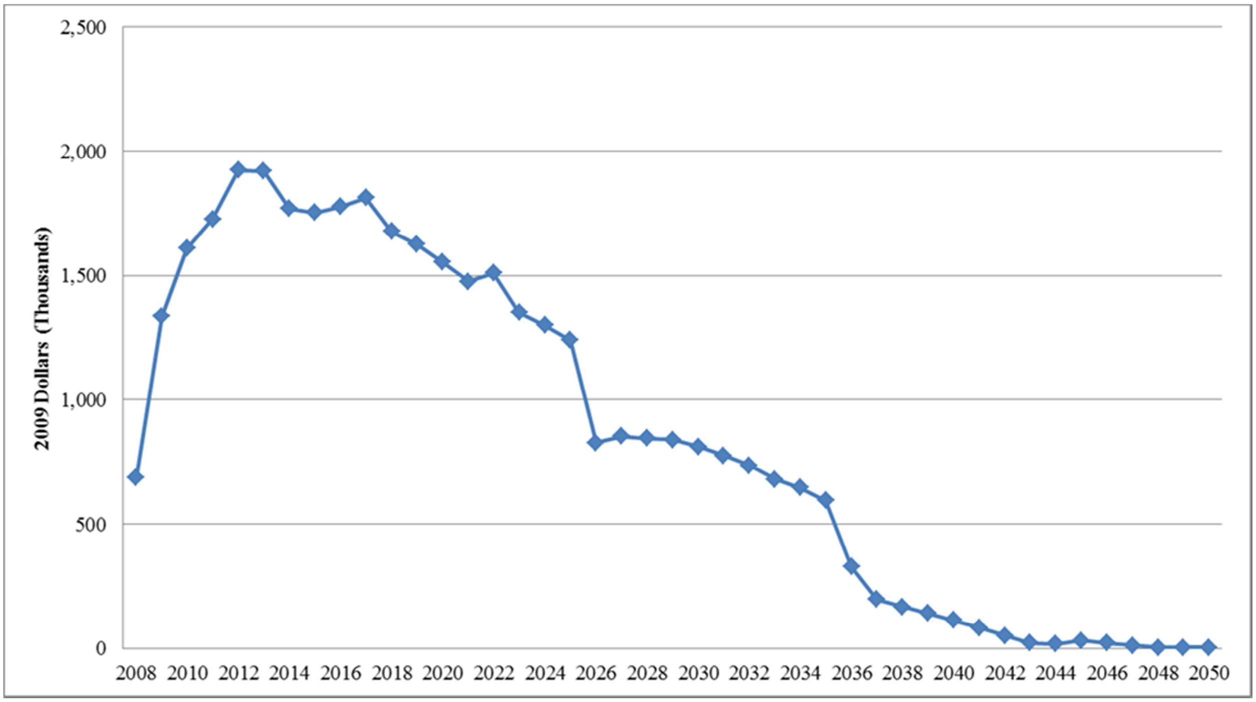

Figure 4-11: Cumulative avoided social costs of carbon over time from PY 2008 activities (Thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-12 shows how those avoided social costs of carbon distribute across sectors. The public institutional sector realizes the most avoided costs at $21.5 million. The other sectors all have similar amounts of avoided costs ($2.5 – $5.2 million). The transportation sector had $602 thousand of avoided social costs of carbon from alternative fuels.

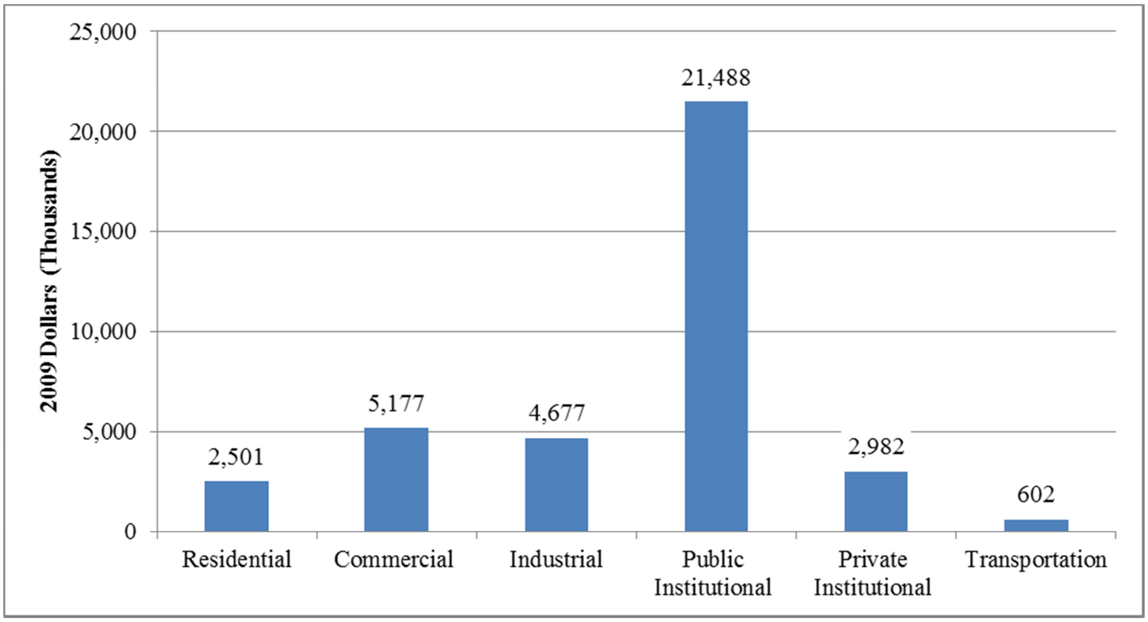

Figure 4-12: Cumulative avoided lifetime social costs of carbon by sector from PY 2008 activities (Thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.1.4 Bill savings and cost-effectiveness (PY 2008)

This section presents findings on bill savings and cost-effectiveness indicators for overall studied activities funded in PY 2008 through SEP. Bill savings are presented in 2009 dollars, and include direct customer savings from energy efficiency and on-site renewable generation, as well as indirect customer bill savings related to utility-scale renewable generation. For cost-effectiveness, two indicators are presented in this report: the SEP RAC test result and a ratio of SEP-attributable bill savings to SEP expenditures in present value terms.

4.1.4.1 Customer energy bill savings (PY 2008)

Total bill savings attributable to SEP associated with PY 2008 BPAC activities are shown in **Table 4-10**. Cumulative bill savings total $94.6 million through the year 2050, compared to estimated program funding of $25.2 for these BPACs in PY 2008.[73]

[73] Customer bill savings related to on-site generation are included in total bill savings for the Clean Energy Policy Support and Technical Assistance BPACs. All on-site renewable generation evaluated in this study is customer-owned and therefore the savings accrue to the customer.

Table 4-10: Bill savings for PY 2008 studied BPACs

BPAC	Bill Savings ($Thousands)
Clean Energy Policy Support	$33,868
Building Retrofits	$10,917
Loans, Grants, and Incentives	$25,420*
Technical Assistance	$24,429
Total	**$94,634**

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

Figure 4-13 shows how bill savings distribute across different sectors over time, with the majority going to the public institutional sector, followed by the commercial and the private institutional sectors, with relatively fewer bill savings to the residential and industrial sectors.

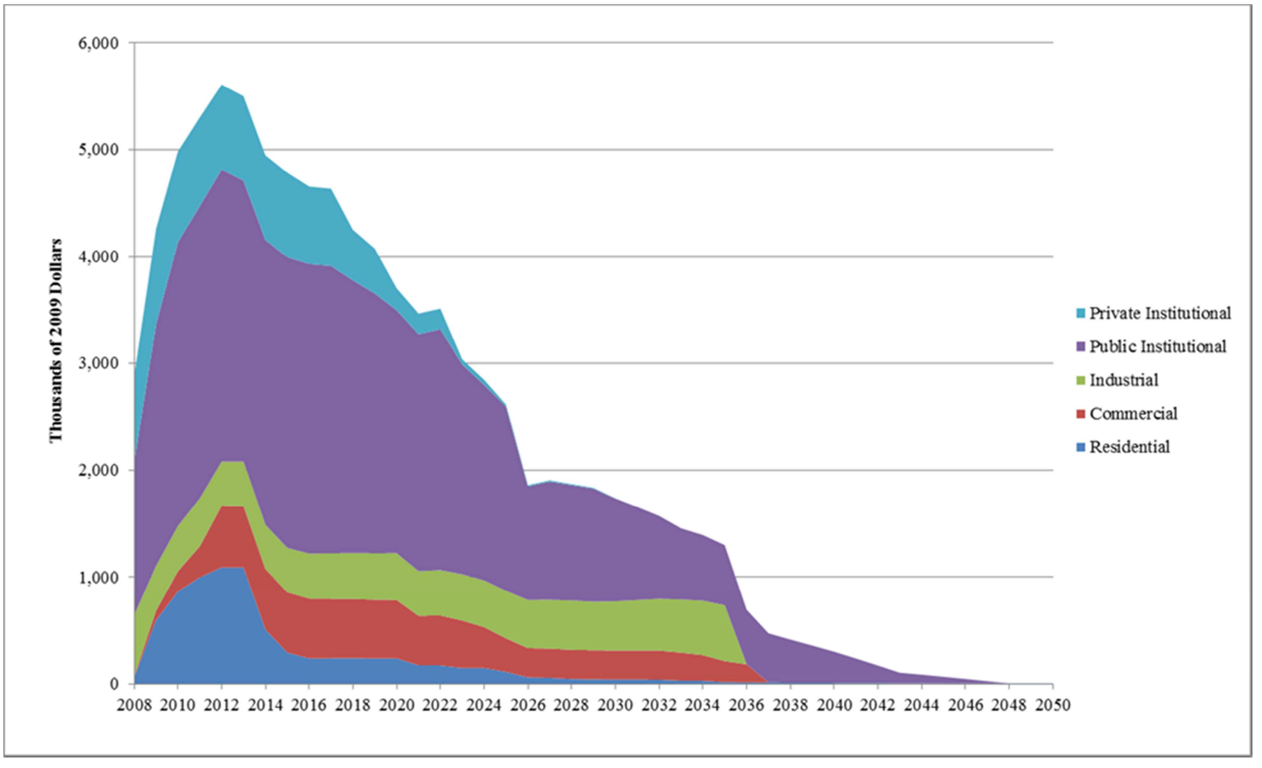

Figure 4-13: **Cumulative bill savings for PY 2008 activities by sector by year (Thousands of $2009)**

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-11 shows SEP-attributable bill savings by fuel and sector. The majority of bill savings are accounted for in the public institutional customer sector—mostly related to electricity savings—followed by the industrial sector from which most of the bill savings are derived from natural gas.

Table 4-11: SEP-attributable cumulative bill savings for PY 2008 activities by fuel type by sector (thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	$5,954	$9,975	$651	$40,771	$7,413*	$64,764
Natural Gas	$2,006	$511*	$11,934*	$12,579	$2,211*	$29,242
Oil	$2*	-	-	-	-	$2*
Propane	-	-	-	$86	-	$86
Kerosene	-	-	-	-	-	-
Wood	$1*	-	-	-	-	$1*
Diesel	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-
Gasoline	-	-	-	$522	-	$522
Other	$9*	-	$9	-	-	$18
Total	**$7,972**	**$10,486**	**$12,594***	**$53,958**	**$9,625***	**$94,634**

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

4.1.4.2 Cost-effectiveness (PY 2008)

Table 4-12 shows the SEP RAC test result for all four PY 2008 BPACs studied. SEP 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.[74]

The SEP RAC test result for the all studied BPACs from PY 2008 was 20.4 from the building perspective and 21.2 from the system perspective when including loans. Without loans, the SEP RAC test result was 31.7 from the building perspective and 32.9 from the system perspective. This exceeds the SEP ARRA-established benchmark of 10. This value is a savings weighted average of all four BPACs studied.

The SEP RAC test results are presented both with and without the initial loan disbursements for the Loans, Grants, and Incentives BPAC, which includes loans that are included as program expenditures. As these loans are eventually repaid by borrowers, however, they can alternatively be viewed as not being a program expenditure, which is why it is presented with and without loans.

[74] The substantive distinction between the SEP 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 4-12: SEP RAC test result for PY 2008 studied BPACs

BPACs	SEP RAC Test Result (Building)	SEP RAC Test Result (System)
Clean Energy Policy Support	26.4	30.7
Building Retrofits	25.6	25.6
Loans, Grants, and Incentives (with loans)	4.5	4.5
Loans, Grants, and Incentives (without loans)	17.6	17.6
Technical Assistance	48.5	48.6
Total (with loans)	**20.4**	21.2
Total (without loans)	**31.7**	32.9

Under all three discounting scenarios, all studied PY 2008 BPACs produced positive present value ratios. Total present value ratios ranged from 2.5 to 3.4 under different discount rate scenarios when including loans. When excluding loans, the combined present value ratios range from 3.8 to 5.3.[75]

Table 4-13: Lifetime present value ratio for PY 2008 studied BPACs

Discount Rate	0.7%	2.7%	4.7%
Clean Energy Policy Support	6.7	5.6	4.7
Building Retrofit	3.0	2.6	2.3
Loans, Grants, and Incentives (with loans)	1.9	1.4	1.1
Loans, Grants, and Incentives (without loans)	7.3	5.6	4.4
Technical Assistance	4.4	4.0	3.6
Total (with loans)	**3.4**	**2.9**	**2.5**
Total (without loans)	**5.3**	**4.5**	**3.8**

The SEP RAC test results and PV ratios for the same BPACs (i.e., Building Retrofits; Loans, Grants, and Incentives) were found to vary from PY 2008 to the ARRA period. For Building Retrofits, the cost-effectiveness numbers were lower under ARRA than in PY 2008. This can largely be explained by differences in the nature of the programs in the two periods, with the ARRA-funded activities often involving larger projects and covering a greater share of total costs. The state leveraging requirement for PY 2008, which did not apply under ARRA, also contributed to the greater SEP-attributable savings per SEP dollar because that state investment would not have occurred in the absence of SEP. For Loans, Grants, and Incentives, the PY 2008 RAC test results and PV ratios are lower than for the ARRA period because PY 2008 included more programmatic activities that focused on carbon reduction, especially in the transportation and alternative fuel areas, where energy savings were lower than those achieved by other types of activities. As explained in **Sections 3.4.4** and **3.5.4**, cost-effectiveness is calculated by dividing SEP-attributable savings by SEP funding only.

4.2 Energy savings/renewable generation (PY 2008)

This section presents the following findings related to energy savings and renewable generation for each PY 2008 BPAC:

- 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

[75] Customer costs associated with switching electricity service for on-site generation technologies are not considered in the PV ratios for the Clean Energy Policy Support and Technical Assistance BPACs.

Energy impacts are originally calculated in site energy, but are reported in source MMBtu. This means that energy savings and renewable generation at a consumer site is converted to the equivalent amount of raw fuel consumed at the fuel source. Ratio adjustments from EPA's ENERGY STAR© PortfolioManager® account for loss of energy from transmission and production of heat and electricity not combusted on-site.[76] These ratio adjustments are provided in Appendix J.

4.2.1 Clean energy policy support (PY 2008)

The Clean Energy Policy Support BPAC encompasses programmatic activities aimed to educate state legislators, administration officials and regulators on policies to facilitate energy efficiency or renewable energy projects. Examples might include statewide zoning laws, feed-in tariffs, favorable back-up tariffs, renewable portfolio standards.

> Typical PAs for Clean Energy Policy Support include funding for staff to research or support a new policy to promote energy efficiency or renewable energy. In one case an employee attended stakeholder meetings to advocate for solar initiatives, which eventually came into effect. These projects tend to be only partially attributable to SEP due to the numerous stakeholders involved in these types of initiatives.

4.2.1.1 Energy impacts for all fuel types and sectors combined (Clean Energy Policy Support)

The PY 2008 Clean Energy Policy Support BPAC resulted in SEP-attributable energy savings of 1.2 million source MMBtu over the 2008 to 2050 study period. **Figure 4-14** shows the SEP-attributable impacts over time. Energy impacts increase rapidly to a peak in 2012 and 2013, followed by a sharp decline to 2015 at the end of the peak, and slower decline through 2032.

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

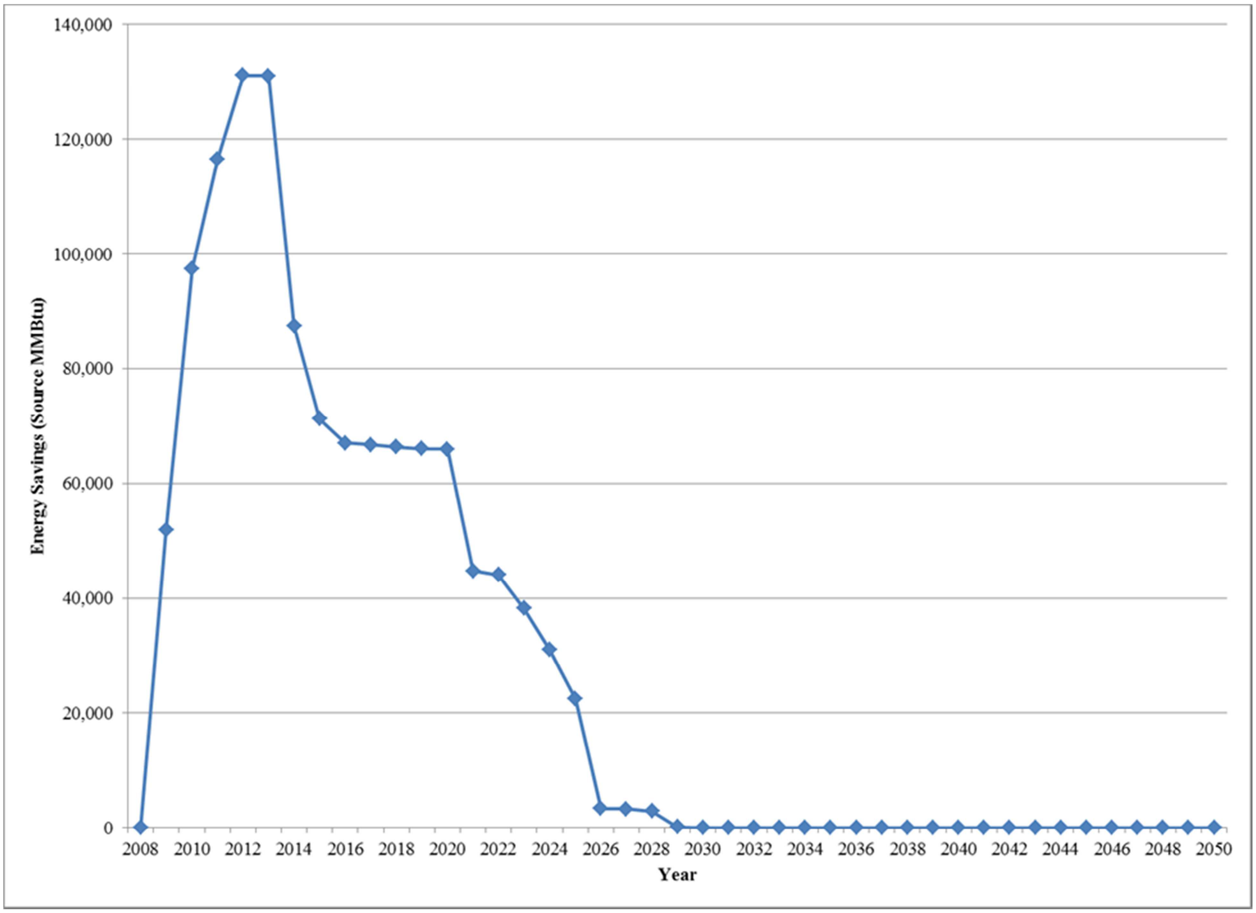

Figure 4-14: SEP-attributable clean energy policy support energy savings in source MMBtu by year

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

The PY 2008 Clean Energy Policy Support BPAC resulted in 1.5 million source MMBtu of SEP-attributable renewable generation from 2008 to 2050. **Figure 4-15** shows the impacts during the period of study. Impacts peak in 2012 and 2013 then drop off gradually until 2035 when they become slightly negative through 2044. The negative impacts between 2037 and 2044 are related to two factors:

- The continuation of negative impacts for the 2008 to 2044 period from policies that were reflected in the sample that caused planned renewable energy resources in the pipeline to not be built based on the cost of regulatory compliance from those policies.
- The conclusion of renewable generation impacts in 2037 at the end of their expected useful life, which when combined with the negative impacts during that period, resulted in an overall positive incremental impact in renewable generation before 2037.

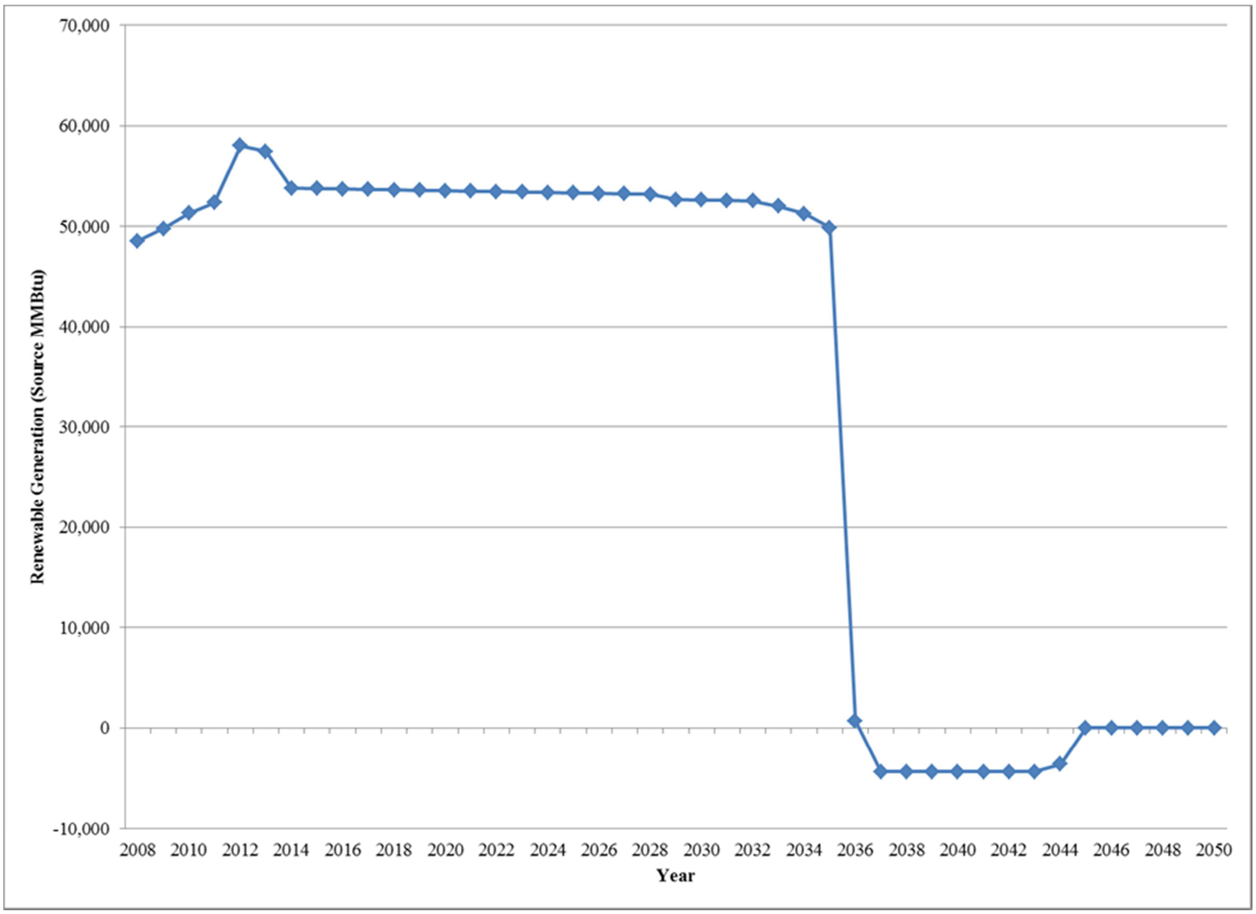

Figure 4-15: SEP-Attributable clean energy policy support renewable generation in source MMBtu by year

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.2.1.2 Energy impacts by fuel type (clean energy policy support)

Table 4-14 and **Table 4-15** show the SEP-attributable energy savings and renewable generation over time by fuel type in Source MMBtu.

The data suggest SEP-attributable energy savings of over one million source MMBtu of electricity and 193 thousand source MMBtu of natural gas between 2008 and 2050. The Clean Energy Policy BPAC also resulted in SEP-attributable energy savings for wood, propane, oil, and other fuel types.

Table 4-15 shows that the electric renewable generation amounted to about 100 thousand source MMBtu during the study period. Generation of digester gas amounted to 1.4 million source MMBtu.

Table 4-14: SEP-attributable energy savings for clean energy policy support activities over time by fuel type (source MMBtu)

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	-	49,855*	93,562	103,875	118,395	118,285	402,980	128,108	14*	-	1,015,074
Natural Gas	-	2,006*	3,883	12,636	12,751	12,751	87,446	61,890	-	-	193,363
Oil	-	-	2*	3*	5*	5*	35*	30*	-	-	81*
Propane	-	-	-	-	-	-	1*	1*	-	-	3*
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	1*	3*	3*	22*	22*	-	-	51*
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	37*	34*	39*	39*	276*	205*	-	-	630*
Total	**-**	**51,861***	**97,484**	**116,549**	**131,194**	**131,084**	**490,761**	**190,256**	**14***	**-**	**1,209,203**

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

Table 4-15: SEP-attributable renewable generation for clean energy policy support activities by fuel type over time (source MMBtu)

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	325*	1,568*	3,099*	4,140*	9,832*	9,255*	38,106*	49,762*	539*	-16,692*	99,934*
Methane	-	-	-	-	-	-	-	-	-	-	-
Landfill Gas	-	-	-	-	-	-	-	-	-	-	-
Digester Gas	48,223*	48,223*	48,223*	48,223*	48,223*	48,223*	337,560*	482,229*	241,114*	-	1,350,241*
Biodiesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**48,548***	**49,791***	**51,322***	**52,363***	**58,055***	**57,478***	**375,666***	**531,991***	**241,653***	**-16,692***	**1,450,175***

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

4.2.1.3 Energy impacts by sector (Clean Energy Policy Support)

Figure 4-16 displays the SEP-attributable energy savings by sector from 2008 to 2050. The most energy savings occurred in the public institutional and residential sectors followed by the commercial sector.

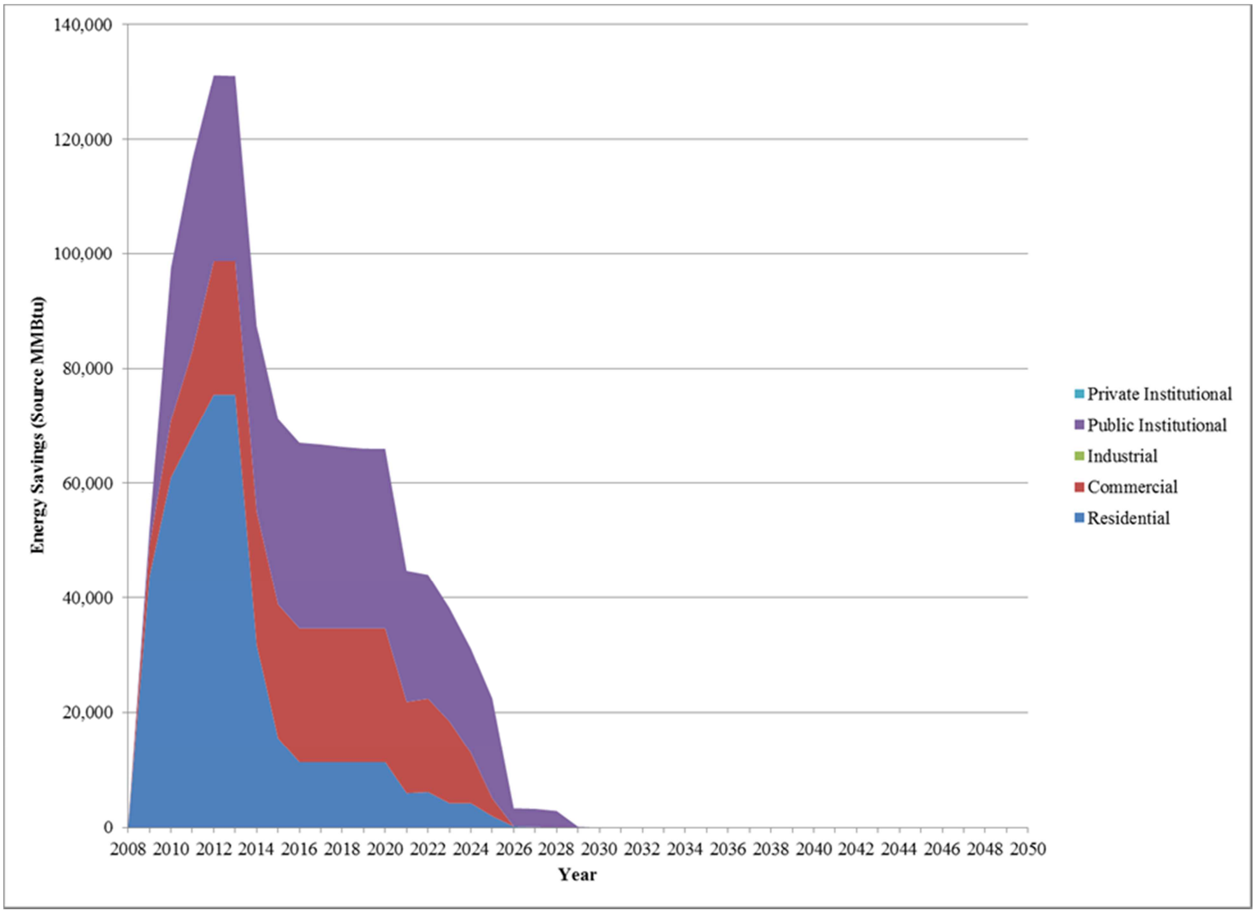

Figure 4-16: SEP-attributable energy savings for clean energy policy support activities by sector by year (Source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-16 shows the total SEP-attributable energy savings by sector in source MMBtu for the 2008 through 2050 period. The public institutional and residential sectors saved over 450 thousand source MMBtu, followed by the commercial sector, which saved about 298 thousand source MMBtu.

Table 4-16: SEP-attributable energy savings for clean energy policy support activities by sector (source MMBtu)

	SEP-Attributable Energy Savings 2008-2050
Residential	451,027
Commercial	297,793
Industrial	-
Public Institutional	460,383*
Private Institutional	-
Total	**1,209,203**

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

Figure 4-17 displays the SEP-attributable renewable generation by sector over time. The majority of the renewable generation occurred in the industrial sector followed by the commercial sector. The residential and public institutional sectors had some renewable generation, but they are not visible in **Figure 4-17**. The total impacts turn negative in 2037 as described in Section 4.2.1.1.

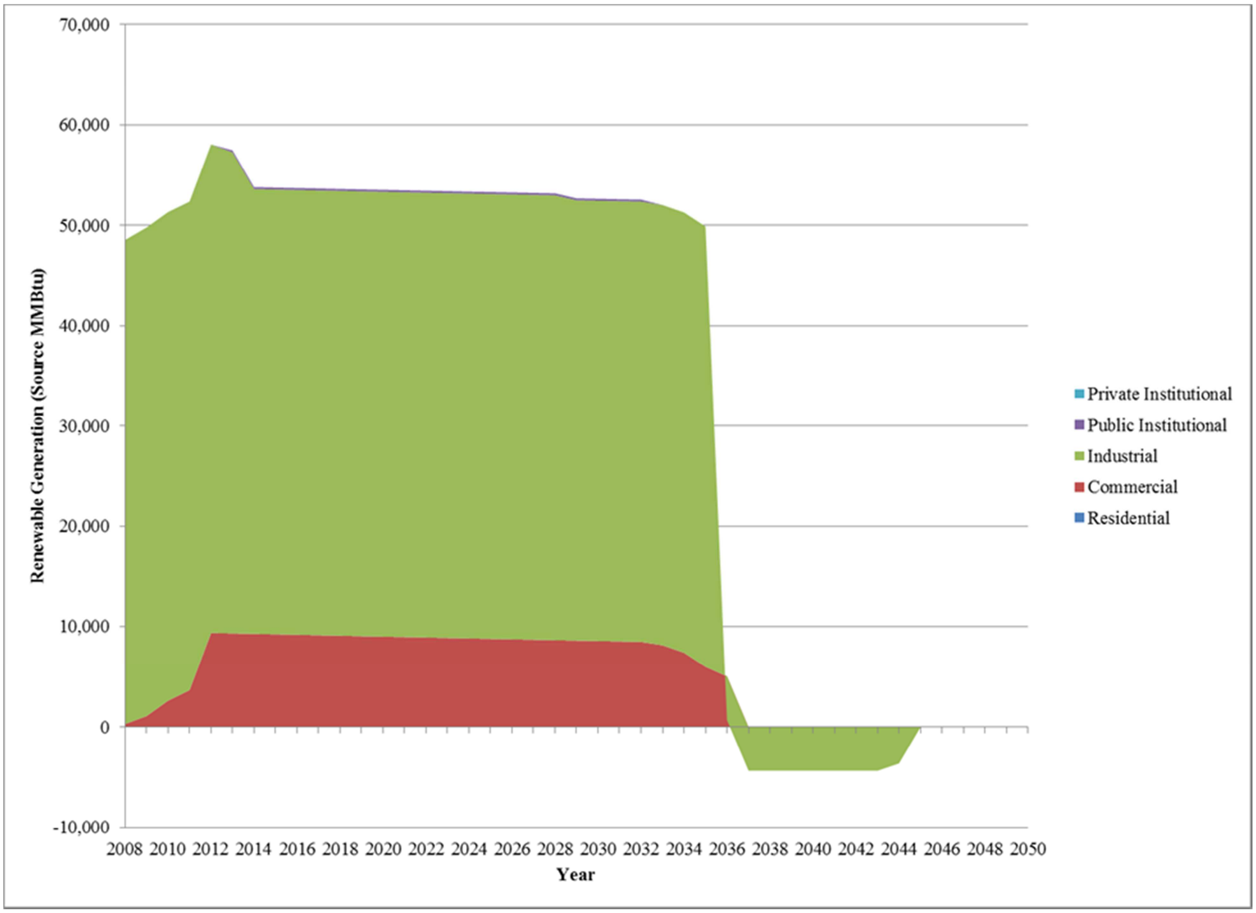

Figure 4-17: SEP-attributable renewable generation for clean energy policy support activities by sector over time (Source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-17 shows the total SEP-attributable renewable generation during the 2008 through 2050 study period by sector in source MMBtu. The industrial sector had 1.2 million source MMBtu of renewable generation. The commercial sector had about 221 thousand source MMBtu of renewable generation. The public institutional sector had four thousand source MMBtu of renewable generation, followed by the residential sector with one thousand source MMBtu of renewable generation.

Table 4-17: SEP-attributable renewable generation for clean energy policy support activities by sector (source MMBtu)

	SEP-Attributable Renewable Generation 2008-2050
Residential	1,078*
Commercial	220,879*
Industrial	1,224,318*
Public Institutional	3,901*
Private Institutional	-
Total	**1,450,175***

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

4.2.2 Building retrofits (PY 2008)

The Building Retrofits BPAC encompasses programmatic activities that provide financial incentives for building retrofit and equipment replacement projects in nonresidential and residential buildings. The PY 2008 Building Retrofits BPAC did not have any renewable generation impacts over the 2008 through 2050 period; therefore, this section will only discuss energy savings impacts.

Building Retrofits programs cover a broad range of activities that support energy efficient projects in multiple sectors. In 2008, in addition to traditional building retrofit grants for specific technologies, programs also funded workshops, training, and technical assistance efforts.

4.2.2.1 Energy impacts for all fuel types and sectors combined (Building Retrofits)

The PY 2008 Building Retrofits BPAC resulted in SEP-attributable energy savings of 1.3 million source MMBtu over the 2008 to 2050 period. SEP-attributable energy savings peak in 2009 and 2010, have two small declines in 2013 and 2019, followed by a steep drop in 2026 as the effective useful lifetime[77] of the associated efficiency technologies expire. A smaller amount of energy savings persist through 2050, the end of this evaluation's study period. The majority of the later impacts occur as a result of revolving loan programs. **Figure 4-18** shows the impacts over time.

[77] 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.

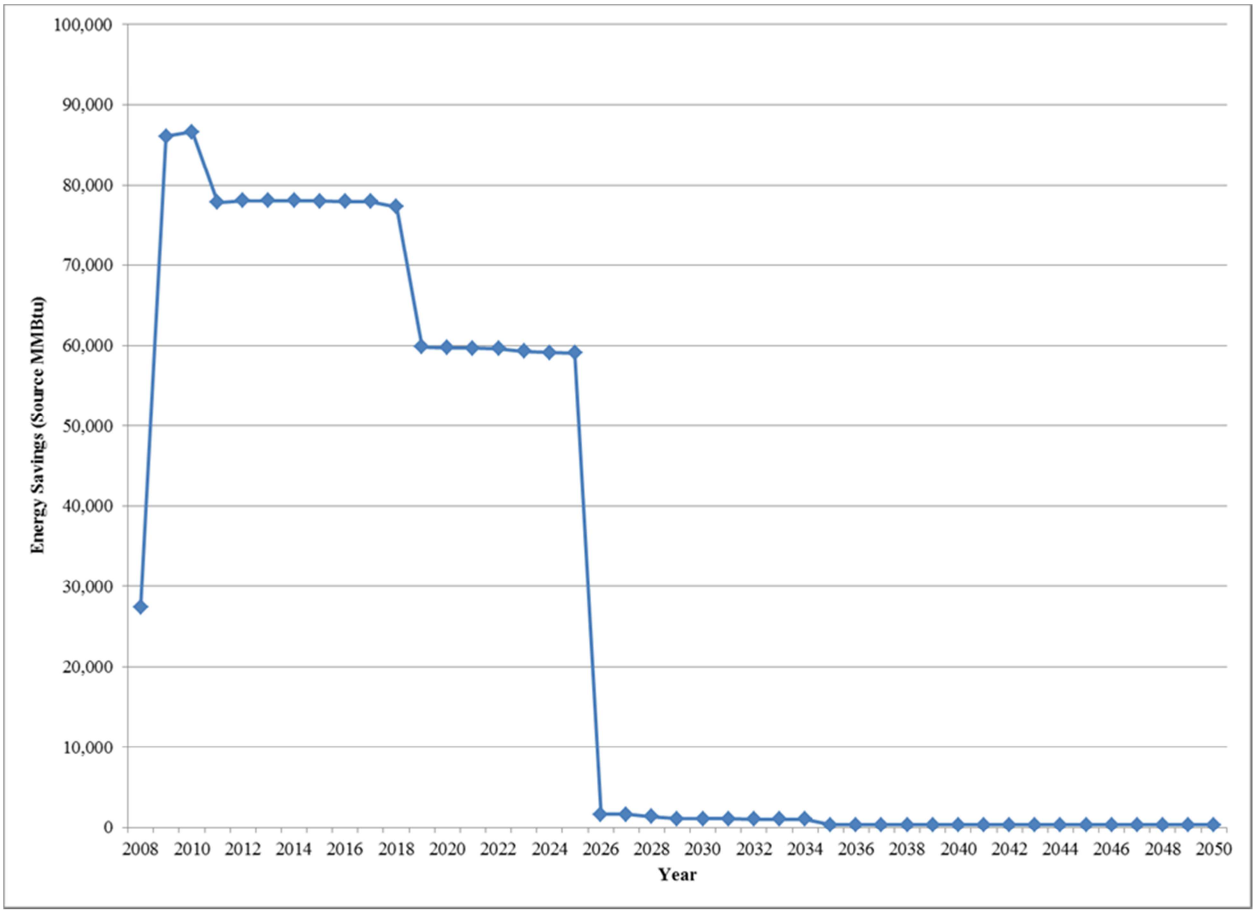

Figure 4-18: PY 2008 Building Retrofits energy savings in source MMBtu by year
A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.2.2.2 Energy impacts by fuel type (Building Retrofits)

Table 4-18 shows the SEP-attributable energy savings over time by fuel type. Electricity savings amounted to 806 thousand source MMBtu during the 2008 to 2050 study period. Natural gas savings amounted to about 449 thousand source MMBtu over the same period.

Table 4-18: SEP-attributable energy savings for PY 2008 building retrofits activities by fuel type over time (source MMBtu)

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	10,074	54,752	54,604	45,611*	45,729*	45,754*	318,051*	225,251*	3,388*	3,208*	806,421*
Natural Gas	17,302*	31,324	32,041	32,246	32,318	32,318	190,786	78,313*	2,841*	-	449,489
Oil	-	-	-	-	-	-	-	-	-	-	-
Propane	-	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**27,376**	**86,076**	**86,645**	**77,857**	**78,046**	**78,072**	**508,837**	**303,565***	**6,229***	**3,208***	**1,255,910**

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

4.2.2.3 Energy impacts by sector (Building Retrofits)

Figure 4-19 displays the energy savings by sector over time. The majority of energy savings are from the public institutional sector.

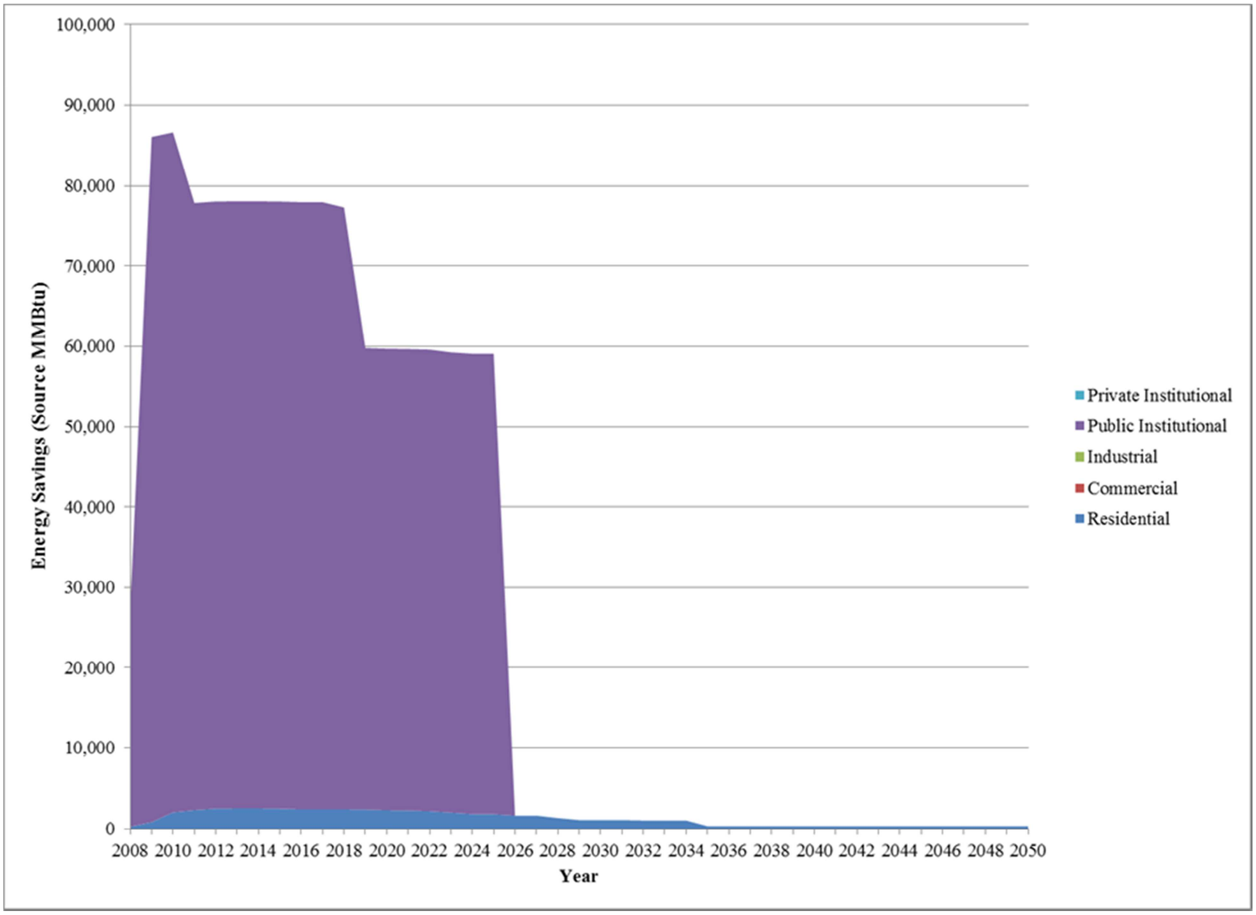

Figure 4-19: SEP-attributable energy savings for PY 2008 building retrofits activities by sector by year (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-19 shows the total SEP-attributable energy savings by sector in source MMBtu for the 2008 through 2050 period. The majority of the energy savings occur in the public institutional sector (1.2 million source MMBtu), followed by the residential sector (54 thousand source MMBtu).

Table 4-19: SEP-attributable energy savings for PY 2008 building retrofits activities by sector (source MMBtu)

	SEP-Attributable Energy Savings 2008-2050
Residential	54,109*
Commercial	-
Industrial	-
Public Institutional	1,201,802
Private Institutional	-
Total	**1,255,910**

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

4.2.3 Loans, grants, and incentives (PY 2008)

The Loans, Grants, and Incentives BPAC encompasses programmatic activities aimed to provide financial incentives for building retrofit and equipment replacement projects across all sectors. The PY 2008 Loans, Grants, and Incentives BPAC did not have any renewable generation impacts over the 2008 through 2050 period; therefore, this section will only discuss energy savings impacts.

4.2.3.1 Energy impacts for all fuel types and sectors combined (Loans, Grants, and Incentives)

Typical PAs for PY 2008 Loans, Grants, and Incentives include programs that promote alternative transportation, such as one PA that provided funding for a biofuel fuel tank and pump station. Another PA involved a revolving loan program to fund energy conservation projects in the public sector.

The PY 2008 Loans, Grants, and Incentives BPAC resulted in SEP-attributable energy savings of 2.7 million source MMBtu over the 2008 to 2050 period. **Figure 4-20** shows the SEP-attributable impacts in source MMBtu over time. The energy savings continue to rise through 2030 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.[78] Savings continue through 2050, which is the end of the period studied in this evaluation.

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

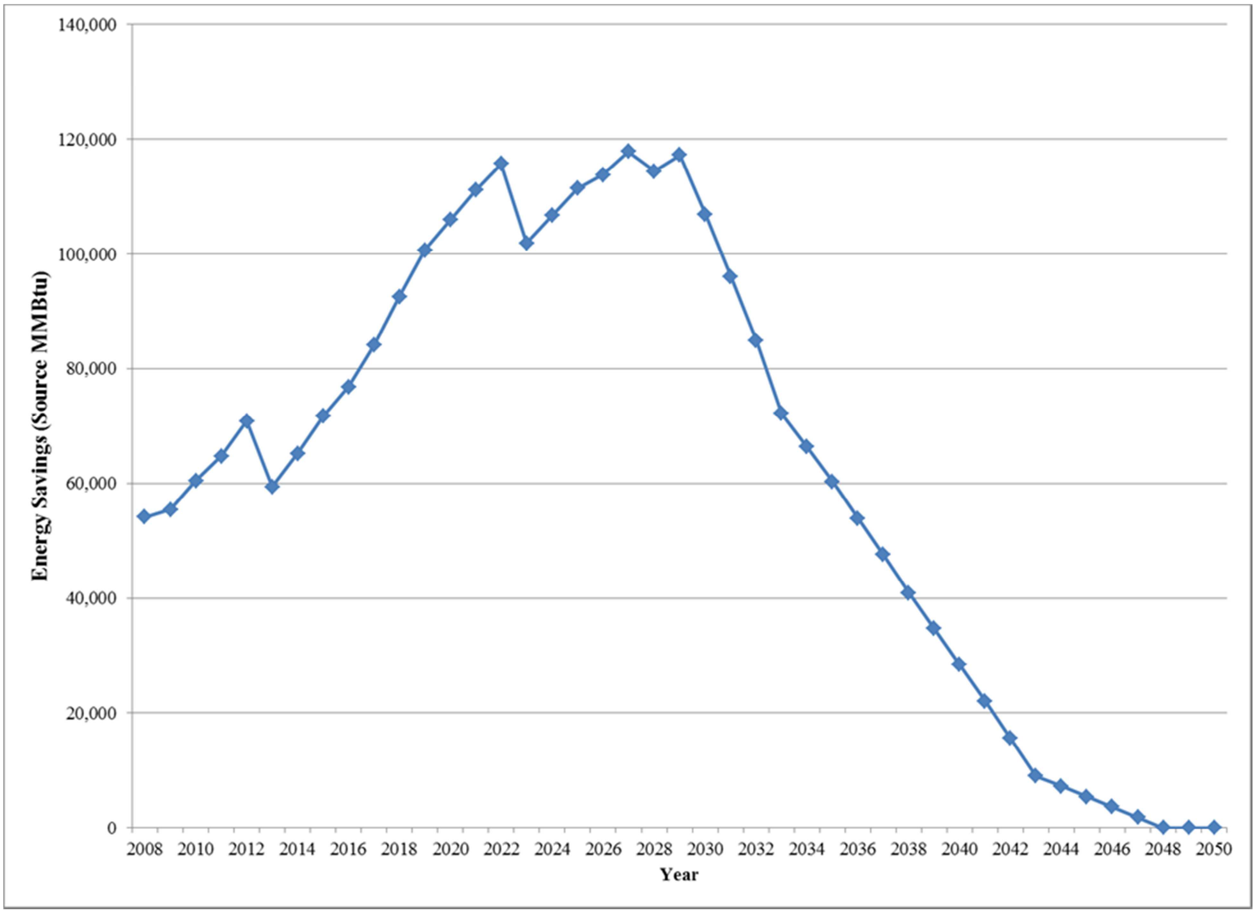

Figure 4-20: SEP-attributable energy savings for loans, grants, and incentives activities by year (Source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.2.3.2 Energy impacts by fuel type (Loans, Grants, and Incentives)

Table 4-20 shows the SEP-attributable energy savings over time by fuel type in source MMBtu. The data suggest energy savings of 2.0 million source MMBtu of electricity, about 747 thousand source MMBtu of natural gas, and about 23 thousand source MMBtu of gasoline between 2008 and 2050.

Table 4-20: SEP-attributable energy savings for loans, grants, and incentives activities by fuel type over time (source MMBtu)

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	40,153*	40,294*	44,317*	47,651*	52,541*	44,372*	450,953*	819,394*	407,437*	26,010*	1,973,121*
Natural Gas	12,765	13,945	14,991	15,895	17,307	14,223	143,783	297,836*	177,771*	38,843*	747,359*
Oil	-	-	-	-	-	-	-	-	-	-	-
Propane	-	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	2,790	2,790	2,790	2,790	2,612	2,389	7,143	-	-	-	23,306
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**55,708**	**57,030**	**62,098**	**66,336***	**72,459***	**60,984**	**601,880***	**1,117,229***	**585,208***	**64,853***	**2,743,785***

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

4.2.3.3 Energy impacts by sector (Loans, Grants, and Incentives)

Figure 4-21 displays the energy savings in source MMBtu by sector over time. The public institutional sector made up the majority of the energy savings.

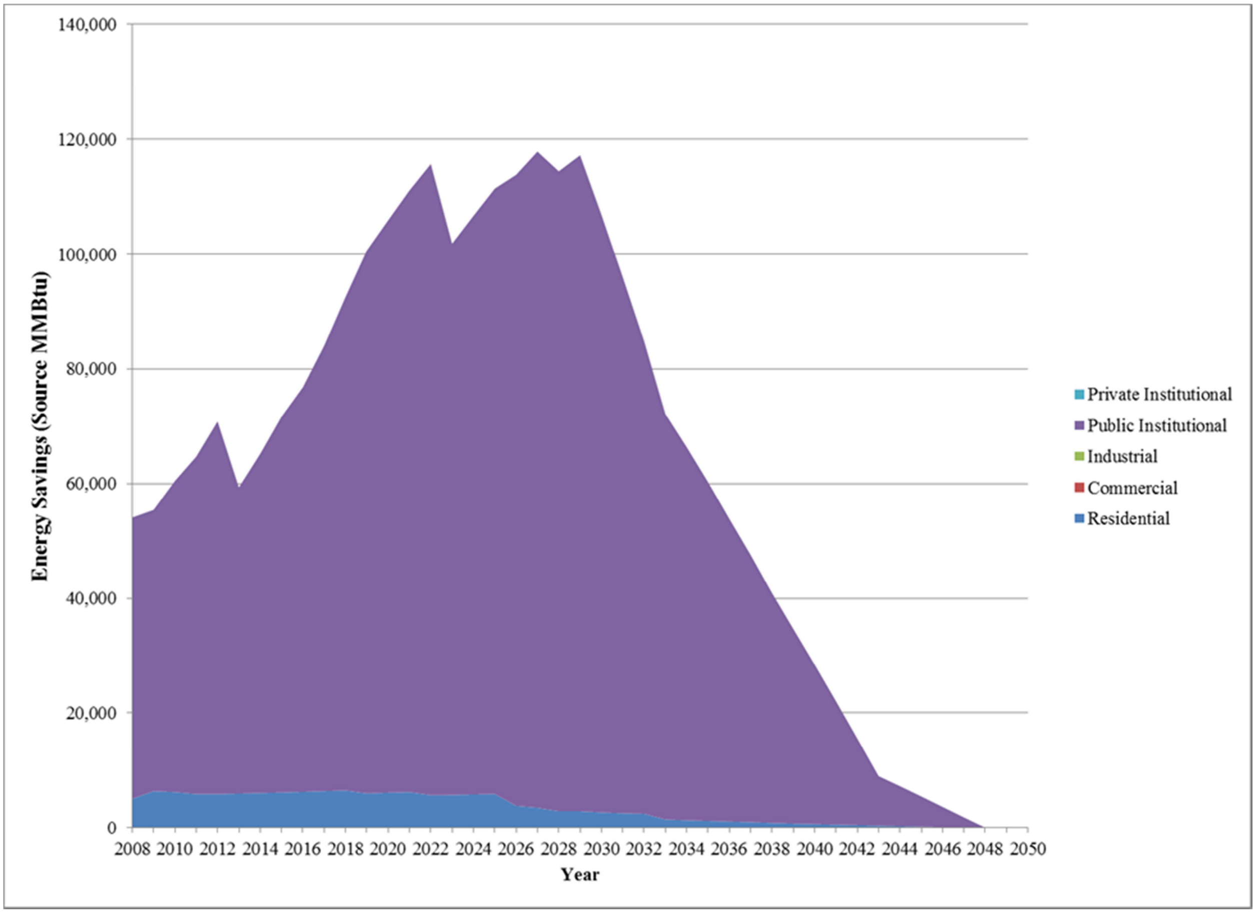

Figure 4-21: SEP-attributable energy savings for loans, grants, and incentives activities by sector by year (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-21 shows the total energy savings by sector in source MMBtu for the 2008 through 2050 period. The public institutional sector had 2.6 million source MMBtu of energy savings and the residential sector had 139 thousand source MMBtu of energy savings.

Table 4-21: SEP-attributable energy savings for loans, grants, and incentives activities by sector (source MMBtu)

	SEP-Attributable Energy Savings 2008-2050
Residential	139,080
Commercial	-
Industrial	-
Public Institutional	2,604,705*
Private Institutional	-
Total	**2,743,785***

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

4.2.4 Technical assistance (PY 2008)

The Technical Assistance BPAC encompasses programmatic activities that aimed to provide technical studies, hands-on support, and other assistance for energy efficiency and renewable generation projects across multiple sectors. These projects were open to commercial, industrial, and agricultural facility owners. Types of projects included technical studies and support in project finance or contracts. Technical Assistance PAs are fundamentally building retrofits or renewable energy projects, but delivered primarily through additional in-house or third-party expertise. SEP-attributable impacts are related to operational improvements from that Technical Assistance that would not have happened absent the SEP funding. As such, PA attribution was determined from two sources. First, the contractor team interviewed facility managers that received the technical assistance to determine the level of contribution the Technical Assistance made to their projects' successes, and associated that with the proportion of impacts that occurred due to SEP funding. The second method was to apply attribution rates from secondary sources for similar projects from the energy program evaluation industry literature. The focus of this BPAC was energy savings from energy efficiency however, some renewable generation also occurred as a result of activities in this BPAC.

> Technical Assistance PAs include a program that facilitated a system-wide energy use reduction through providing technical assistance to help state building managers devise savings plans to meet the state's energy reduction targets.

4.2.4.1 Energy impacts for all fuel types and sectors combined (Technical Assistance)

The studied portion of the PY 2008 Technical Assistance BPAC resulted in SEP-attributable energy savings of 3.0 million source MMBtu over the 2008 to 2050 period. **Figure 4-22** shows the SEP-attributable impacts over time. Energy savings increase from 2008, peaking in 2012. The energy savings then decline from 2017 through 2030.

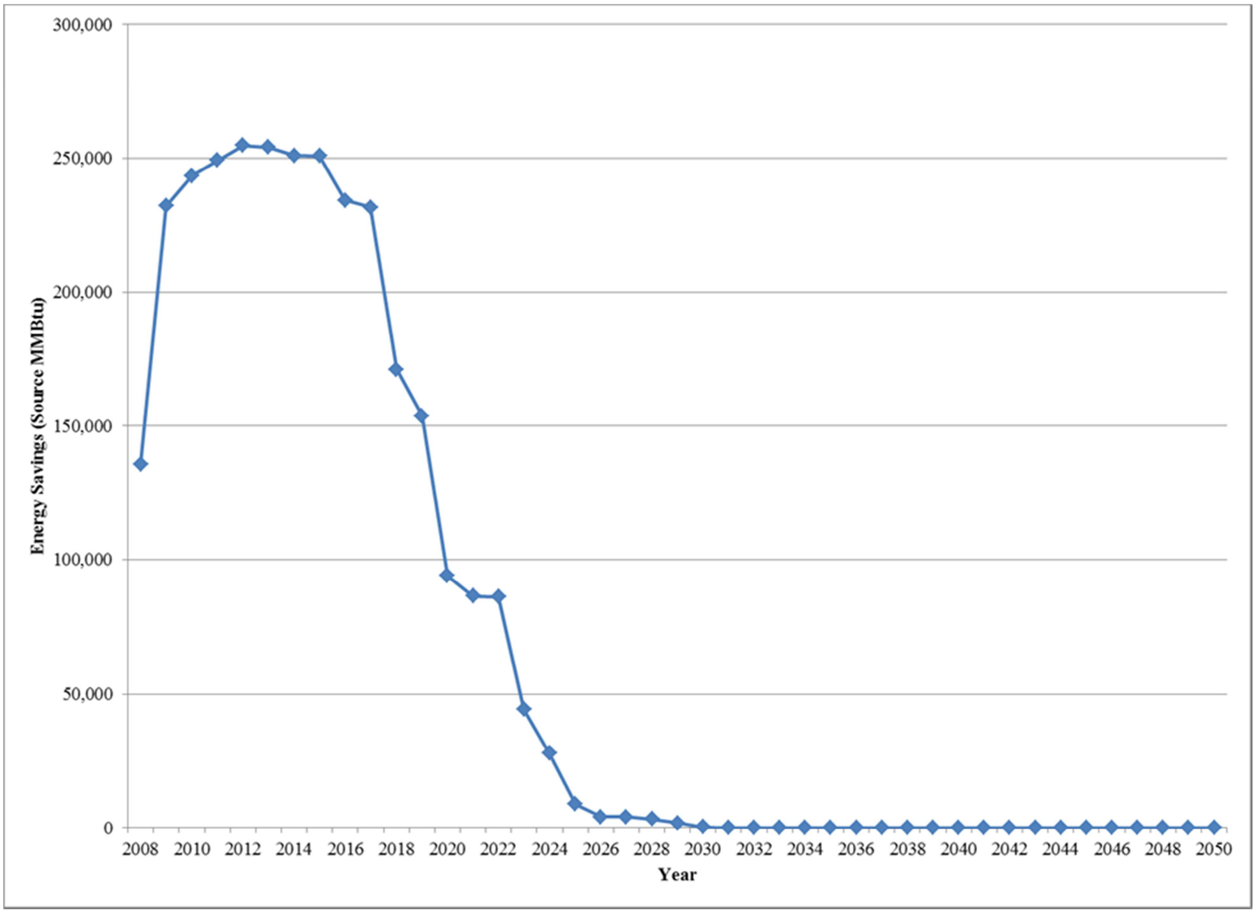

Figure 4-22: SEP-attributable energy savings from technical assistance BPAC activities by year (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

The studied portion of the PY 2008 Technical Assistance BPAC resulted in four thousand source MMBtu of SEP-attributable renewable generation over the 2008 to 2050 period. **Figure 4-23** shows the impacts over time. Generation impacts begin in 2009 and continue through 2033.

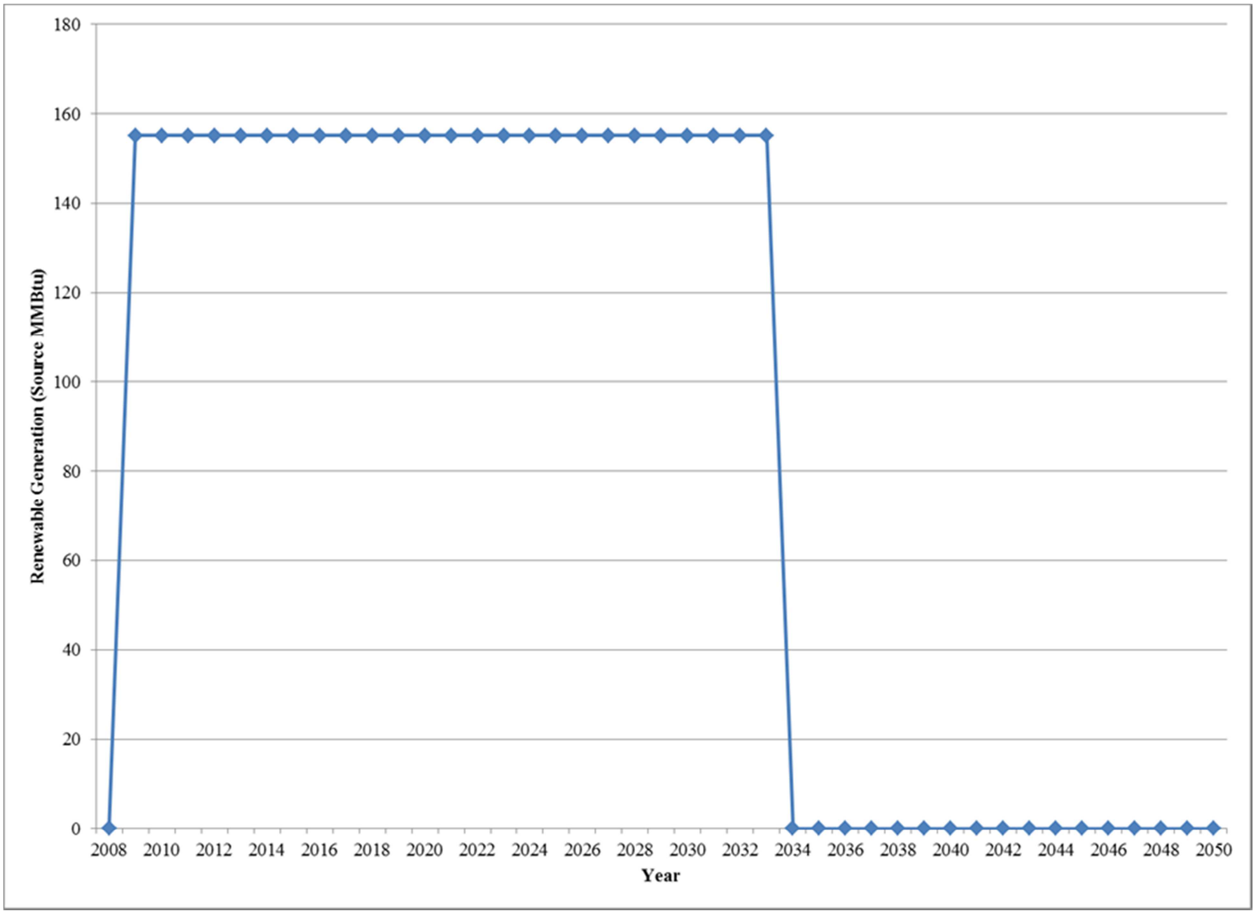

Figure 4-23: SEP-attributable renewable generation for technical assistance activities by year (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.2.4.2 Energy impacts by fuel type (technical assistance)

Table 4-22 and **Table 4-23** show the SEP-attributable energy savings and renewable generation in source MMBtu by fuel type.

Table 4-22 displays electricity savings of over 2.4 million source MMBtu and natural gas savings of about 559 thousand source MMBtu. As **Table 4-23** shows, the electric generation was four thousand source MMBtu.

Table 4-22: SEP-attributable energy savings for technical assistance activities by fuel type over time (source MMBtu)

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	88,483	180,608	191,035	196,516	202,064	201,418	1,165,582	234,234	-	-	2,459,940
Natural Gas	47,262*	51,305	52,119	52,413	52,413	52,413	219,060	31,974	-	-	558,960
Oil	-	-	-	-	-	-	-	-	-	-	-
Propane	-	291	291	291	291	291	1,997	814	-	-	4,265
Kerosene	-	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-	-
Other	-	60	60	60	60	60	361	-	-	-	662
Total	**135,745**	**232,264**	**243,506**	**249,280**	**254,829**	**254,182**	**1,387,000**	**267,022**	**-**	**-**	**3,023,828**

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

Table 4-23: SEP-attributable renewable generation for technical assistance activities by fuel type over time (source MMBtu)

	2008	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Renewable Electricity	-	155	155	155	155	155	1,086	1,552	466	-	3,880
Methane	-	-	-	-	-	-	-	-	-	-	-
Landfill Gas [50% CH4 /50% CO2]	-	-	-	-	-	-	-	-	-	-	-
Digester Gas	-	-	-	-	-	-	-	-	-	-	-
Biodiesel	-	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**155**	**155**	**155**	**155**	**155**	**1,086**	**1,552**	**466**	**-**	**3,880**

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

4.2.4.3 Energy impacts by sector (technical assistance)

Figure 4-24 displays the energy savings by sector over time. The majority of the energy savings occur in the public institutional and private institutional sectors, which both follow a similar savings trajectory. A relatively smaller amount of energy savings also occurs in the industrial sector.

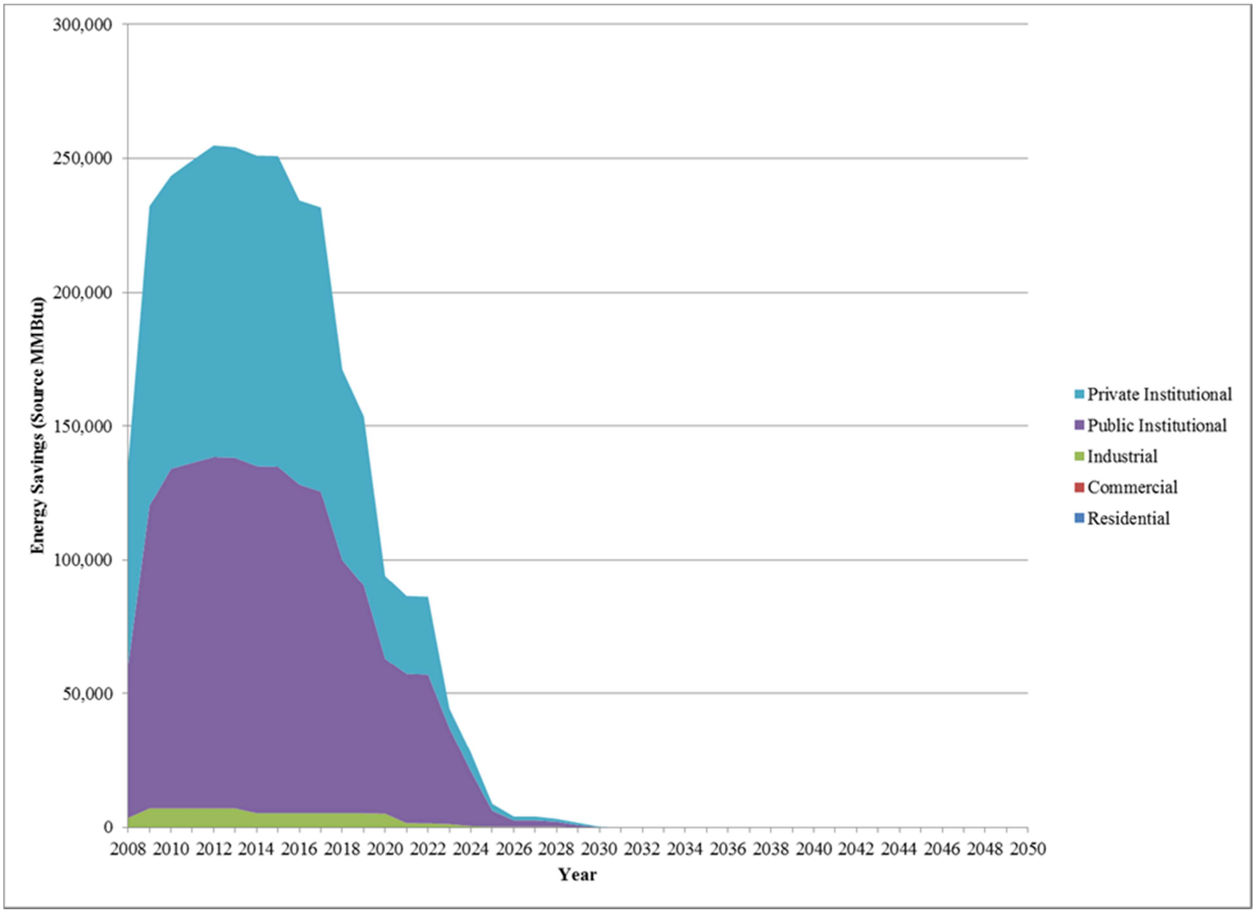

Figure 4-24: SEP-attributable energy savings for technical assistance activities by sector by year (source MMBtu)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-24 shows the total energy savings by sector in source MMBtu for the 2008 through 2050 period.

Table 4-24: SEP-attributable energy savings for technical assistance activities by sector (source MMBtu)

	SEP-Attributable Energy Savings 2008-2050
Residential	-
Commercial	-
Industrial	82,005
Public Institutional	1,609,773
Private Institutional	1,332,049*
Total	**3,023,828**

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

Figure 4-25 displays the renewable generation by sector over time. Renewable generation only occurs in the public institutional sector in the Technical Assistance BPAC.

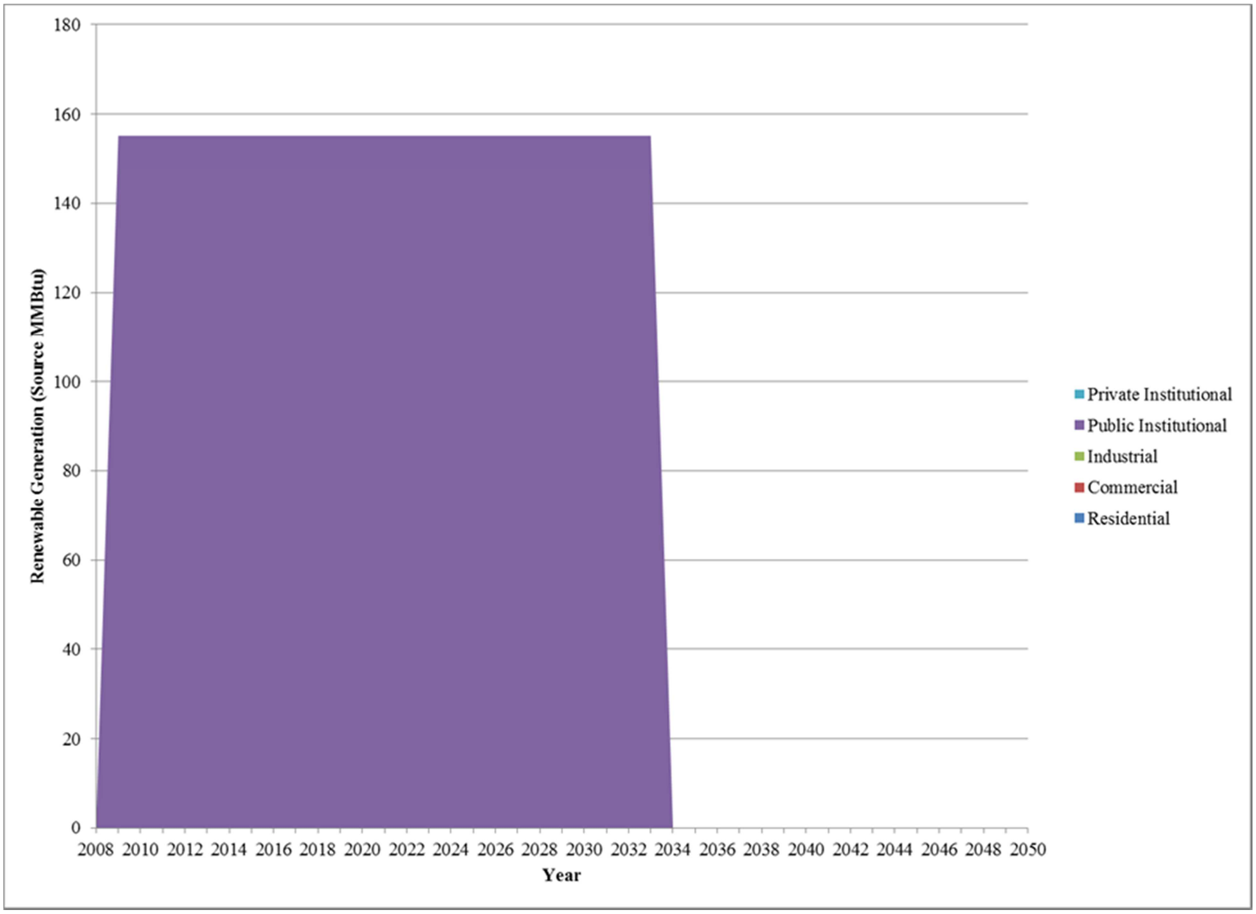

Figure 4-25: SEP-attributable renewable generation for technical assistance activities by sector over time (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-25 shows the total renewable generation by sector in source MMBtu. The public institutional sector had about four thousand source MMBtu of renewable generation.

Table 4-25: SEP-attributable renewable generation for technical assistance activities by sector (source MMBtu)

	SEP-Attributable Renewable Generation 2008-2050
Residential	-
Commercial	-
Industrial	-
Public Institutional	3,880
Private Institutional	-
Total	**3,880**

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

4.3 Labor (PY 2008)

This section addresses the labor impacts for each of the four PY 2008 BPACs studied in this evaluation. Labor impacts are presented in terms of jobs created by PY 2008 SEP activities.[79]

4.3.1 Clean energy policy support (PY 2008)

As shown in **Table 4-26**, the cumulative job-year impacts from the Clean Energy Policy Support BPAC for the U.S. through 2036 is 2,170. Bill savings are a significant driver of labor impacts. Before project-related costs, the industrial sector accrues the largest bill savings, worth $12 million cumulatively, followed by the commercial sector with $10 million in bill savings. The public institutional and residential sectors earn between $5 and $6 million in bill savings.

Table 4-26: Direct, indirect, and induced jobs created in the U.S. from the PY 2008 funded clean energy policy support SEP activities

	Direct, Indirect, and Induced Jobs (2008-2050)									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014-2020**	**2021-2030**	**2031-2040**	**2041-2050**	**Total**
Total	418	105	124	95	282	197	1,162	-206	-8	-	2,170

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

79 Labor impacts vary over time because REMI models economic impacts from sometimes variable evaluation input data, and responds dynamically to public expenditures and related events in the labor and capital markets across regions and over time, including feedbacks from regional changes to the business environment and the cost-of-living relative to surrounding regions. See Section 3.1.2 and Appendix H for more detailed information on the REMI model and the labor impacts methodology.

Figure 4-26 shows the total job impact for the entire interval over which bill savings and lower demand for gas and electricity persist. The spike in job impact for 2014 is reflective of the industrial sector incurring a reduction in the cost-of-doing business (conferring an up-tick in the relative competitiveness of the NAICS within the industrial sector) as a result of some averted clean energy project investment; this reduced cost was able to offset the cancellation of some U.S. manufactured orders and installation contracts. Between 2021 and 2024, job impacts taper across the various sectors as a result of a decay in their respective flows of bill savings.

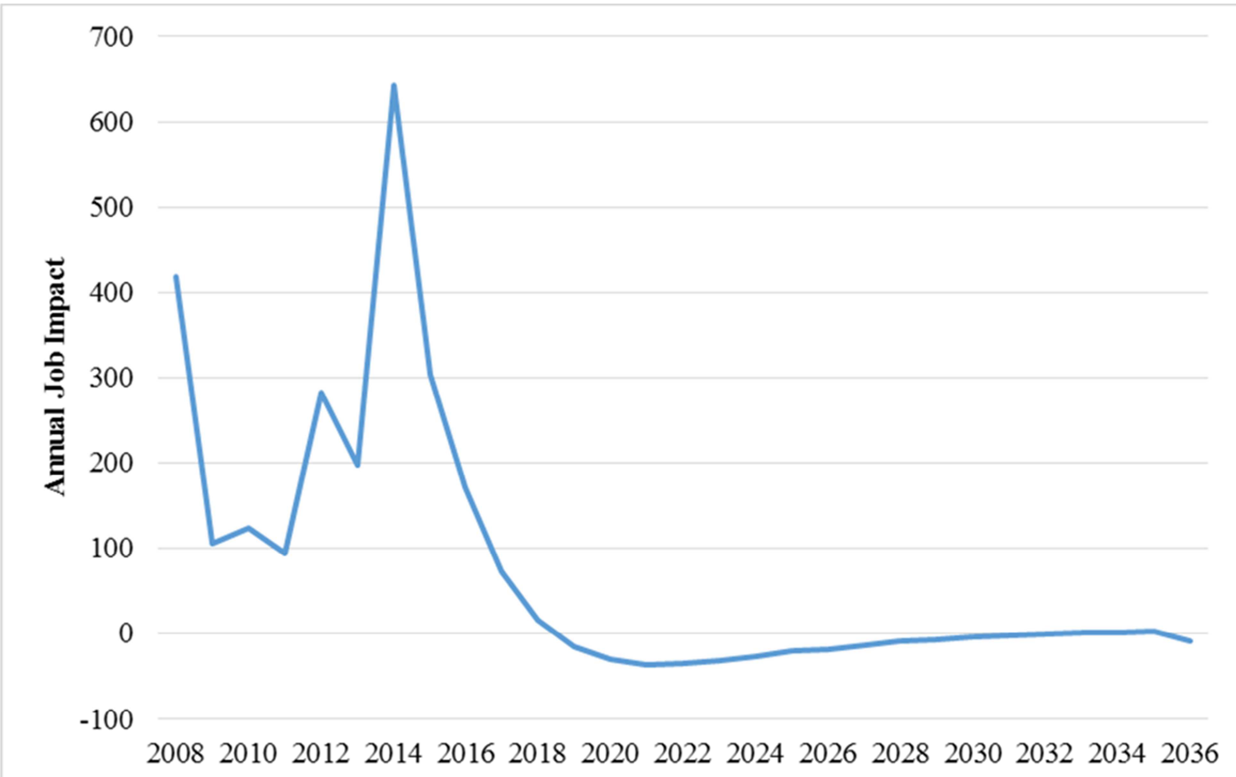

Figure 4-26: Direct, indirect, and induced job changes created in the U.S. from PY 2008 funded clean energy policy support SEP activities

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.
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Figure 4-27 shows the profile of job impacts by NAICS sector. In 2008, the key sectors related to project delivery (state administration, construction and professional, technical services for installation, and manufacturing) receive positive job impacts. Other sectors grow jobs through supply-chain relationships (the indirect multiplier effects) with any of the key project-influenced sectors, and some sectors experience job increases as a result of gains in household income initially related to the residential sector's bill savings. The positive interlude of this BPAC in the U.S. economy also supports wage growth (as direct jobs and positive multiplier jobs materialize) and this adds to household income growth, with more consumer spending requiring jobs from sectors such as retail, and health care.

Figure 4-27: Job Impact from PY 2008 funding into clean energy policy support activities, by NAICS sector

Despite program administration limited to 2008, participating sectors support additional labor contracts and U.S. manufactured equipment orders through 2012 (**Table 4-27**). The commercial, industrial, and public institutional sectors all have relatively high incentives, however. As mentioned previously, the reason for the negative direct job impacts in 2013 and 2014 is due to disinvestment in some clean energy projects that had been scheduled to take place. Had those projects gone forward, they would have supported installation jobs and some U.S. manufacturing jobs (see **Section** Error! Reference source not found. Energy Savings and Renewable Generation for PY 2008).

Table 4-27: Direct jobs created in the U.S. from the PY 2008 funding of clean energy policy support activities

Year	2008	2009	2010	2011	2012	2013	2014	Job-years
Total	133	13	29	25	37	-203	-209	-175

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

4.3.2 Building retrofits (PY 2008)

As shown in **Table 4-28**, for 2008 through 2025, when the public institutional sector's bill savings expire (accounting for 99.4 percent of the bill savings), some 272 job-years have been supported. Six of the eight U.S. regions had program participation in the public institutional sector. These positive jobs impacts are explained by job generating dynamics that occur when public agencies have more money to spend in the presence of lower gas and electricity demand.

Table 4-28: Direct, indirect, and induced jobs created in the U.S. from the PY 2008 funded building retrofit SEP activities

	Direct, Indirect, and Induced Jobs (2008-2025)										
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014-2020**	**2021-2030**	**2031-2040**	**2041-2050**	**Total**
Total	23	19	20	19	19	18	100	54	-	-	272

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

Figure 4-28 shows the total job impact for the entire interval over which bill savings and lower demand for gas and electricity persist. The dip in job impacts for 2019 is reflective of a moderating threshold effect on residential savings profiles for certain regions in the U.S. and similarly for the public institutional sector bill savings. During this period, bill savings to energy consumers diminish while energy demands to the utility sector increase. These two countervailing adjustments affect the macroeconomy at the same time by both reducing the amount of disposable income of program participants and increasing energy sales in the utilities sector. The public agency realm will curtail the added public spending which had been facilitated by the net bill savings, and the small residential participation will also see a curtailing of the added consumer activity. Both slow economic activity. However, the lifting of the demand loss for electricity and natural gas will trigger for the utility sector additional production, and if need be, depending on the region (an endogenous REMI model), an investment response.

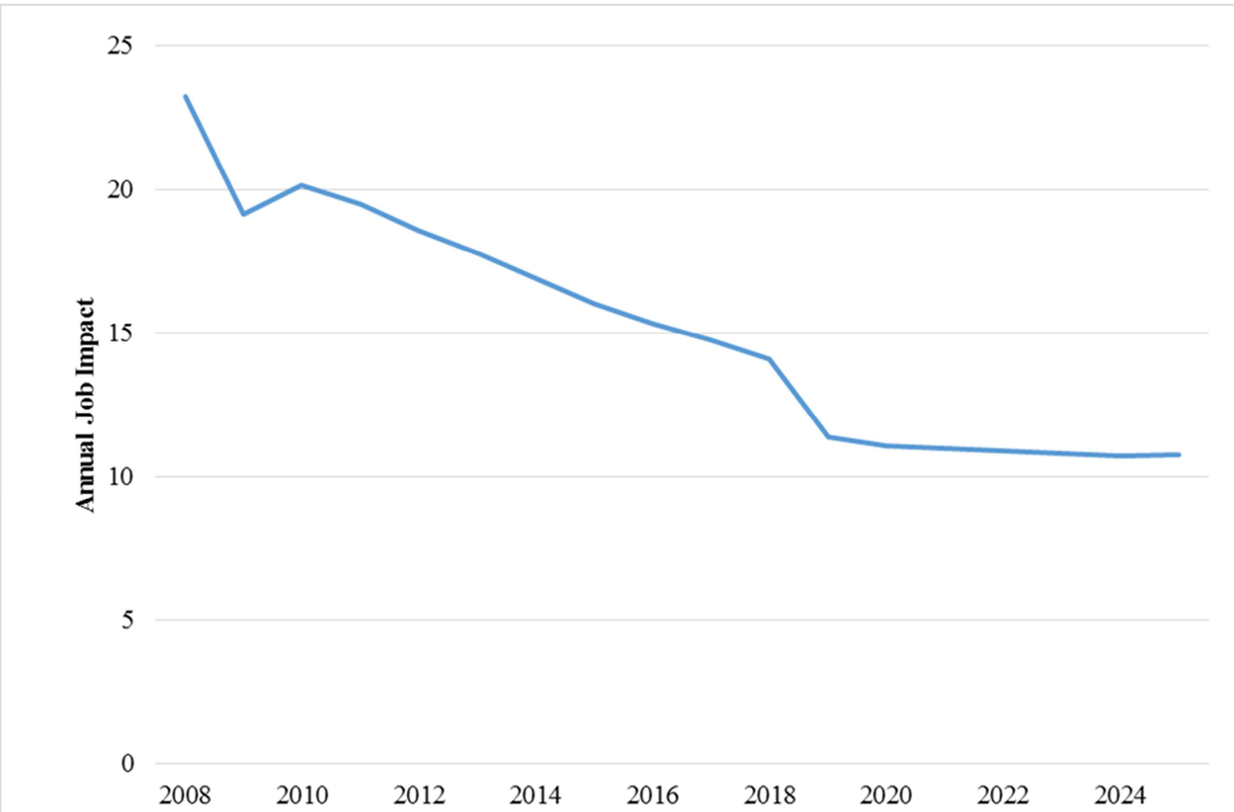

Figure 4-28: Direct, indirect, and induced job changes created in the U.S. from PY 2008 funded building retrofit SEP activities

A zero indicates the estimate rounds to zero and is considered imprecise.
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The profile of job changes by year and by sector across the U.S. is explained by several factors: who received direct benefits (either in the form of bill savings, or installation contracts or manufacturing orders), who might have incurred an offset (such as the one job forfeited in the utility sector in 2022), or which industries were affected through an indirect multiplier response (in light of being a secondary or tertiary supplier) or through an induced multiplier response. In this BPAC the key event is that public agencies have more dollars to spend supporting public programs as a result of bill savings. These additional dollars support State and Local government jobs (in 2022) as well as initial program administration in 2008. As more household income is created as a result of additional wages being paid, households can consume more as well, such as health care services, retail, and other consumer goods from those supplying sectors. This will require additional jobs from those sectors. Some of these same sectors are also in the supply-chain when public agencies make expenditures for their mix of public services. Therefore, the allocations shown for two select years captures a mix of job generating events – the direct and the multiplier effects. Since there was no involvement in this BPAC by for-profit businesses, there is little if any influence on the relative competitiveness of any specific industry within any of the regions with observed program participation.

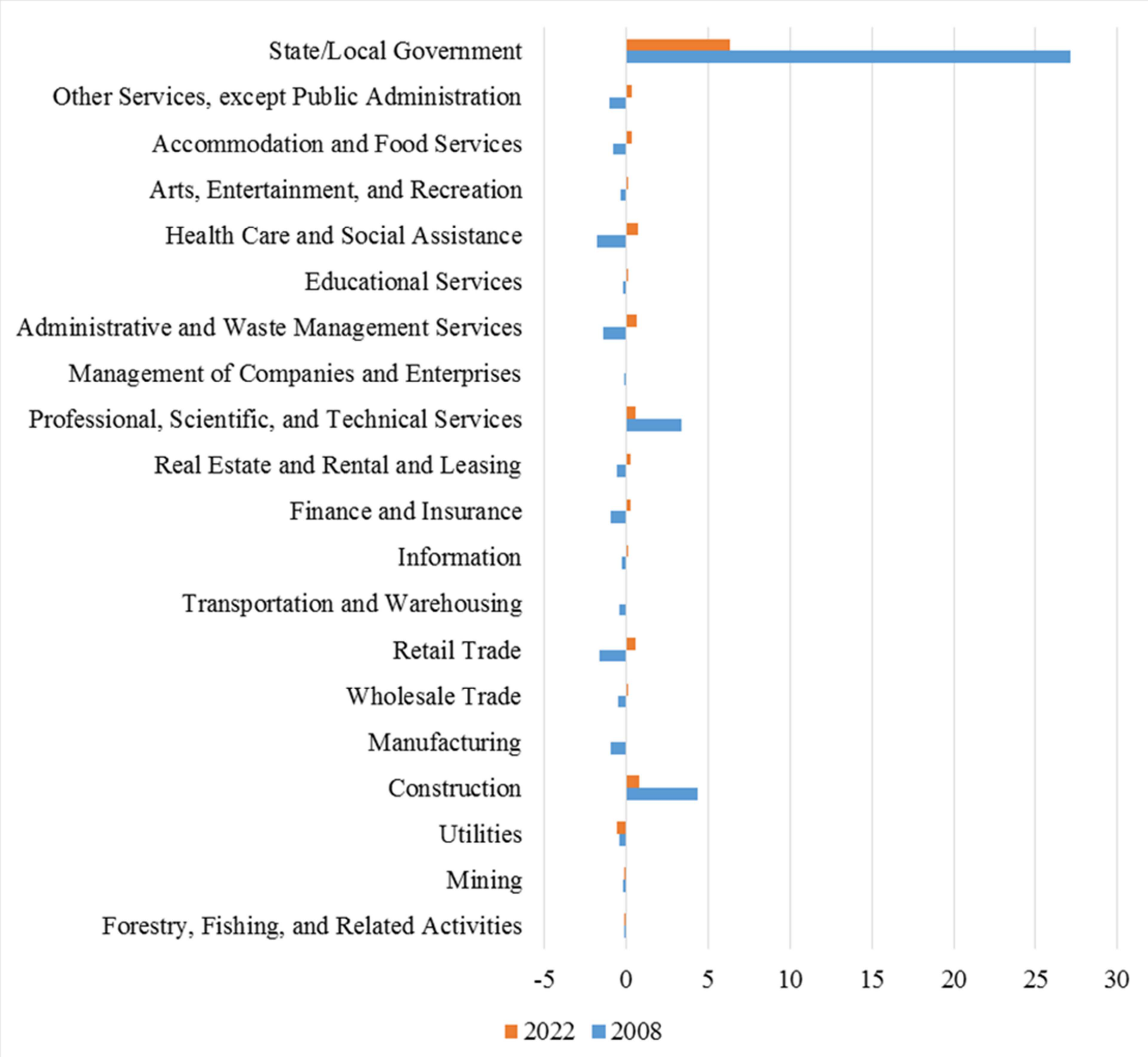

Figure 4-29: Job impact from PY 2008 funding into building retrofit SEP activities, by NAICS sector

The Building Retrofit SEP activities were predominantly contained in the public institutional sector. Public administration spending is contained to 2008, and only the public institutional sector incurs project costs (also in 2008) which are incentivized.

Table 4-29: Direct jobs created in the U.S. from the PY 2008 funding of building retrofit activities

Year	2008	2009	2010	2011	2012	2013	2014	Job-years
Total	48	-	-	-	-	-	-	48

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

4.3.3 Loans, grants, and incentives (PY 2008)

This BPAC accounted for $10 million of U.S. manufactured content and $5 million of labor contracts through 2022. Key customer sector participation included public institutional agencies with project costs after incentives valued at $11.7 million, with loan programs to cover capital. The industrial sector had project costs (no incentives) of $2.7 million for which loans were leveraged. The residential sector had project costs after incentives worth $0.2 million for which loans were leveraged. The commercial sector had project costs after incentives worth $0.12 million (no net bill savings were realized).

The job implications for the U.S. over the interval extending through 2048 is a loss of 922 job-years as shown in **Table 4-30**. This loss is due to revolving loan dynamics in six of seven participating regions, which sustained a small stream of public administration spending but no installation contracts or U.S. manufactured orders beyond 2022. Apart from the commercial sector, all other sectors carried loan repayment costs that exceeded annual bill savings; net bill savings were a loss in residential purchasing power of $1.2 million, a loss of public budget worth $25 million, and an increase in the cost-of-doing-business for the industrial sector worth $3 million, despite spending to make improvements.

Several factors explain the negative job impacts, but they all center on insufficient bill savings to offset the carrying costs of the programs themselves: (1) this PY 2008 BPAC included alternative fuel programs that, as intended, reduced carbon emissions impacts but did not result in substantial energy bill savings; (2) loan programs during PY 2008 offered interest rates that ranged from below market to above market, and the higher the interest rate the more disposable income is eroded from any realized bill savings; and (3) some programs used the loans or incentive funding to bring public sector buildings up to minimum energy efficiency standards, resulting in relatively low energy and bill savings.

Table 4-30: Direct, indirect, and induced jobs created in the U.S. from the PY 2008 funded loans, grants, and incentives SEP activities

	Direct, Indirect, and Induced Jobs (2008-2050)										
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014-2020**	**2021-2030**	**2031-2040**	**2041-2050**	**Total**
Total	25	-29	-33	-36	-40	-46	-377	-431	-7	52	-922

The job trajectory in **Figure 4-30** reflects the consideration of the net (after loan repayment costs) bill savings performance. By 2036, loan repayment costs are nearing zero as they are fully paid off for the industrial and public institutional sectors by 2038.

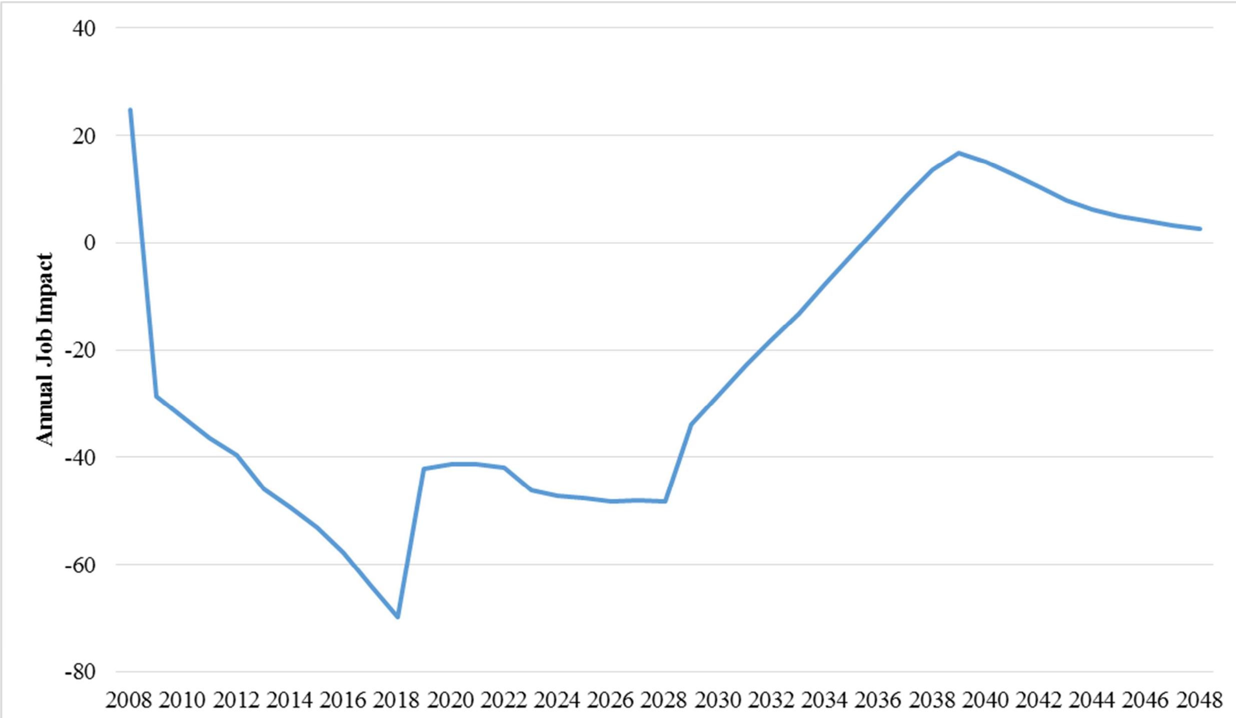

Figure 4-30: Direct, indirect, and induced job changes created in the U.S. from PY 2008 funded loans, grants, and incentives SEP activities

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.
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The distribution of jobs created in **Figure 4-31** depicts that 2008 is predominantly buoyant for the U.S. economy (with project-related spending) but the State/Local government sector carries an initially greater project-related cost than incentives or first year bill savings can defray (despite some State/Local employees to administer programs). By 2022, the pattern depicts an economy where project participants are absorbing project- related loan payments that exceed their bill savings in some cases. This is particularly true for the industrial customer sector (net costs after incentives were $2.7 million and dis-savings were $3 million when loan repayment streams are considered). The situation is similar for the public institutional sector (net costs after incentives were $11.7 million and dis-savings were $25 million). On a smaller scale, the residential sector expended $0.3 million for project costs but lost net $1.3 million, again the result of the loan repayment costs. The job reductions in 2022 is consistent with these high project costs with no energy bill savings benefits.

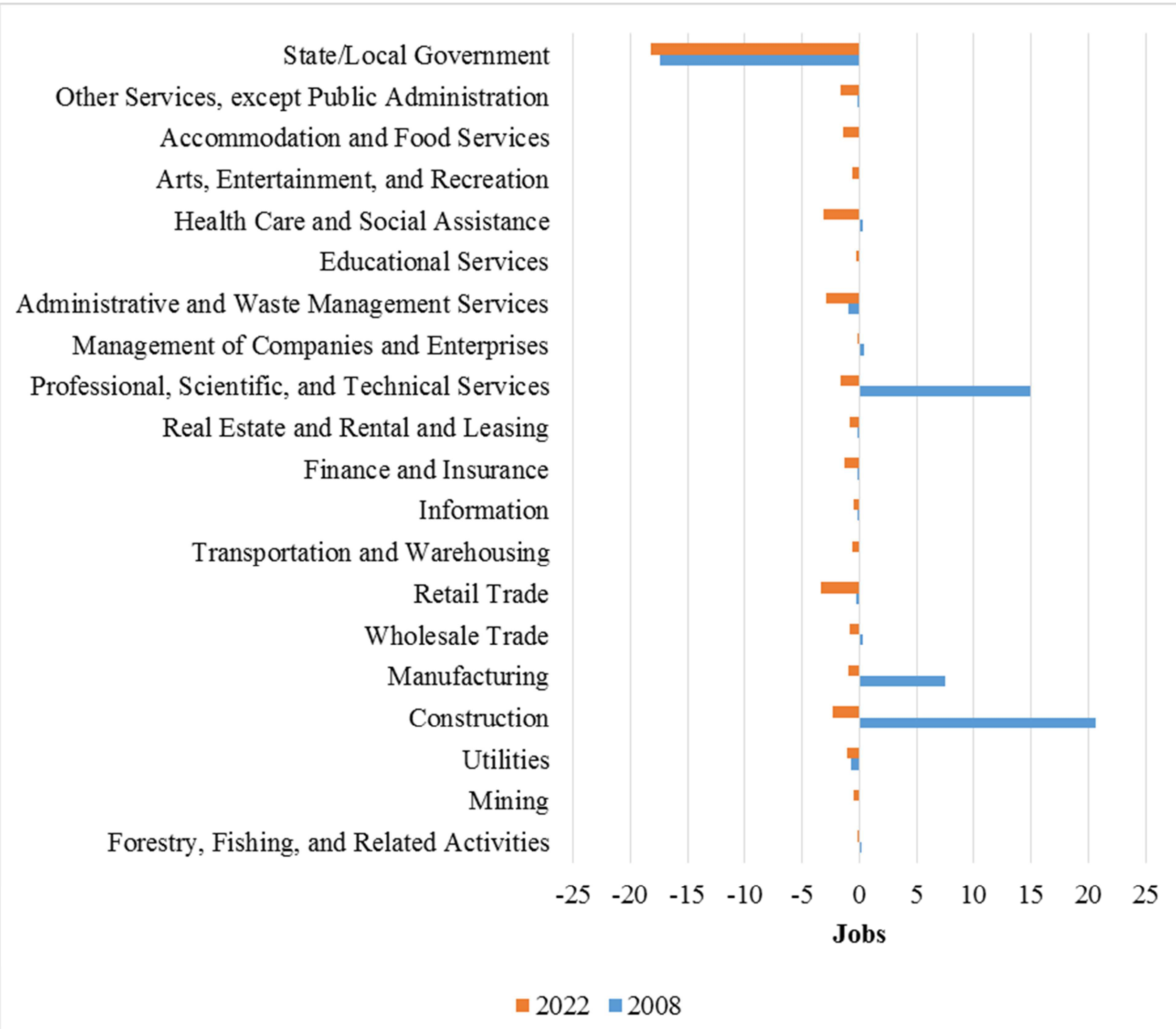

Figure 4-31: Job Impact from PY 2008 funding into loans, grants, and incentives SEP activities, by NAICS sector

For the seven regions that participated in this program, five had a revolving loan fund structure that extended program administrative expenditures through 2038 or 2048. Through 2014, the direct job-years associated with project activity covered by this BPAC was 84 jobs (**Table 4-31**).

Table 4-31: Direct jobs created in the U.S. from the PY 2008 loans, grants, and incentives funded activities

Year	2008	2009	2010	2011	2012	2013	2014	Job-years
Total	53	5	5	5	5	5	6	84

4.3.4 Technical assistance (PY 2008)

The job implications for the U.S. over the interval extending through 2033 is a gain of 525 job-years as shown in **Table 4-32**. This BPAC had participation from both public and private institutional sectors, and a small presence for the industrial sector. Three regions did not participate (the Mid East, the Southwest, and Rocky Mountain). There were not requirements to purchase U.S. manufactured goods nor labor contracts (program administration accomplished what direct program outcomes have been observed) as there were under ARRA. Bill savings persist until 2033 (related to the public institutional sector). The energy savings signal a reduction in regional demand for electricity and gas for those regions that participated in the BPAC.

Table 4-32: Direct, indirect, and induced jobs created in the U.S. from the PY 2008 funded technical assistance SEP activities

	Direct, Indirect, and Induced Jobs (2008-2050)									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014-2020**	**2021-2030**	**2031-2040**	**2041-2050**	**Total**
Total	205	40	41	39	35	33	145	-9	-4	-	525

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

After 2008 (the spike is jobs from project deployment expenditures), the job trajectory in **Figure 4-32** reflects three elements at work. First, the evaluation data show bill savings decay thresholds that in part explain the pattern. A small decay is noticeable in the data for 2018, again in 2020, and then annually from 2023 onward. By 2030, the private institutional bill savings expire. Second, the public institutional sector is the largest beneficiary with $14 million (of the total $24 million) in bill savings, followed by the private institutional sector ($9.6 million). The latter are health care and educational facilities. There are no competitiveness gains that would increase the "U.S. share of the global pie" when public agencies gain the ability to spend more. This is simply the result of public agencies not trading with other regions or countries. The $9.6 million of bill savings between health care and educational facilities does improve the job outlook, but the global competitiveness potential is limited since they are more local-serving and generally not export-base types of industries. Nonetheless, these bill savings will support jobs for these sectors and along their supply-chains, they just will be limited. Third, the reduction in regional demand for electricity and gas in light of bill savings dampens job generation in the utility sector.

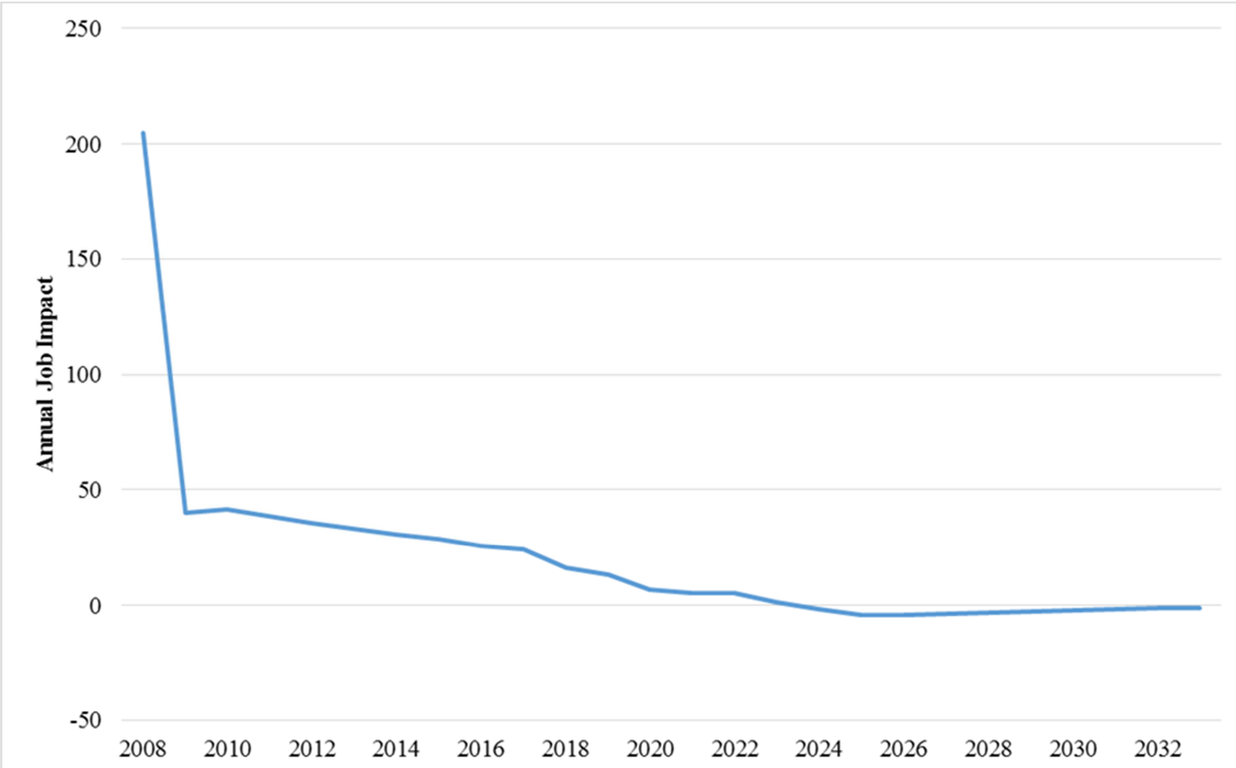

Figure 4-32: Direct, indirect, and induced job changes created in the U.S. from PY 2008 funded technical assistance SEP activities

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.
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The job allocation in **Figure 4-33** shows that in 2008 job requirements are spread over all the private sector industries, and that job requirements are greatest in the State and Local government sector due to initial program administration efforts. In 2022, there is little discernable job creation but there are small gains related to the presence of public institutional and private institutional bill savings (the portion allocated to Health Care facilities).

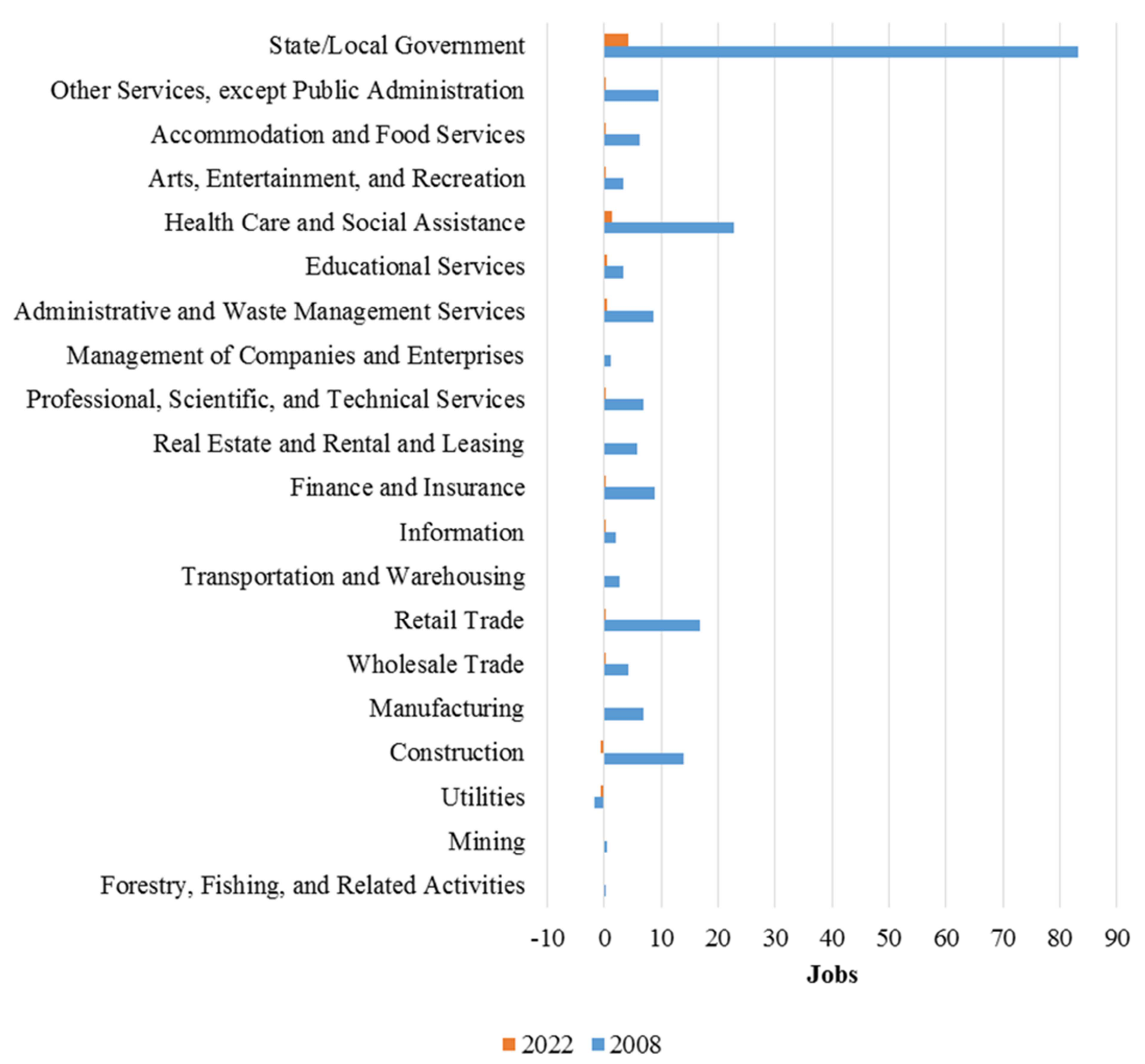

Figure 4-33: Job Impact from PY 2008 funding into technical assistance SEP activities, by NAICS sector

Table 4-33 shows that the direct jobs required (contained to 2008) are 67 for the entire U.S. These are jobs associated with the program administration spending.

Table 4-33: Direct jobs created in the U.S. from the PY 2008 technical assistance funded activities

Year	2008	2009	2010	2011	2012	2013	Job-years
Total	67	-	-	-	-	-	67

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

4.4 Avoided carbon emissions and avoided social cost estimated (PY 2008)

This section addresses avoided carbon emissions and avoided social cost impacts for each of the four PY 2008 BPACs studied in this evaluation. The avoided emissions impacts are all reported in million metric tons of carbon equivalent (MMTCE). The avoided social costs are reported in 2009 dollars.

4.4.1 Clean energy policy support (PY 2008)

4.4.1.1 Avoided carbon emissions (Clean Energy Policy Support)

Avoided carbon emissions from the Clean Energy Policy Support BPAC are derived from energy savings and energy displaced from renewable generation. As shown in **Figure 4-34**, avoided carbon emissions from Clean Energy Policy Support BPAC activities total .20 MMTCE, where 0.12 avoided MMTCE comes from energy displaced from renewable generation and 0.08 avoided MMTCE result from energy savings.

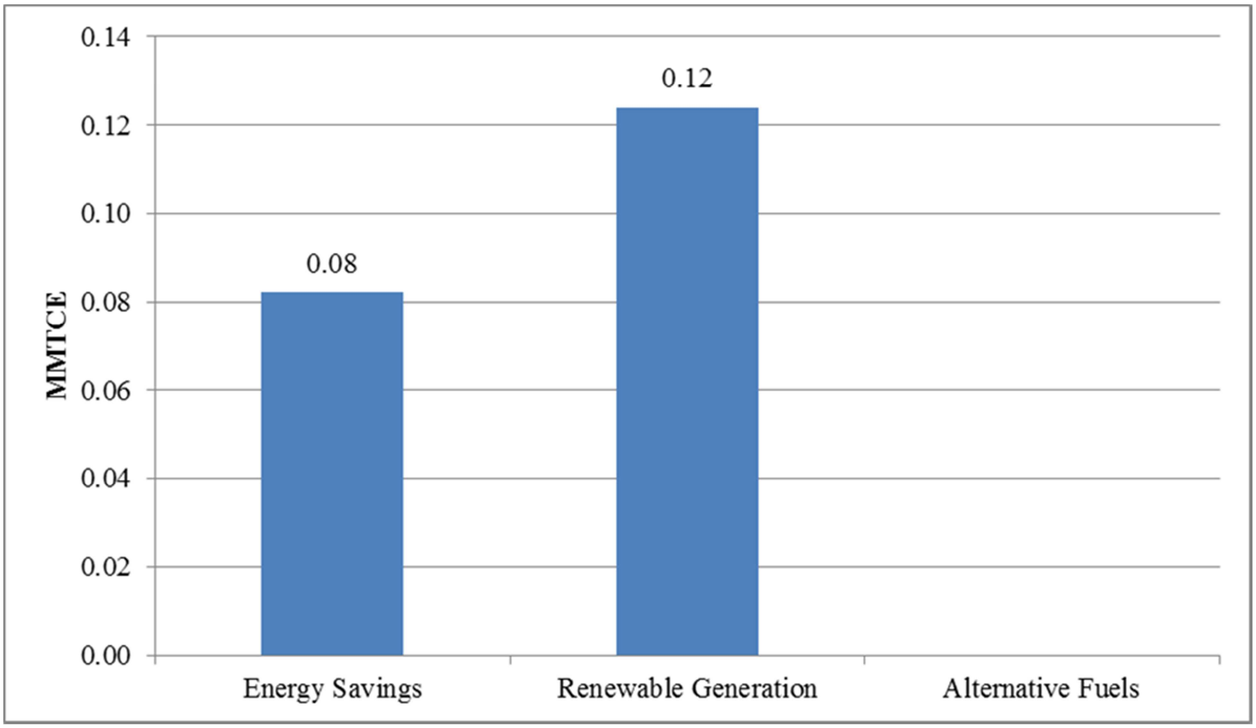

Figure 4-34: Avoided carbon emissions for Clean Energy Policy Support activities by program mechanism (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-35 shows SEP-attributable avoided carbon emissions over time from Clean Energy Policy Support programmatic activities in MMTCE. Avoided carbon emissions rise quickly from 2008, peak in 2012 and 2013, and fall over time to 2038, after the impacts of all programmatic activities have ceased. Similar and related to the renewable generation impact stream, the total impacts turn negative in 2037 as described in **Section 4.2.1.1** Impact estimates return to zero in 2045 as the effective useful lives of installed technologies end.

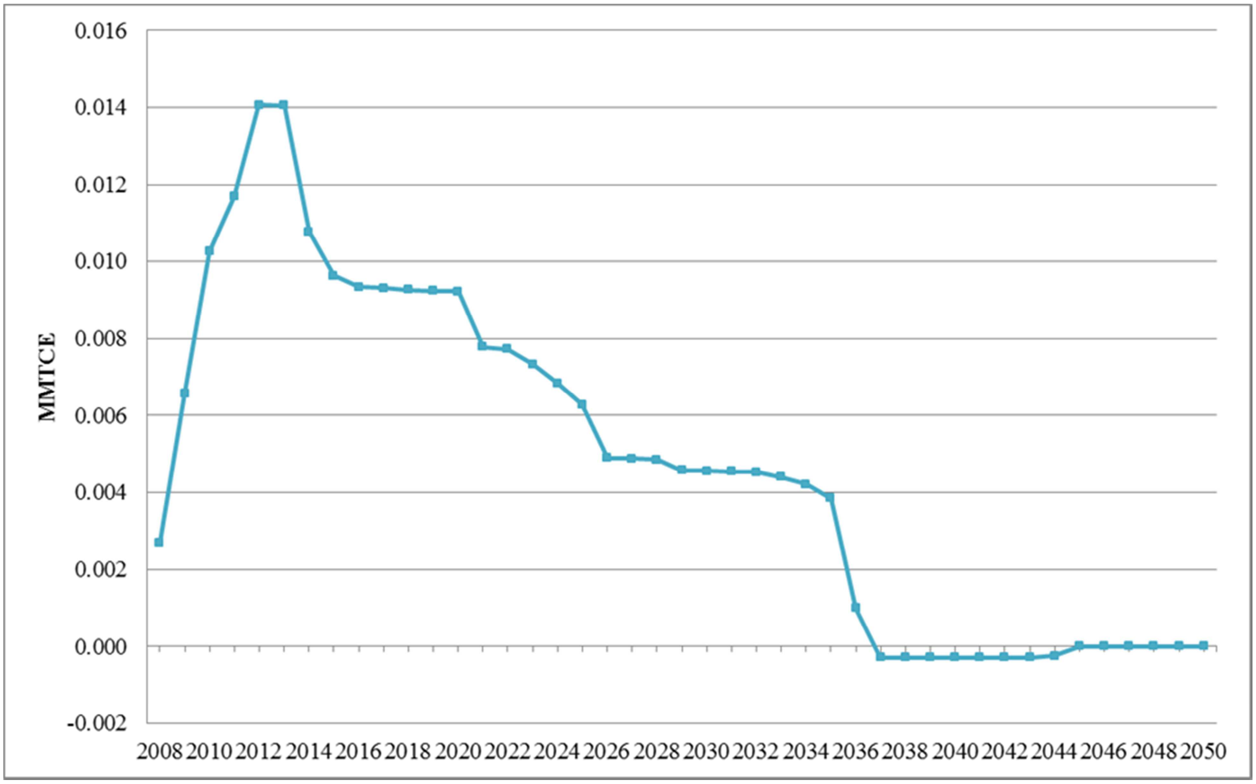

Figure 4-35: Avoided carbon emissions from clean energy policy support activities over time (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Over the lifetime of energy impacts, avoided carbon emissions are presented by sector in **Figure 4-36**. The commercial sector accounts for the largest amount of avoided MMTCEs (0.08 MMTCEs), followed by industrial (0.07), and then the residential and public institutional sectors (0.03 each).

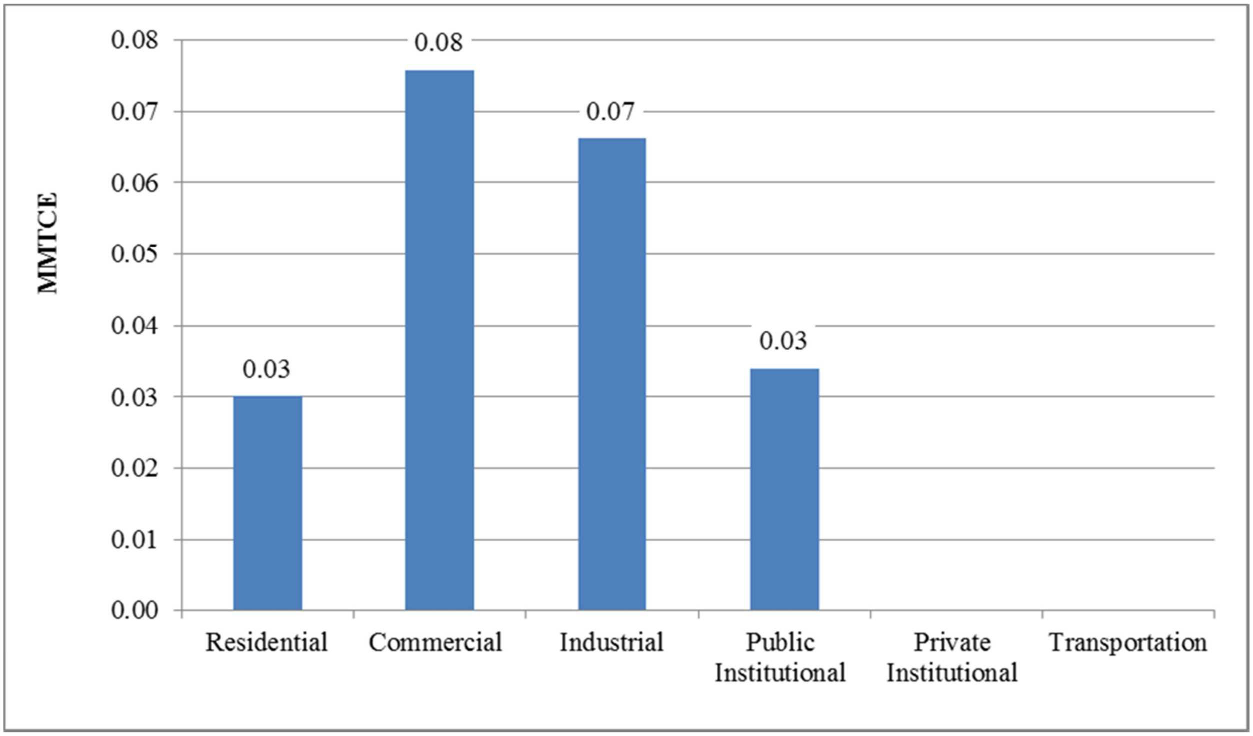

Figure 4-36: Avoided lifetime carbon emissions from clean energy policy support activities by sector (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.4.1.2 Avoided social costs of carbon (clean energy policy support)

As shown below in **Figure 4-37**, avoided social costs from carbon total approximately $13.5 million. Energy displaced from renewable generation accounts for the majority of the avoided social costs at $8.5 million, followed by energy savings at about $5 million.

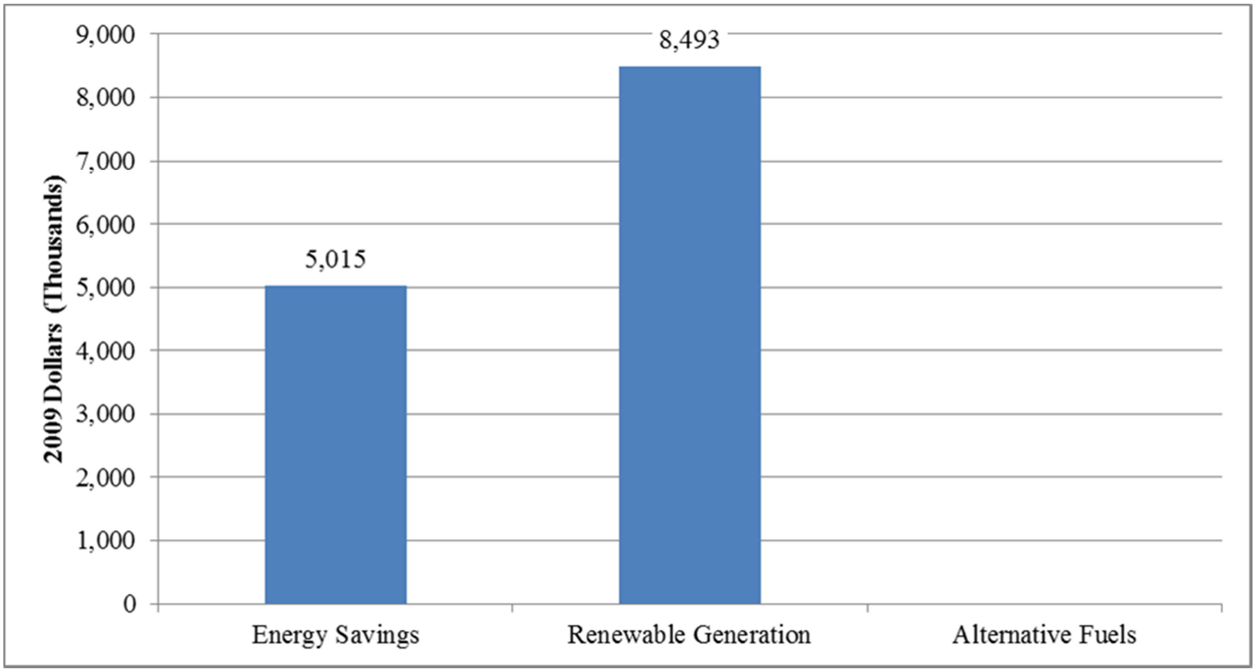

Figure 4-37: Avoided social costs of carbon emissions from clean energy policy support activities by program mechanism (thousands of 2009$)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided social costs of carbon over time are presented in **Figure 4-38** for the Clean Energy Policy Support BPAC. Similar to the pattern of avoided carbon emissions, the associated avoided social costs rise quickly but peak in 2013, and decline over time as various technologies' reach the end of their expected useful lives. At the end of the cost stream, the total impacts turn negative in 2037 as described in **Section 4.2.1.1**.

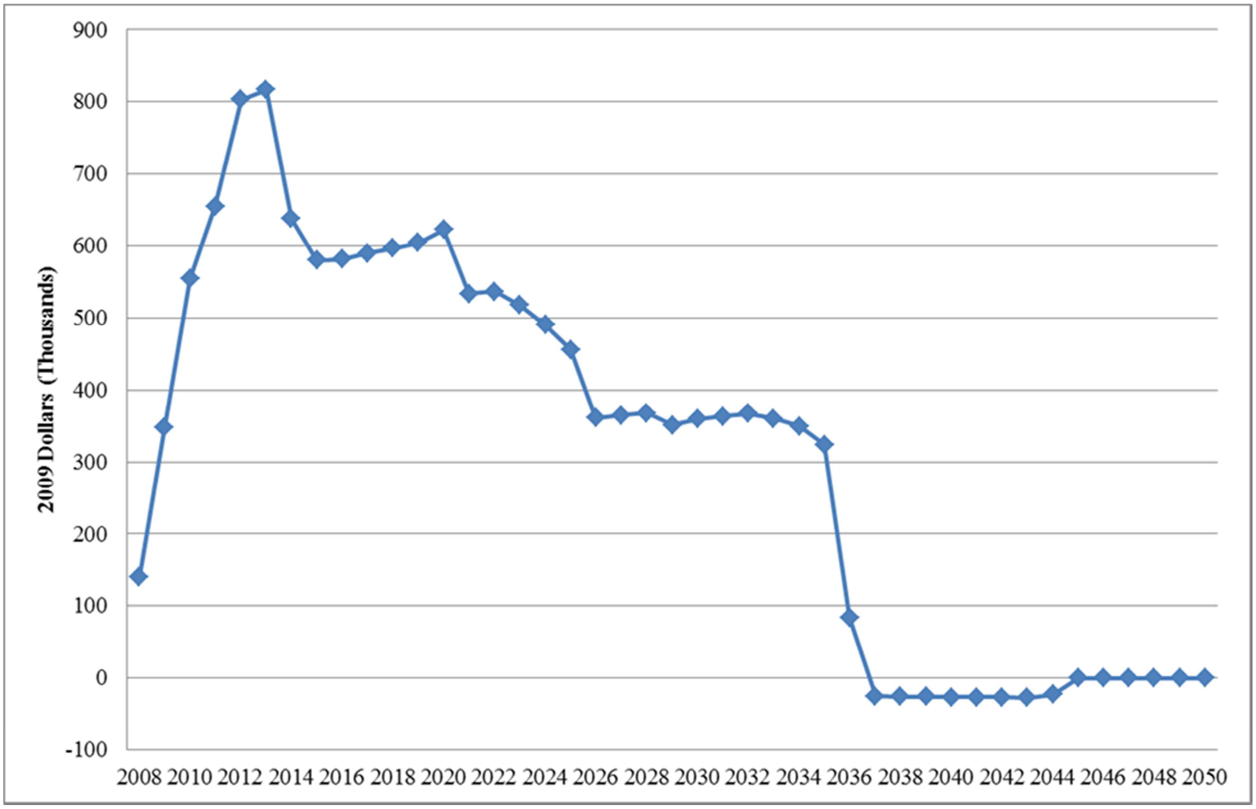

Figure 4-38: Avoided social costs of carbon from clean energy policy support activities over time (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-39 shows how those avoided social costs of carbon distribute across sectors. The commercial sector realizes the most avoided costs at $5.2 million dollars, followed by the industrial sector ($4.4 million), the public institutional sector ($2.1 million) and the residential sector ($1.7 million).

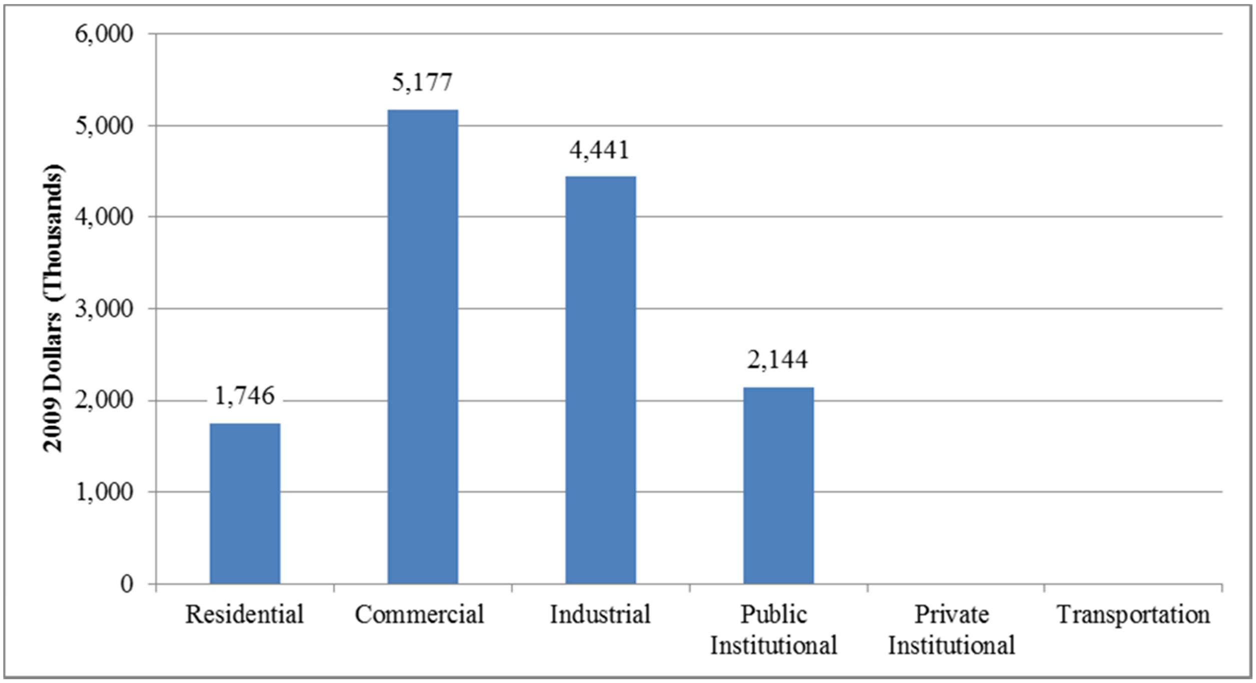

Figure 4-39: Avoided lifetime social costs of carbon from clean energy policy support activities by sector (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.4.2 Building retrofits (PY 2008)

4.4.2.1 Avoided carbon emissions (building retrofits)

Avoided carbon emissions from the Building Retrofits BPAC are derived from energy savings. As shown in **Figure 4-40**, avoided carbon emissions from Building Retrofits BPAC activities total 0.09 MMTCE.

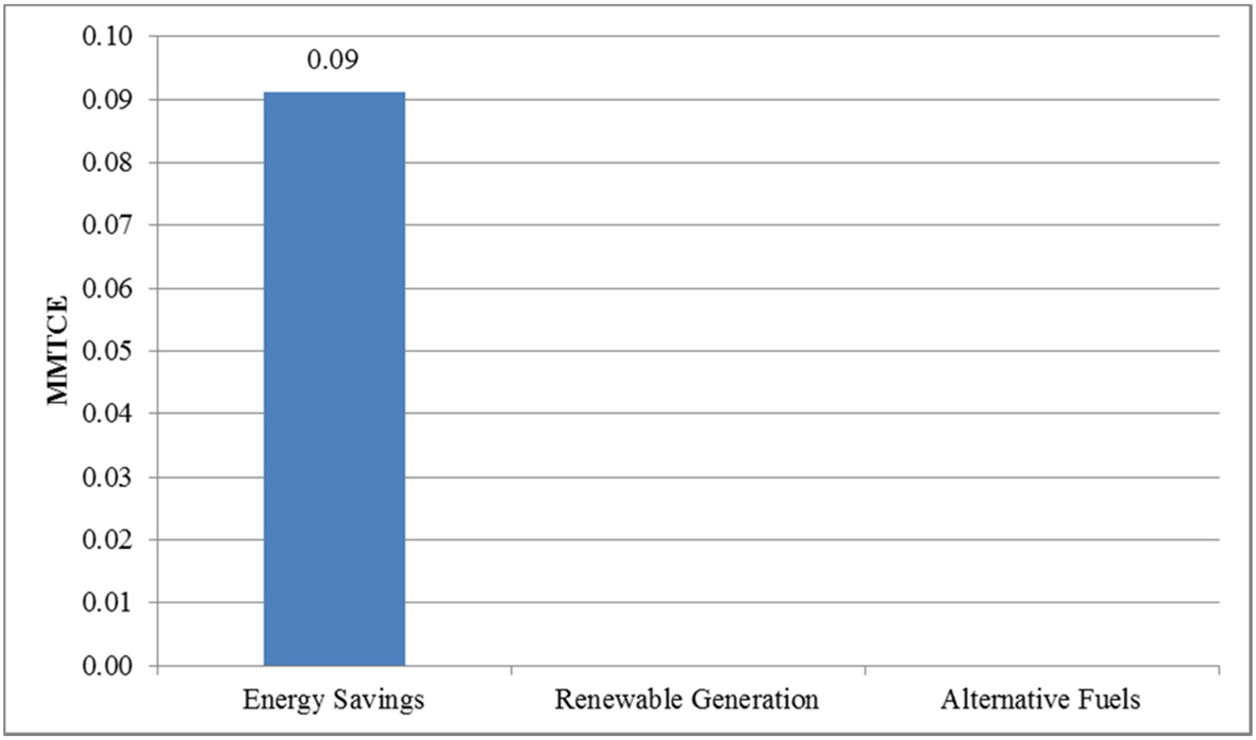

Figure 4-40: Avoided carbon emissions for building retrofits by program mechanism (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-41 shows SEP-attributable avoided carbon emissions over time from Building Retrofit programmatic activities in MMTCE. Avoided carbon emissions rise quickly from 2008, reach a peak in 2009 and 2010, and then begin to drop off over time. In 2026, savings drop quickly, but a low level of avoided carbon emissions persist through 2035.

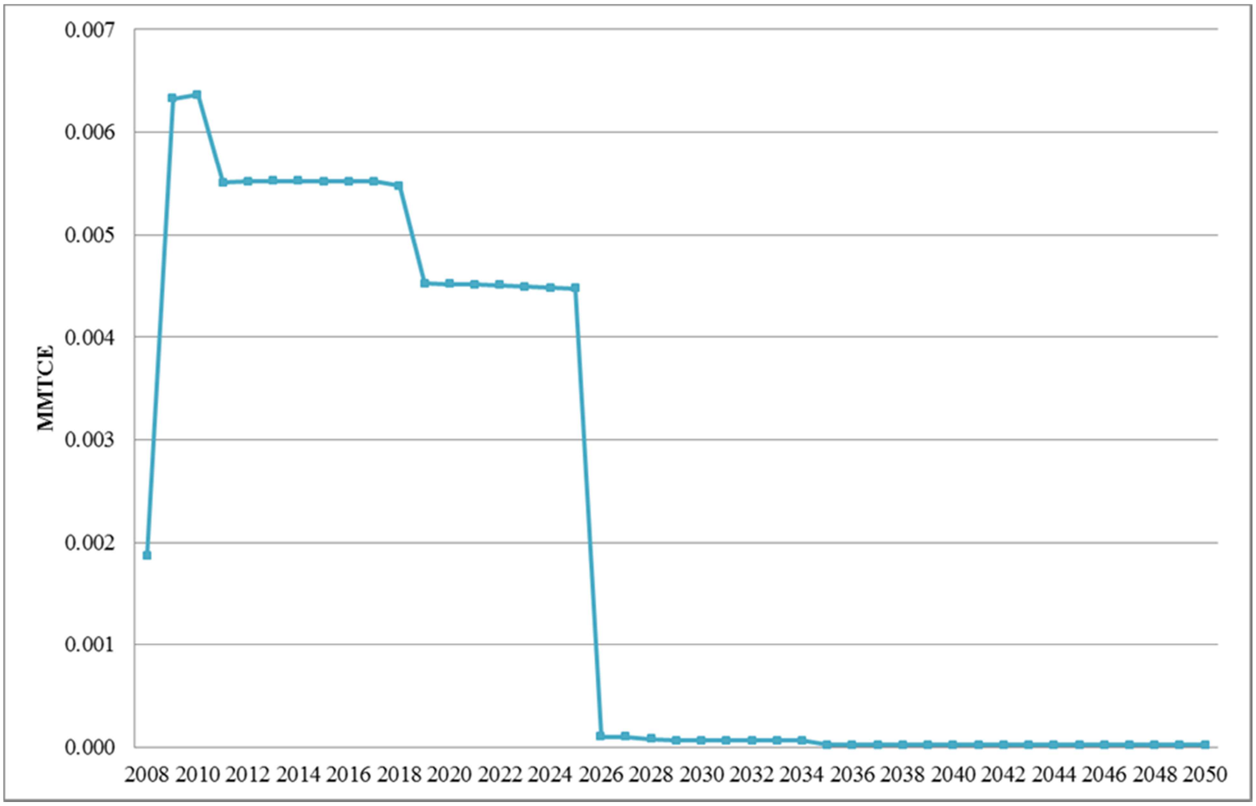

Figure 4-41: Avoided carbon emissions from building retrofits activities over time (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided carbon emissions over the lifetime of energy impacts, by sector, are presented in **Figure 4-42**. The public institutional sector accounts for the largest amount of avoided MMTCE (0.09 MMTCE), followed by the residential sector, which had less than 0.01 MMTCE.

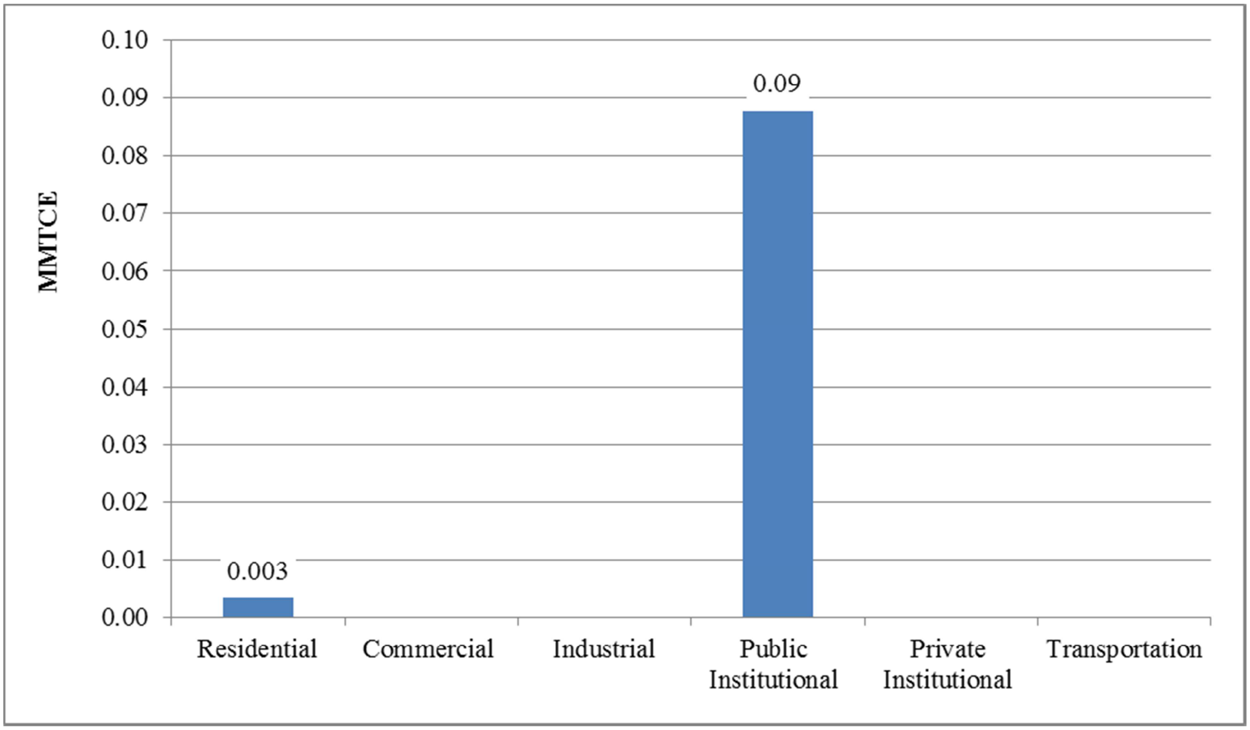

Figure 4-42: Avoided lifetime carbon emissions from building retrofits activities by sector (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.4.2.2 Avoided social costs of carbon (Building Retrofits)

As shown below in **Figure 4-43**, energy savings account for all of the $5.7 million of avoided social costs.

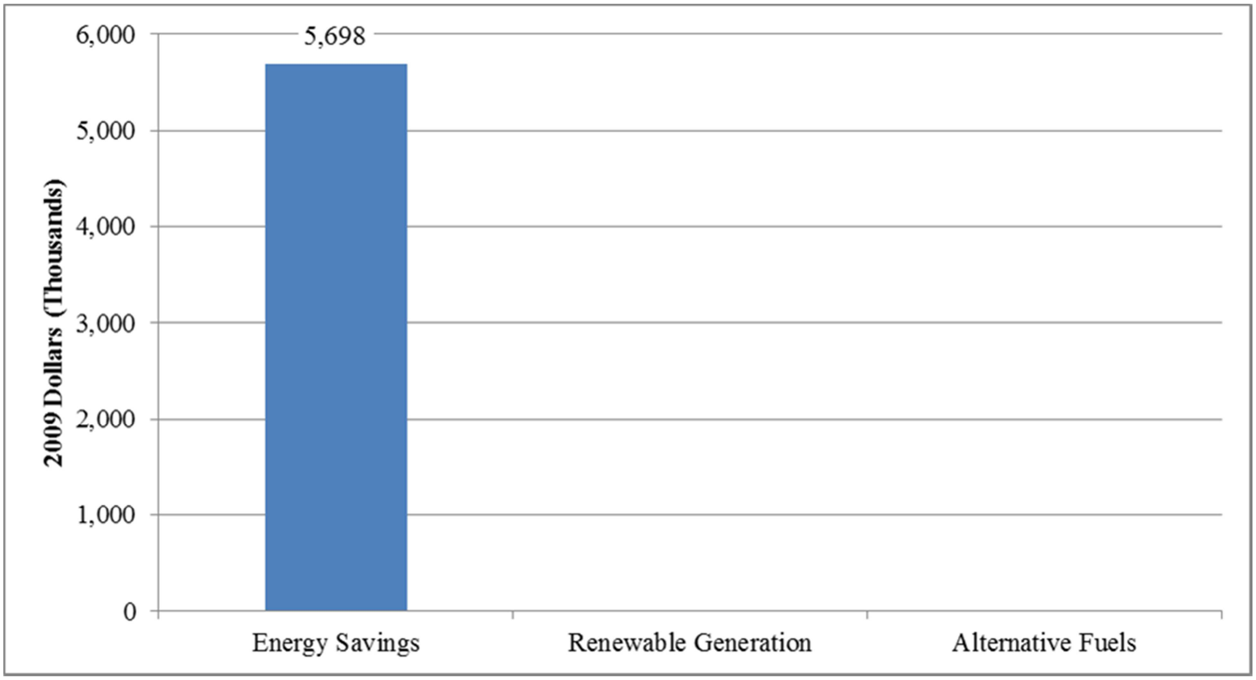

Figure 4-43: Avoided social costs of carbon emissions for building retrofits activities by program mechanism (thousands of 2009$)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-44 shows SEP-attributable avoided social costs of carbon emissions over time from Building Retrofit programmatic activities in MMTCE. The associated avoided social costs of carbon rise for an initial peak in 2010, then fall and rise again twice, in line with the drops in avoided carbon emissions. Finally, in 2026, the avoided social costs quickly decline over time as most technologies reach the end of their expected useful lives. Small amounts of avoided social costs do persist through 2050, the end of the study's evaluation period.

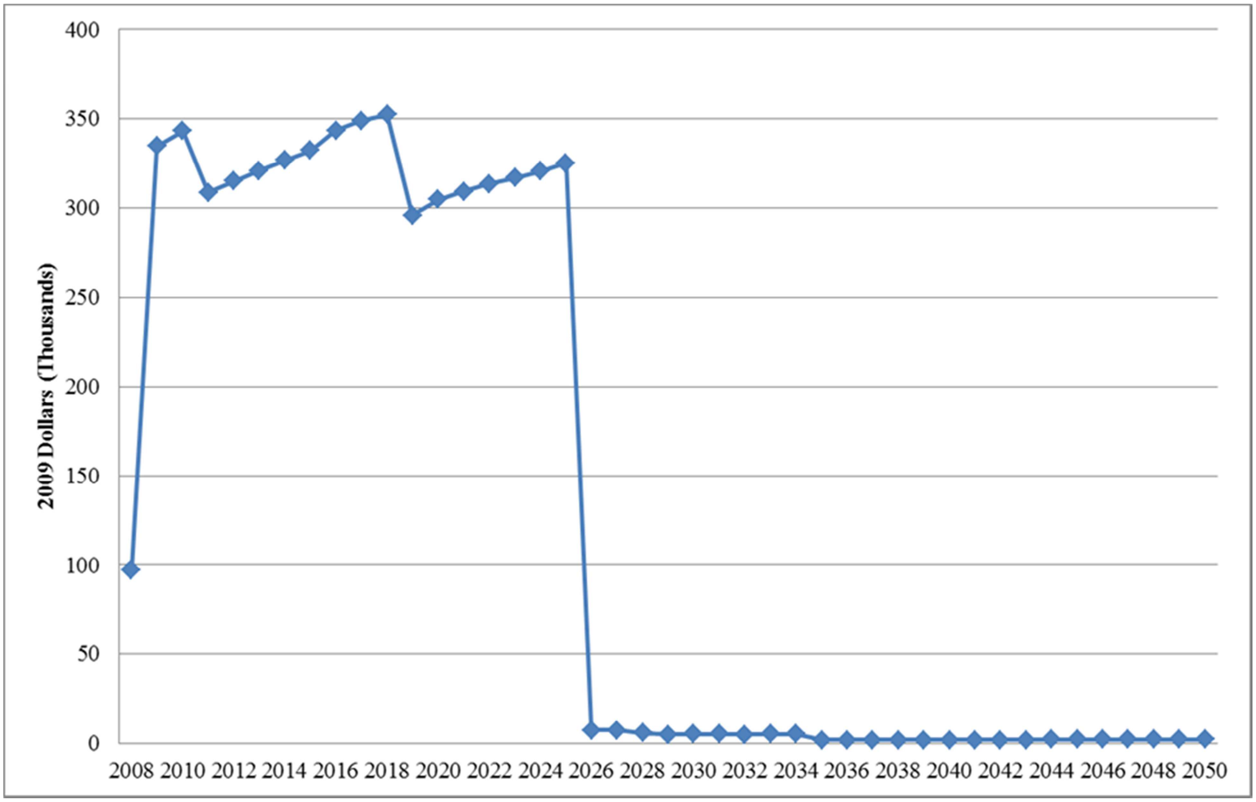

Figure 4-44: Avoided social costs of carbon from building retrofits activities over time (thousands of 2009$)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-45 shows how those avoided social costs of carbon distribute across sectors. The public institutional sector realizes the most avoided costs at $5.5 million dollars, followed by the residential sector ($237 thousand).

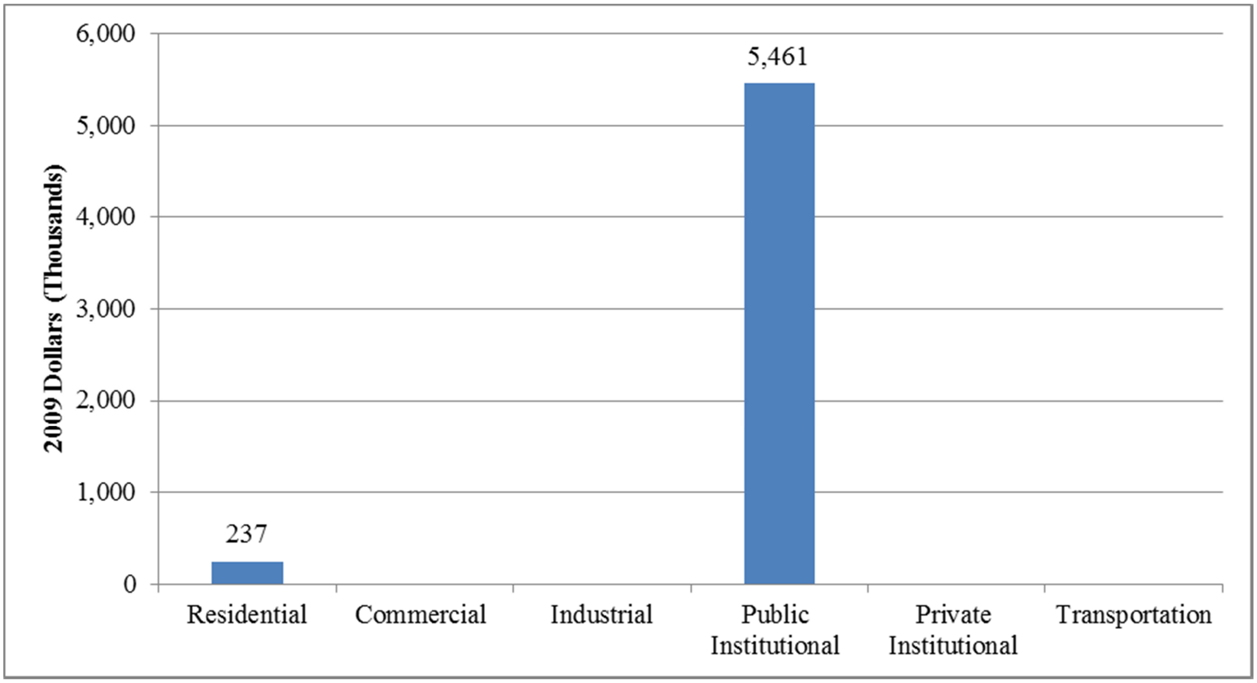

Figure 4-45: Avoided lifetime social costs of carbon from building retrofits activities by sector (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.4.3 Loans, grants, and incentives (PY 2008)

4.4.3.1 Avoided carbon emissions (loans, grants, and incentives)

As shown in **Figure 4-47**, avoided carbon emissions from Loans, Grants, and Incentives BPAC activities total 0.16 MMTCE, which are derived almost exclusively from energy savings at 0.15 MMTCE, with about 0.01 MMTCE coming from direct carbon as a result of alternative fuels.

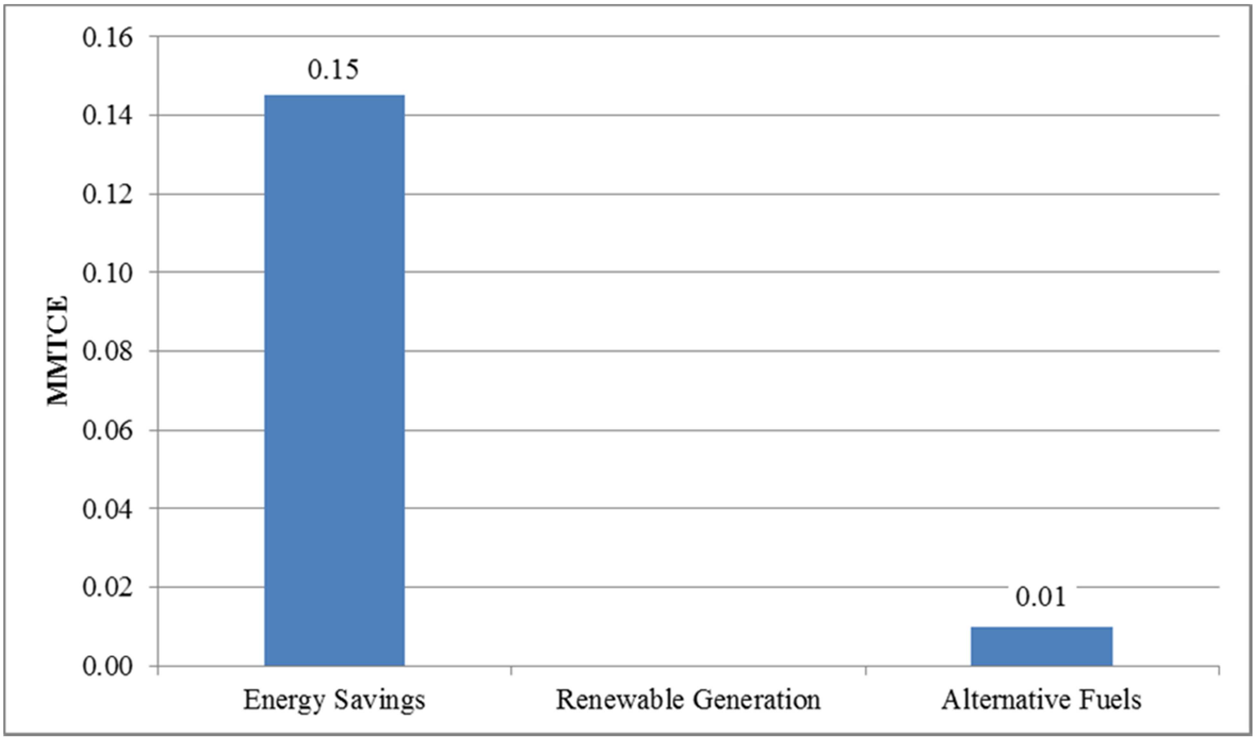

Figure 4-46: Avoided carbon emissions for loans, grants, and incentives by program mechanism (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-47 shows SEP-attributable avoided carbon emissions over time from Loans, Grants, and Incentives programmatic activities in MMTCE. Avoided carbon emissions rise from 2008 through 2030, and fall gradually over time through 2050, the end of the study period for this evaluation.

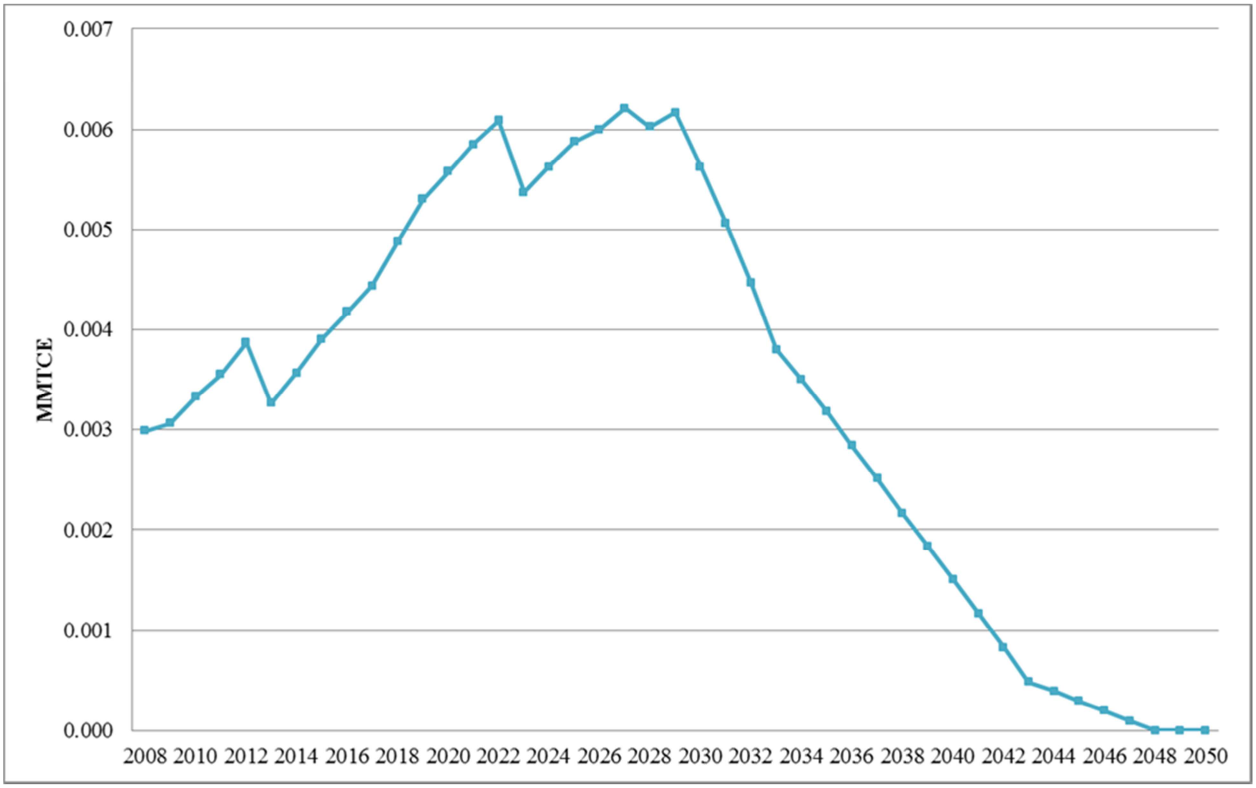

Figure 4-47: Avoided carbon emissions from loans, grants, and incentives activities over time (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided carbon emissions over the lifetime of energy impacts are presented by sector in **Figure 4-48**. The public institutional sector accounts for the largest amount of avoided MMTCEs (0.14 MMTCEs), followed by the transportation and residential sectors (.01 MMTCEs).

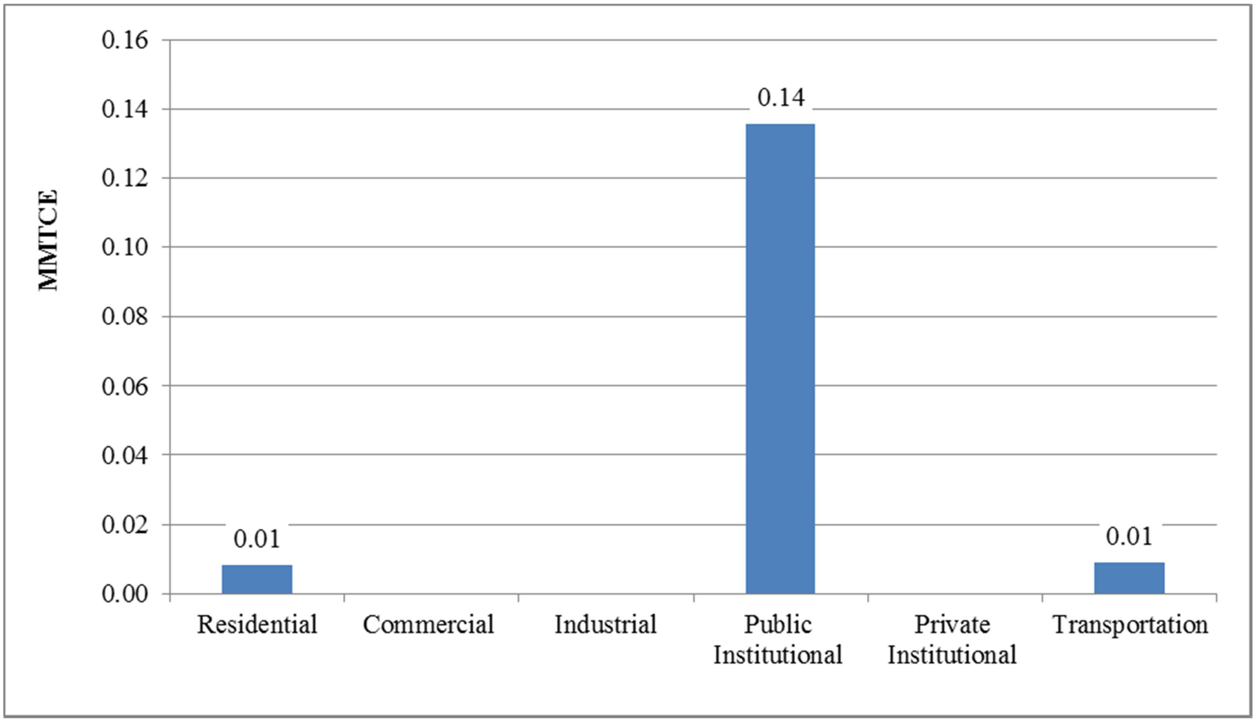

Figure 4-48: Avoided lifetime carbon emissions from loans, grants, and incentives activities by sector (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.4.3.2 Avoided social costs of carbon (loans, grants, and incentives)

As shown below in **Figure 4-49**, total avoided social costs of carbon are approximately $11.0 million. Energy savings account for the vast majority of the cumulative avoided social costs at $10.4 million, with a smaller amount coming from direct carbon reductions from alternative fuels.

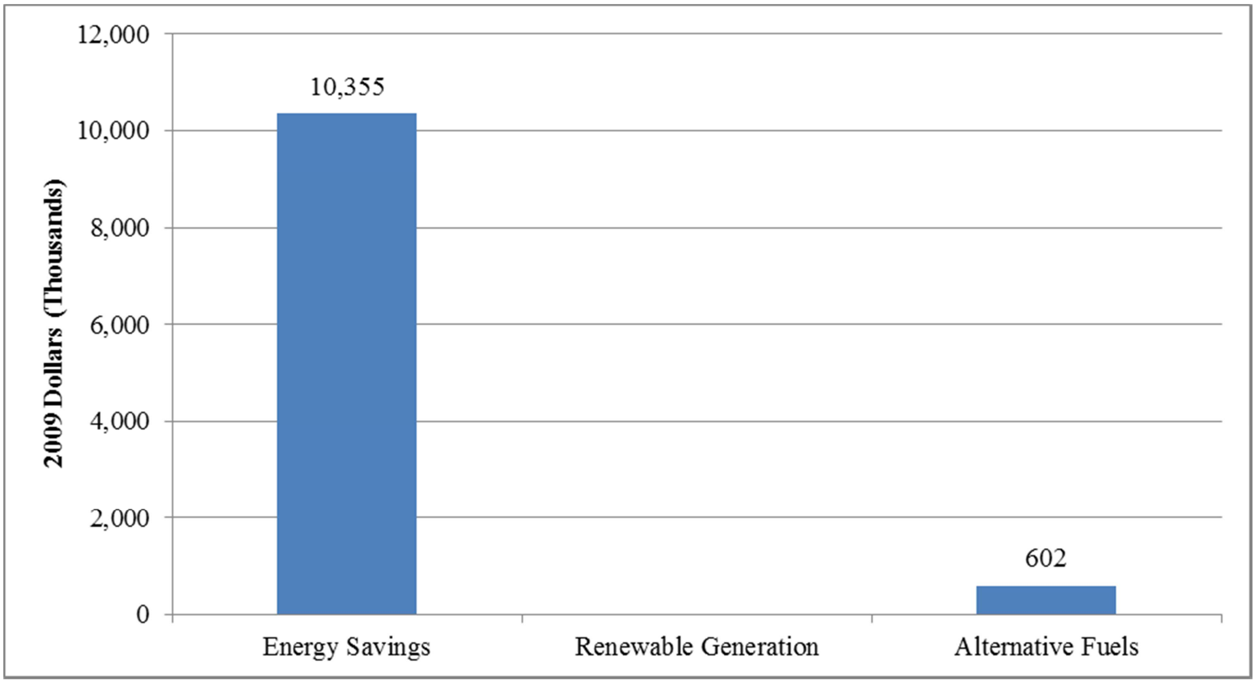

Figure 4-49: Avoided social costs of carbon emissions from loans, grants, and incentives activities by program mechanism (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided social costs of carbon over time are presented in **Figure 4-50** for the Loans, Grants, and Incentives BPAC. Similar to the pattern of avoided carbon emissions, the associated avoided social costs rise gradually, peak in 2030, and decline gradually over time as various technologies' reach the end of their expected useful lives. There are still slight avoided social costs in 2050, the final year of the evaluated program period.

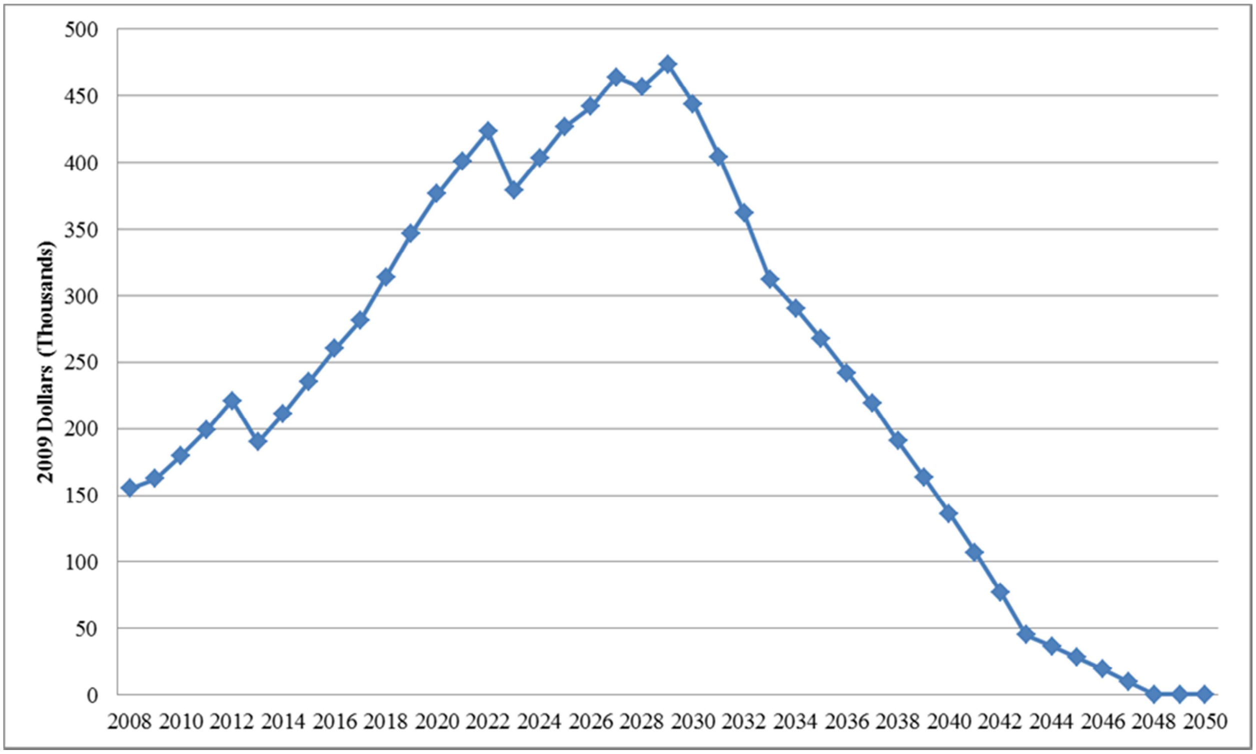

Figure 4-50: Avoided social costs of carbon over time from loans, grants, and incentives activities (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-51 shows how those avoided social costs of carbon distribute across sectors. Similar to the distribution of avoided carbon emissions, the public institutional sector accounts for the largest amount of avoided social costs ($9.8 million). The transportation and residential sectors each have $602 and $518 thousand avoided social costs of carbon, respectively.

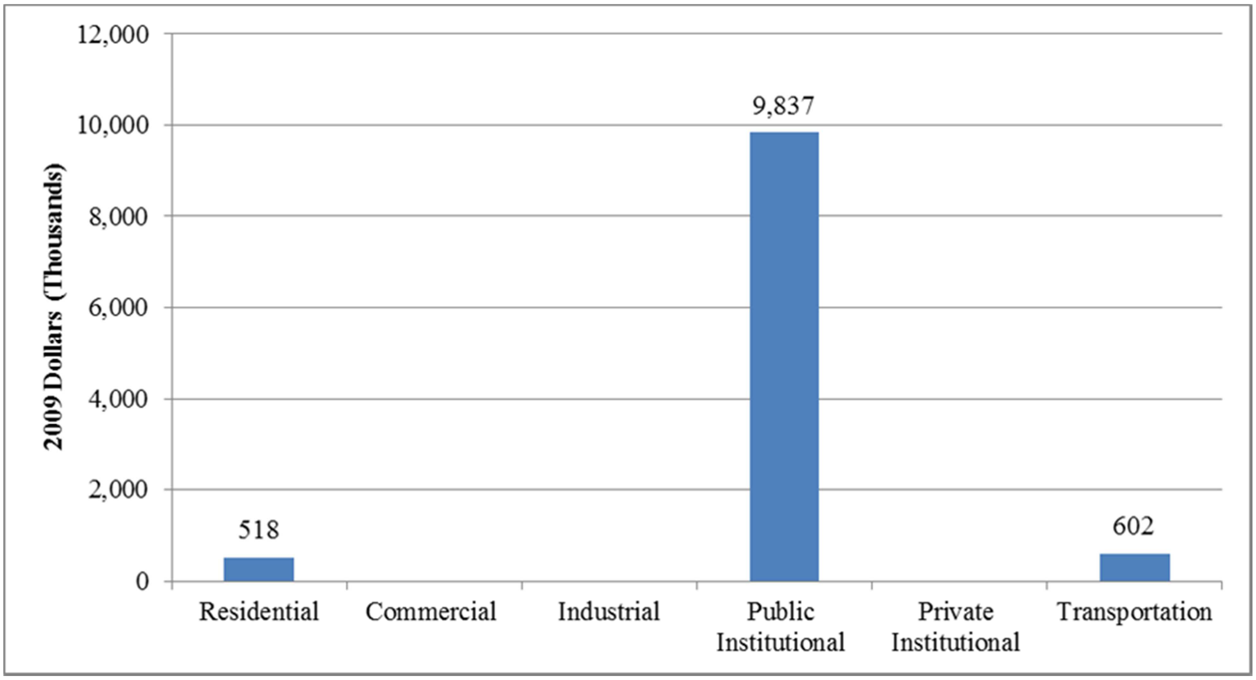

Figure 4-51: Avoided lifetime social costs of carbon by sector from loans, grants, and incentives activities (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.4.4 Technical assistance (PY 2008)

4.4.4.1 Avoided carbon emissions (technical assistance)

Avoided carbon emissions from the Technical Assistance BPAC are derived almost exclusively from energy savings with a small amount of energy displaced from on-site renewable generation. As shown in **Figure 4-52**, avoided carbon emissions from Technical Assistance BPAC activities total 0.12 MMTCE, which are derived almost exclusively from energy savings at 0.12 MMTCE. There was less than .01 MMTCE of avoided carbon emissions from energy displaced from renewable generation.

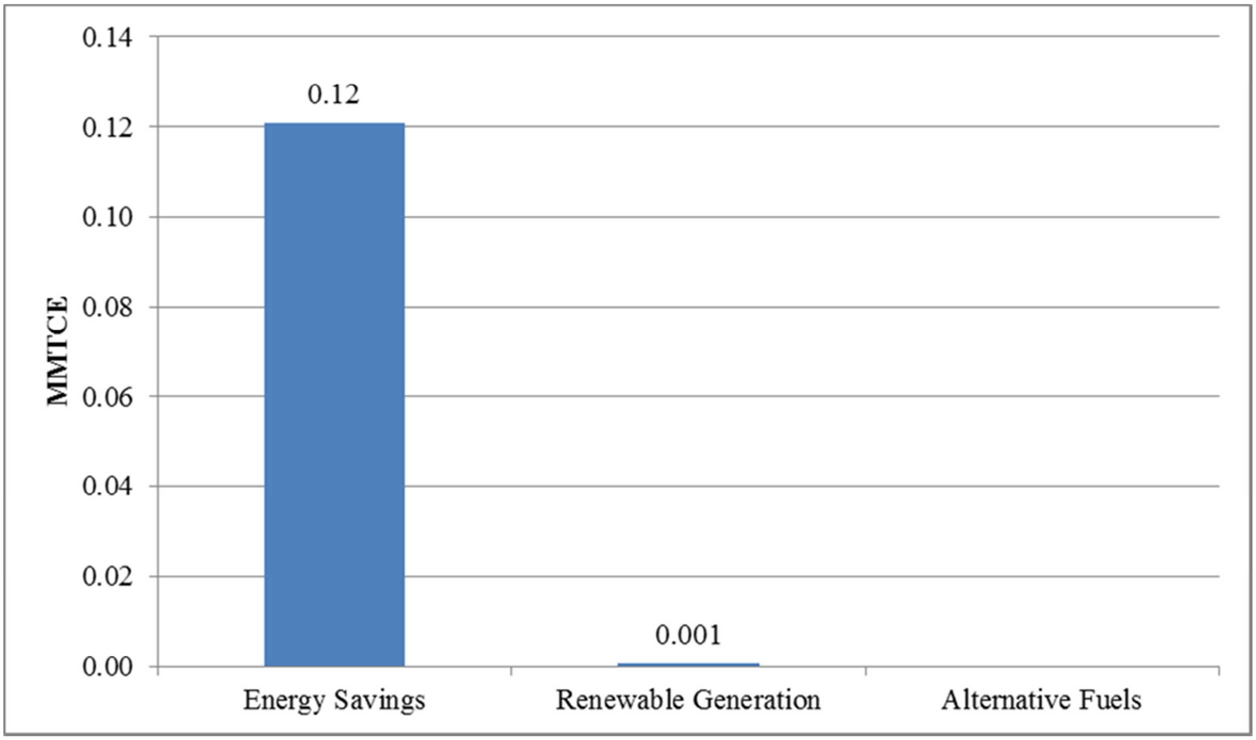

Figure 4-52: Avoided carbon emissions from technical assistance activities by program mechanism (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-53 shows SEP-attributable avoided carbon emissions over time from Technical Assistance programmatic activities in MMTCE. Avoided carbon emissions rise quickly from 2008, reach a peak from 2012 through 2015, and fall quickly over time to 2030, after the impacts of all programmatic activities have ceased.

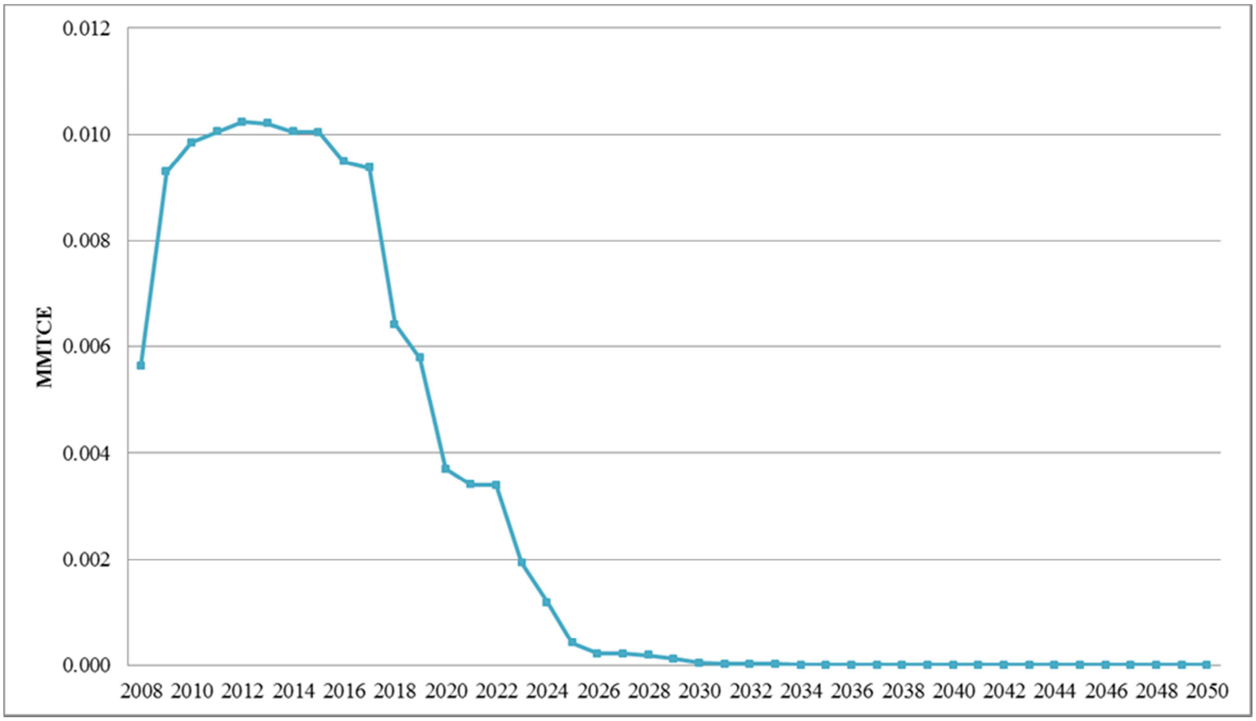

Figure 4-53: Avoided carbon emissions from technical assistance activities over time (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided carbon emissions over the lifetime of energy impacts, by sector, are presented in **Figure 4-54**. The public institutional sector accounts for the largest amount of avoided MMTCE (0.07 MMTCE), followed by the private institutional sector (0.05).

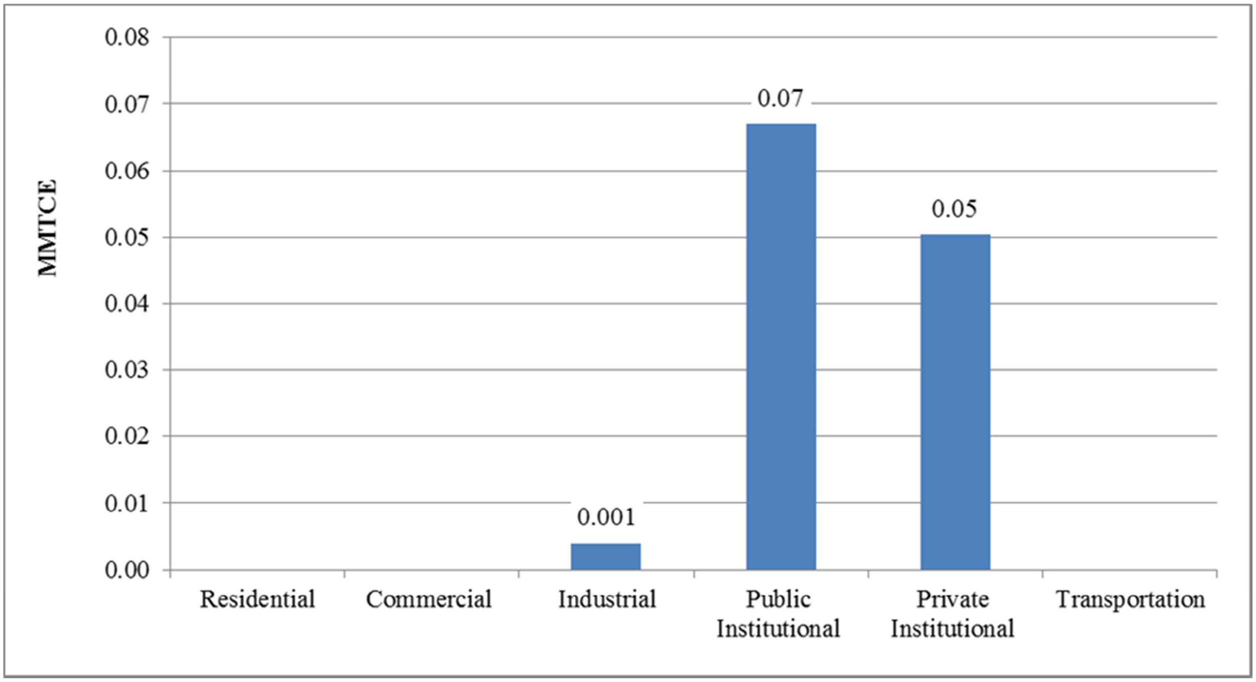

Figure 4-54: Avoided lifetime carbon emissions from technical assistance activities by sector (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.4.4.2 Avoided Social Costs of Carbon (Technical Assistance)

As shown below in **Figure 4-55**, energy savings account for the vast majority of the avoided social costs at $7.2 million.

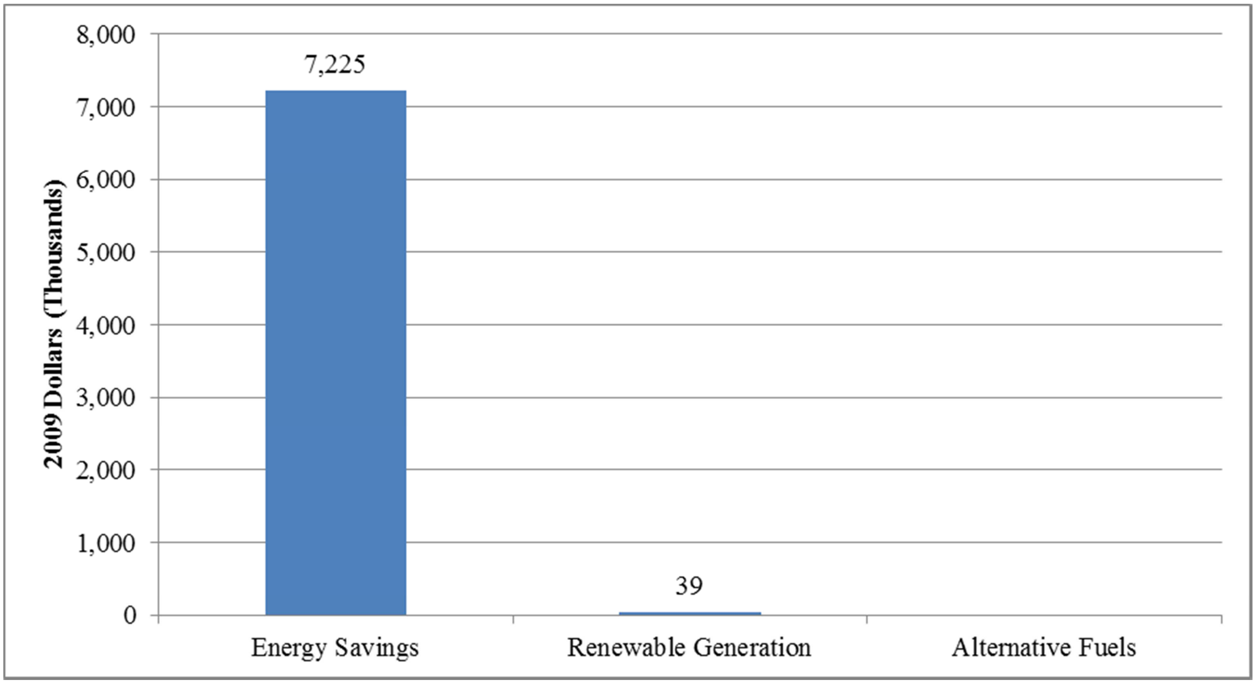

Figure 4-55: Avoided social costs of carbon emissions from technical assistance activities by program mechanism (Thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided social costs of carbon over time are presented in **Figure 4-56** for the Technical Assistance BPAC. Similar to the pattern of avoided carbon emissions, the associated avoided social costs rise quickly but peak in 2015, and decline quickly over time as various technologies reach the end of their expected useful lives in 2030.

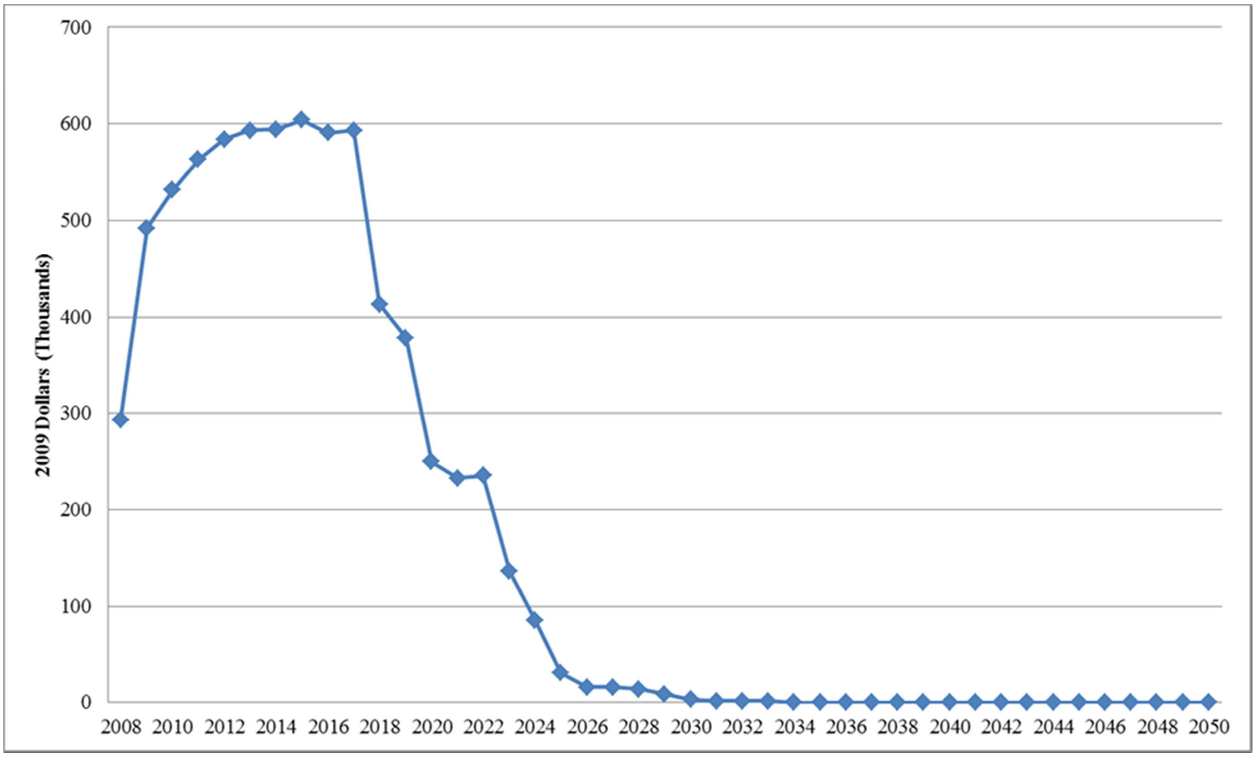

Figure 4-56: Avoided social costs of carbon from technical assistance activities over time (Thousands of 2009$)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 4-57 shows how those avoided social costs of carbon distribute across sectors. The public institutional sector realizes the most avoided costs at $4.0 million dollars, followed by the private institutional sector ($3.0 million). The industrial sector accounted for about $236 thousand avoided costs.

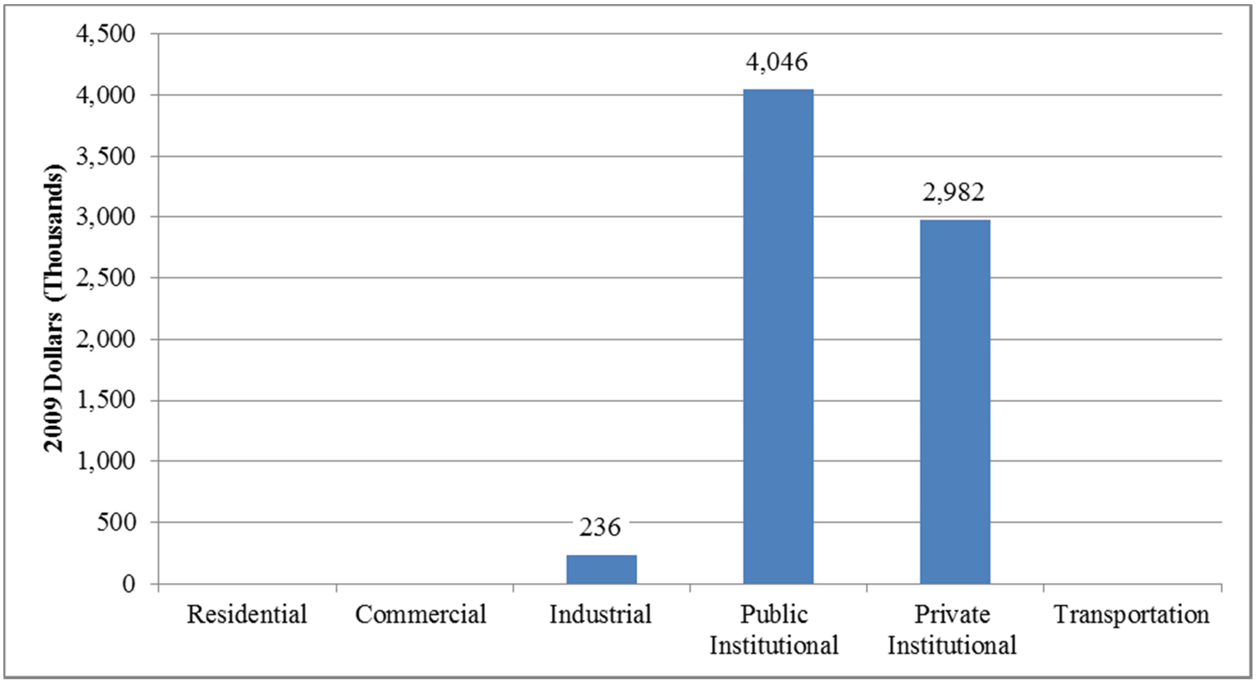

Figure 4-57: Avoided lifetime social costs of carbon from technical assistance activities by sector (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

4.5 Bill savings and cost-effectiveness (PY 2008)

This section presents findings on bill savings and cost-effectiveness indicators for each of the four studied BPACs funded in PY 2008 through SEP. Bill savings are presented in 2009 dollars, and include direct customer savings from energy efficiency and on-site renewable generation, as well as indirect customer bill savings related to utility-scale renewable generation. For cost-effectiveness, two indicators are presented in this report: the SEP RAC test result and a ratio of SEP-attributable bill savings to SEP expenditures in present value terms.

4.5.1 Clean energy policy support (PY 2008)

4.5.1.1 Customer energy bill savings (clean energy policy support)

Total bill savings attributable to SEP from energy savings and renewable generation associated with the Clean Energy Policy Support BPAC activities are shown in **Figure 4-58** and **Table 4-34**. Cumulative bill savings for the study period total $33.9 million, compared to estimated program funding of $4.6 million for this BPAC. Bill savings distribute across different sectors over time, with the majority going to the commercial sector, followed by the residential sector, public institutional sector and the industrial sector.[80]

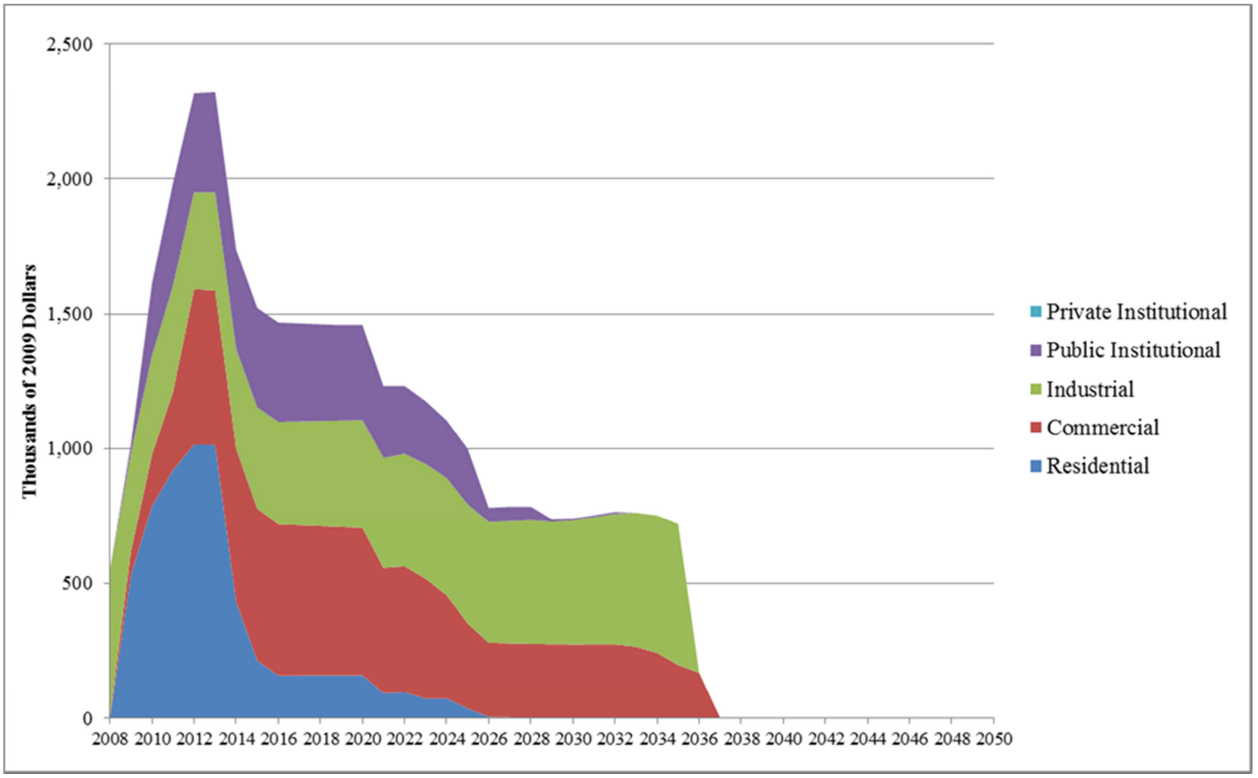

Figure 4-58: Bill savings for PY 2008 clean energy policy support activities by sector by year (thousands of $2009)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-34 shows a cross tabulation of SEP-attributable bill savings by fuel and sector. The majority of bill savings are accounted for in the industrial sector – mostly related to natural gas savings – followed by the commercial sector, the residential sector, and the public institutional sector for which most of the bill savings are derived from electricity savings.

80 Customer bill savings related to on-site generation are included in total bill savings. All on-site renewable generation evaluated in this study is customer-owned and therefore the savings accrue to the customer.

Table 4-34: SEP-attributable bill savings for PY 2008 clean energy policy support activities by fuel type by sector (thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	$5,259	$9,975	$219*	$3,877*	-	$19,330
Natural Gas	$825*	$511*	$11,755*	$1,436*	-	$14,527
Oil	$2*	-	-	-	-	$2*
Propane	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-
Wood	$1*	-	-	-	-	$1*
Diesel	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-
Other	$9*	-	-	-	-	$9*
Total	**$6,096**	**$10,486**	**$11,974***	**$5,312***	**-**	**$33,868**

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

4.5.1.2 Cost-effectiveness indicators (clean energy policy support)

As shown in **Table 4-35**, the results of the SEP RAC test result for this BPAC was 26.4 from the building perspective, exceeding the benchmark of 10 by 207%. The SEP RAC test result was 30.7 from the system perspective.

Table 4-35: SEP RAC test result for PY 2008 clean energy policy support BPAC (source MMBtu/$1,000)

Perspective	Benchmark	Finding
Building	10	26.4
System	10	30.7

Under all three discount scenarios this BPAC produced present value ratios greater than 1.0 when comparing participant bill savings to program expenditures, indicating that bill savings exceeded expenditures. These ratios ranged from 4.7 to 6.7 under three discount rate scenarios (**Table 4-36**).[81]

Table 4-36: Lifetime present value ratios for PY 2008 clean energy policy support BPAC

Discount Rate	0.7%	2.7%	4.7%
Ratio of Bill Savings to PA Funding	6.7	5.6	4.7

4.5.2 Building retrofits (PY 2008)

4.5.2.1 Customer energy bill savings (building retrofits)

For this BPAC, the cumulative bill savings attributable to SEP from energy savings and renewable generation was $10.9 million in 2009 dollars, compared to estimated program funding of $3.4 million for this BPAC. **Figure 4-59** displays the energy bill savings by sector over time. The bill savings from the public institutional sector represent nearly all of the bill savings for this BPAC.

[81] Customer costs associated with switching electricity service for on-site generation technologies are not considered in the PV ratio.

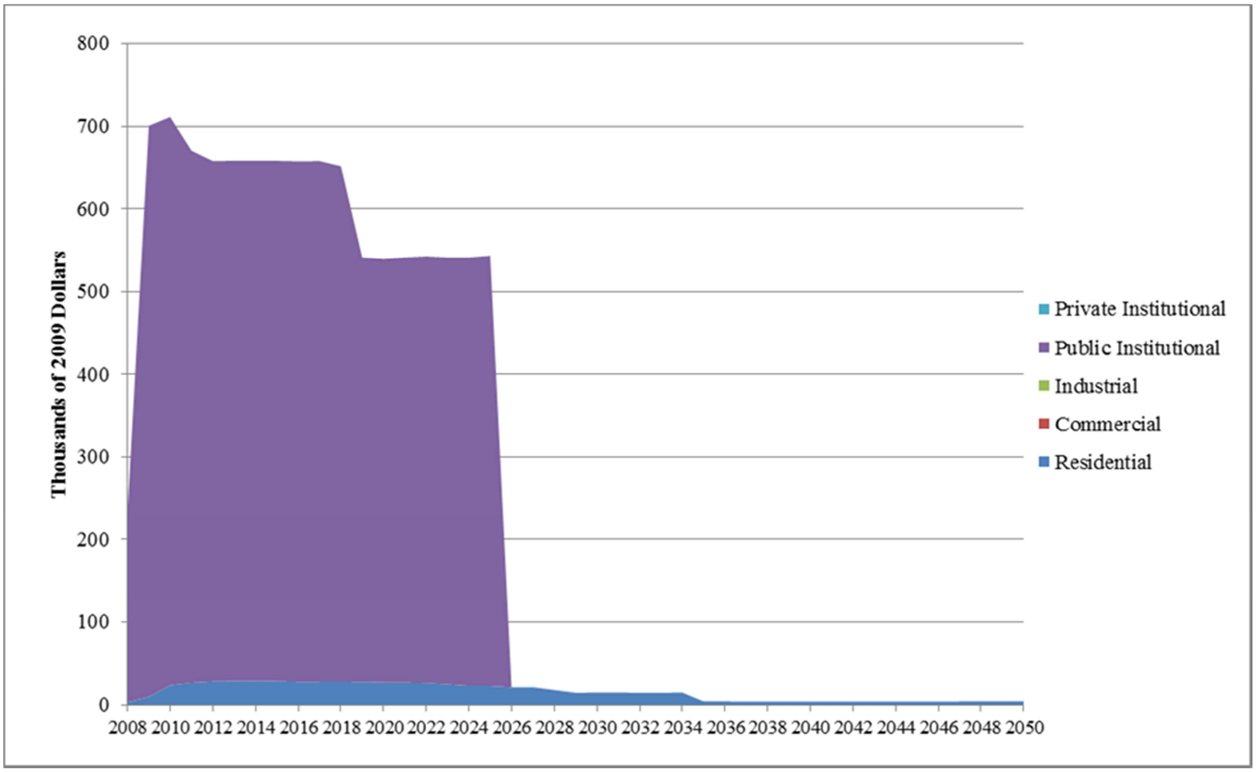

Figure 4-59: Bill savings for PY 2008 building retrofits activities by sector by year (thousands of $2009)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-37 shows SEP-attributable Building Retrofits bill savings by fuel and sector. As stated earlier, nearly all of the bill savings are accounted for in the public institutional customer sector—mostly related to electricity savings. The residential sector bill savings occur from electricity and natural gas.

Table 4-37: SEP-attributable bill savings for PY 2008 building retrofits activities by fuel type by sector (thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	$299*	-	-	$6,785*	-	$7,083*
Natural Gas	$354*	-	-	$3,480	-	$3,833
Oil	-	-	-	-	-	-
Propane	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-
Wood	-	-	-	-	-	-
Diesel	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-
Other	-	-	-	-	-	-
Total	**$653***	**-**	**-**	**$10,264**	**-**	**$10,917**

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

4.5.2.2 Cost-effectiveness indicators (building retrofits)

As shown in **Table 4-38**, the SEP RAC test result for this BPAC was 25.6 from both the building and system perspectives and exceeded the benchmark of 10 by 156%.

Table 4-38: SEP RAC test result for PY 2008 building retrofits BPAC (Source MMBtu/$1,000)

Perspective	Benchmark	Finding
Building	10	25.6
System	10	25.6

Under all three discount scenarios this BPAC produced present value ratios greater than 1.0 when comparing participant bill savings to program expenditures, indicating that bill savings exceeded expenditures. The present value ratios ranged from 2.3 to 3.0, depending on the discount rate used in the analysis (**Table 4-39**).

Table 4-39: Lifetime present value ratios for PY 2008 building retrofits BPAC

Discount Rate	0.7%	2.7%	4.7%
Ratio of Bill Savings to PA Funding	3.0	2.6	2.3

The higher SEP RAC test result and lifetime present value ratio for Building Retrofits in PY 2008, compared to ARRA period outcomes, can largely be explained by differences in the nature of the programmatic activities undertaken in the two periods, as previously noted. The state leveraging requirement for PY 2008, which did not apply under ARRA, also contributed to the finding of greater SEP-attributable savings per SEP dollar in PY 2008 because that state investment would not have occurred in the absence of SEP. As explained in **Sections 3.4.4** and **3.5.4**, cost-effectiveness is calculated by dividing SEP-attributable savings by SEP funding only.

4.5.3 Loans, grants, and incentives (PY 2008)

4.5.3.1 Customer energy bill savings (loans, grants, and incentives)

For this BPAC, the cumulative bill savings attributable to SEP from energy savings and renewable generation were $25.4 million, compared to estimated program funding of $12 million for this BPAC. **Figure 4-60** displays the energy bill savings by sector over time. The bill savings from the public institutional sector represent nearly all of the bill savings for this BPAC. While bill savings climb over time, this is partially due to forecasted increases in natural gas prices, and partially due to the timing of new projects and the associated accumulation of bill savings from projects funded by prior loans. Due to the revolving nature of these loan programs, savings extend beyond the life of the measures installed from the initial set of loans. Each value shown below is an annual bill savings value in 2009 dollars.

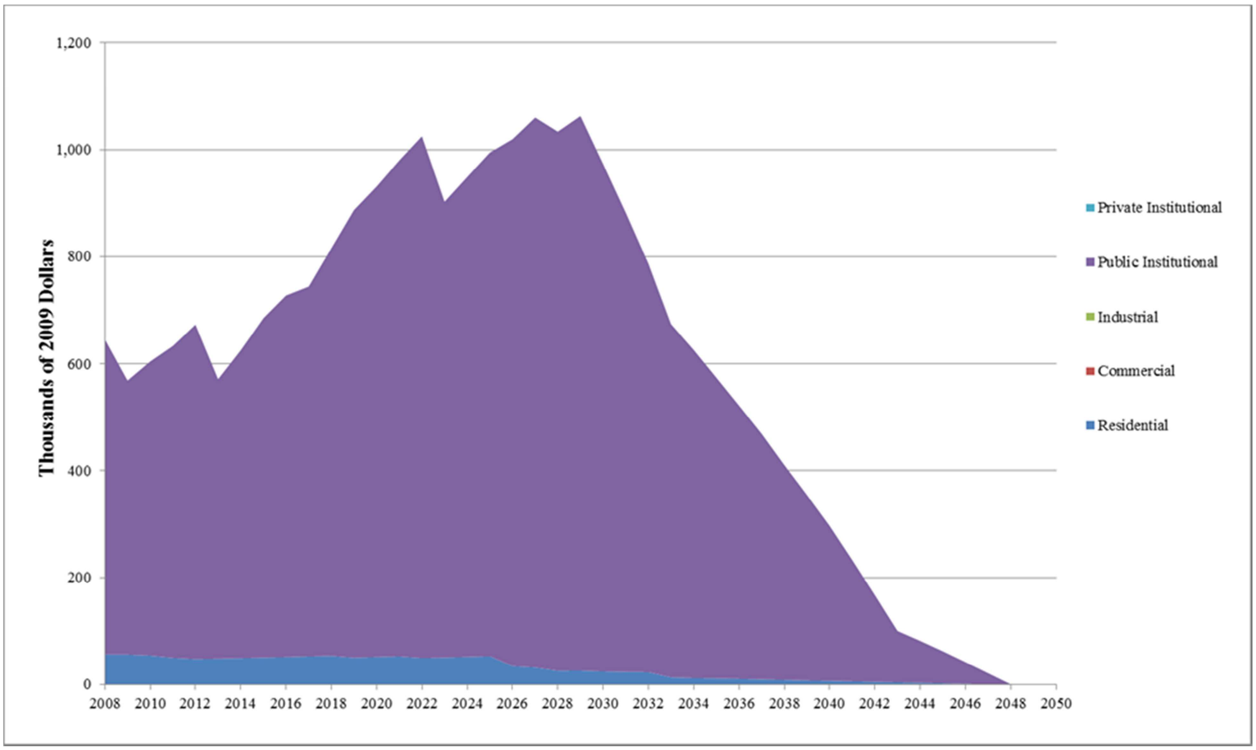

Figure 4-60: Bill savings for PY 2008 loan, grant and incentive activities by sector by year (thousands of $2009)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 4-40 shows bill savings by sector and fuel type. The majority of bill savings, $24.2 million, occurred in the public institutional sector, with a small amount in the residential sector.

Table 4-40: SEP-attributable bill savings for PY 2008 loan, grant and incentive activities by fuel type by sector (thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	$396	-	-	$17,823*	-	$18,219*
Natural Gas	$828	-	-	$5,852*	-	$6,680*
Oil	-	-	-	-	-	-
Propane	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-
Wood	-	-	-	-	-	-
Diesel	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-
Gasoline	-	-	-	$522	-	$522
Other	-	-	-	-	-	-
Total	**$1,223**	**-**	**-**	**$24,197***	**-**	**$25,420***

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

4.5.3.2 Cost-effectiveness indicators (loans, grants, and incentives)

This section presents cost effectiveness indicators for the PY 2008 Loans, Grants, and Incentives BPAC activities. This BPAC differs from its counterpart BPAC during the ARRA-period because it included programs that focused on carbon reductions especially in the area of transportation and alternative fuels programs. When we apply cost effectiveness indicators based on bill savings to carbon reduction programs we expect to see lower values since these projects incur start-up and operational costs but do not necessarily result in direct measureable energy or bill savings.

Additionally, this BPAC includes loans that are included as program expenditures. These loans are eventually repaid by borrowers, however, and can be alternatively viewed as not being a program expenditure. Therefore, the SEP RAC test results are presented both with and without the initial loan disbursements.

As shown in **Table 4-41**, the SEP RAC test result with SEP-funded loan disbursements does not exceed the benchmark of 10 MMBtu per year, per $1,000 program dollars spent. With loan principal, this ratio is 4.5 from both the building and system perspectives and is 55% below the benchmark. Without loan principal, the SEP RAC test result is 17.6 from both the building and system perspectives, and is 76% above the benchmark.

Table 4-41: SEP RAC test result for PY 2008 loans, grants, and incentives BPAC

Perspective	Benchmark	Finding
Building, with loan principal	10	4.5
Building, without loan principal	10	17.6
System, with loan principal	10	4.5
System, without loan principal	10	17.6

Under all three discount scenarios this BPAC produced present value ratios greater than 1.0 when comparing participant bill savings to program expenditures, indicating that bill savings exceeded expenditures. With loan dollars included, the present value ratios ranged from 1.1 to 1.9 across the range of discount rates from 0.7% to 4.7%. Without loan costs, present value ratios covered a range from 4.4 to 7.3 (**Table 4-42**).

Table 4-42: Lifetime present value ratios for PY 2008 loans, grants, and incentives BPAC

	0.7%	2.7%	4.7%
Ratio of Bill Savings to PA Funding, with Loans	1.9	1.4	1.1
Ratio of Bill Savings to PA Funding, without Loans	7.3	5.6	4.4

4.5.4 Technical assistance (PY 2008)

4.5.4.1 Customer energy bill savings (technical assistance)

For this BPAC, the cumulative bill savings from energy savings and renewable generation was over $24.4 million, compared to estimated program funding of $5.2 million for this BPAC. **Figure 4-61** displays the energy bill savings by sector over time. Bill savings peak rapidly in 2010, remain at relatively high levels until 2017, and then falling steadily until 2030. Bill savings accrue primarily to the public institutional and residential sectors. Each value is an annual bill savings value in 2009 dollars.[82]

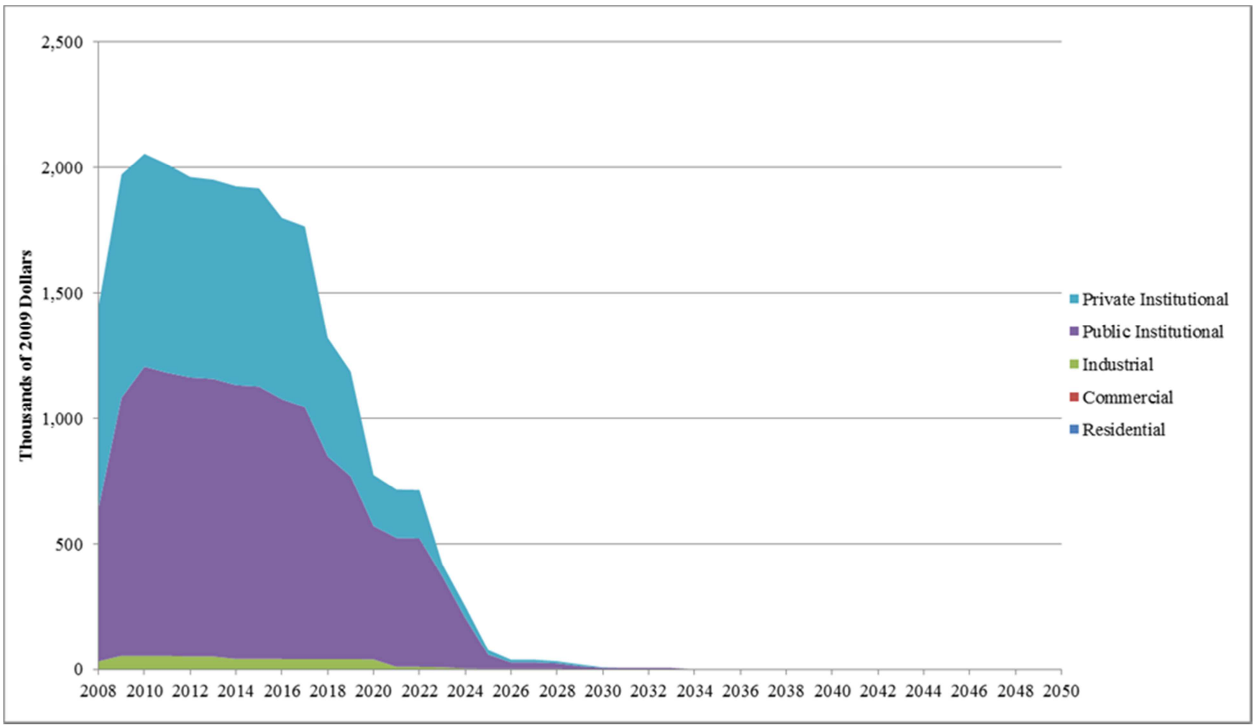

Figure 4-61: Bill savings for PY 2008 technical assistance activities by sector by year (thousands of $2009)

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.
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[82] Customer bill savings related to on-site generation are included in total bill savings. All on-site renewable generation evaluated in this study is customer-owned and therefore the savings accrue to the customer.

Table 4-43 shows a cross tabulation of SEP-attributable bill savings by sector and fuel type. The vast majority of bill savings occurred from electricity reductions in the public and private institutional sectors, with a small amount in the industrial sector.

Table 4-43: SEP-attributable bill savings for PY 2008 technical assistance activities by fuel type by sector (thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	-	-	$432	$12,287	$7,413*	$20,132
Natural Gas	-	-	$179	$1,811	$2,211*	$4,202
Oil	-	-	-	-	-	-
Propane	-	-	-	$86	-	$86
Kerosene	-	-	-	-	-	-
Wood	-	-	-	-	-	-
Diesel	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-
Other	-	-	$9	-	-	$9
Total	**-**	**-**	**$620**	**$14,184**	**$9,625***	**$24,429**

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

4.5.4.2 Cost-effectiveness indicators (Technical Assistance)

For the Technical Assistance BPAC, the SEP RAC test result is 48.5 from the building perspective and 48.6 from the system perspective, as shown in **Table 4-44**. This ratio exceeds the benchmark of 10 by 385% and 386% respectively.

Table 4-44: SEP RAC test result for PY 2008 Technical Assistance BPAC

Perspective	Benchmark	Finding
Building	10	48.5
System	10	48.6

Under all three discount scenarios this BPAC produced present value ratios greater than 1.0 when comparing participant bill savings to program expenditures, indicating that bill savings exceeded expenditures. The present value ratios ranged from 3.6 to 4.4, depending on the discount rate used in the analysis (**Table 4-45**).[83]

Table 4-45: Lifetime present value ratios for PY 2008 technical assistance BPAC

Discount Rate	0.7%	2.7%	4.7%
Ratio of Bill Savings to PA Funding	4.4	4.0	3.6

[83] Customer costs associated with switching electricity service for on-site generation technologies are not considered in the PV ratio.

5 ARRA-PERIOD SEP FINDINGS BY OUTCOME

The following sections will present the cumulative and BPAC-specific impacts by key outcome for the four ARRA-period BPACs studied in this evaluation: Building Retrofits; Building Codes and Standards; Loans, Grants, and Incentives; and Renewable Energy Market Development. The four outcomes presented are as follows, with the Appendices that provide additional methodological detail indicated in parentheses:

- Energy savings/renewable generation (Appendices F and G)
- Labor impacts (Appendix H)
- Avoided carbon emissions and avoided social cost estimates (Appendix I)
- Bill savings and cost-effectiveness (Appendix J)

The impacts are calculated by year through 2050 and by sector (residential, commercial, industrial[84], public institutional and private institutional). All outcomes presented in this chapter (and elsewhere in the body of the report) are attributable to funding received from the State Energy Program, meaning they are the impacts that occurred as a result of SEP funding. These "SEP-attributable" impacts are analogous to the "net" impacts discussed in many other evaluations. Overall energy savings and renewable generation, associated with the totality of support provided by SEP and other funding sources, are presented in Appendix K. Those "overall" impacts are analogous to the "gross" impacts discussed in other studies.

> In contrast with PY 2008 programs, ARRA programs were much larger projects, which were often fully funded by SEP dollars. Two BPACs, Building Retrofits, and Loans, Grants, and Incentives were evaluated in both PY 2008 and ARRA.
>
> Individual Building Retrofit PAs received substantially more SEP funding and less support from other sources under ARRA than in PY 2008.
>
> For Loans, Grants, and Incentives, ARRA programmatic activities focused more on building retrofits and renewable technology projects.

5.1 Summary of impacts (ARRA-period)

5.1.1 Energy savings/renewable generation (ARRA-period)

This section addresses energy savings and renewable generation impacts for all four ARRA-period BPACs studied in this evaluation. The impacts are all reported in source MMBtu, which takes into account all energy consumption saved, including losses due to storage, transmission and distribution of the energy to its final destination. The combined energy impact of the PY 2008 BPACs, displayed in **Table 5-1**, is about 2.8 billion source MMBtu for the 2008 to 2050 period. Energy impacts came primarily from energy savings in the Building Retrofits and Building Codes and Standards BPACs. The Loans, Grants, and Incentives BPAC had a similar magnitude of impacts from energy savings and renewable generation; while the Renewable Energy Market Development BPAC's primary energy impacts came from renewable generation.

[84] The industrial sector includes manufacturing, mining, construction, agriculture, and, for the purpose of this report, electric and gas utilities.

Table 5-1: SEP-attributable cumulative energy impacts for ARRA-period activities, by BPAC (Source MMBtu)

	SEP-Attributable Energy Savings, 2009-2050	SEP-Attributable Renewable Generation, 2009-2050
Building Retrofits	89,173,094	-
Building Codes and Standards	326,239,072	-
Loans, Grants, and Incentives	271,650,484	231,622,460
Renewable Energy Market Development	1,106,448*	1,847,880,257*
Total	**688,169,099**	**2,079,502,716**

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

5.1.1.1 Energy impacts for all fuel types and sectors combined (ARRA-period)

The studied ARRA-period BPACs resulted in SEP-attributable energy savings of 688 million source MMBtu over the 2009 to 2050 period. **Figure 5-1** shows the SEP-attributable energy savings over time. Energy impacts rise rapidly through 2012 as the programs come into effect, and then continue to rise more gradually to the peak in 2021. After peaking, there is a steady decline from 2025 on as the effective useful lives of various technologies end. Impacts continue through 2050, the end of the evaluation's study period. The majority of the later impacts occur as a result of revolving loan programs.

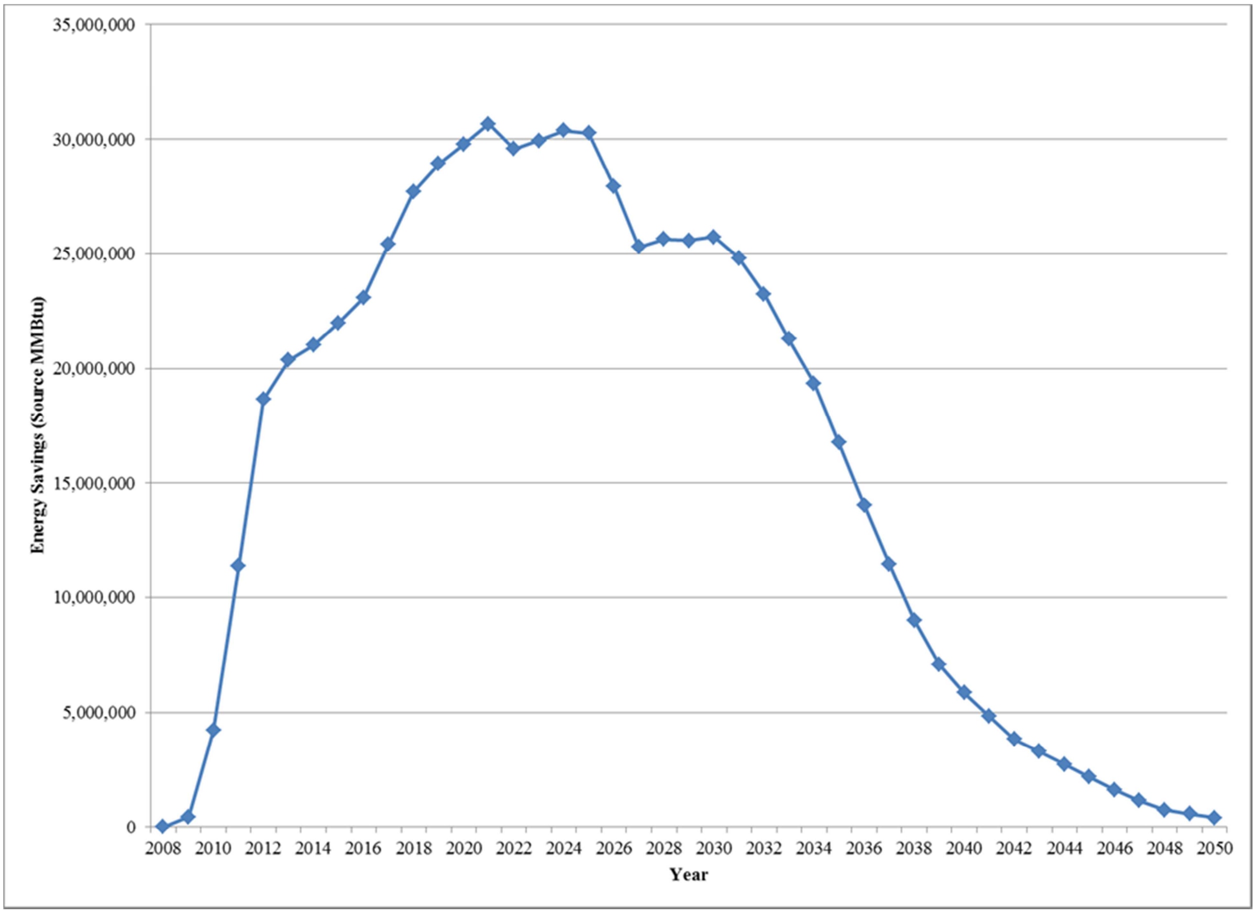

Figure 5-1: SEP-attributable cumulative energy savings for ARRA-period activities by year (Source MMBtu)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

The ARRA-period BPACs resulted in 2.1 billion source MMBtu of SEP-attributable renewable generation over the 2009 to 2050 period. **Figure 5-2** shows the impacts during the period of study. Impacts rise rapidly through 2020, remain relatively stable through 2028, and then begin to decline. Renewable generation begins to taper off slowly from 2040 through 2050, the end of the study period. The majority of the later impacts occur as a result of revolving loan programs.

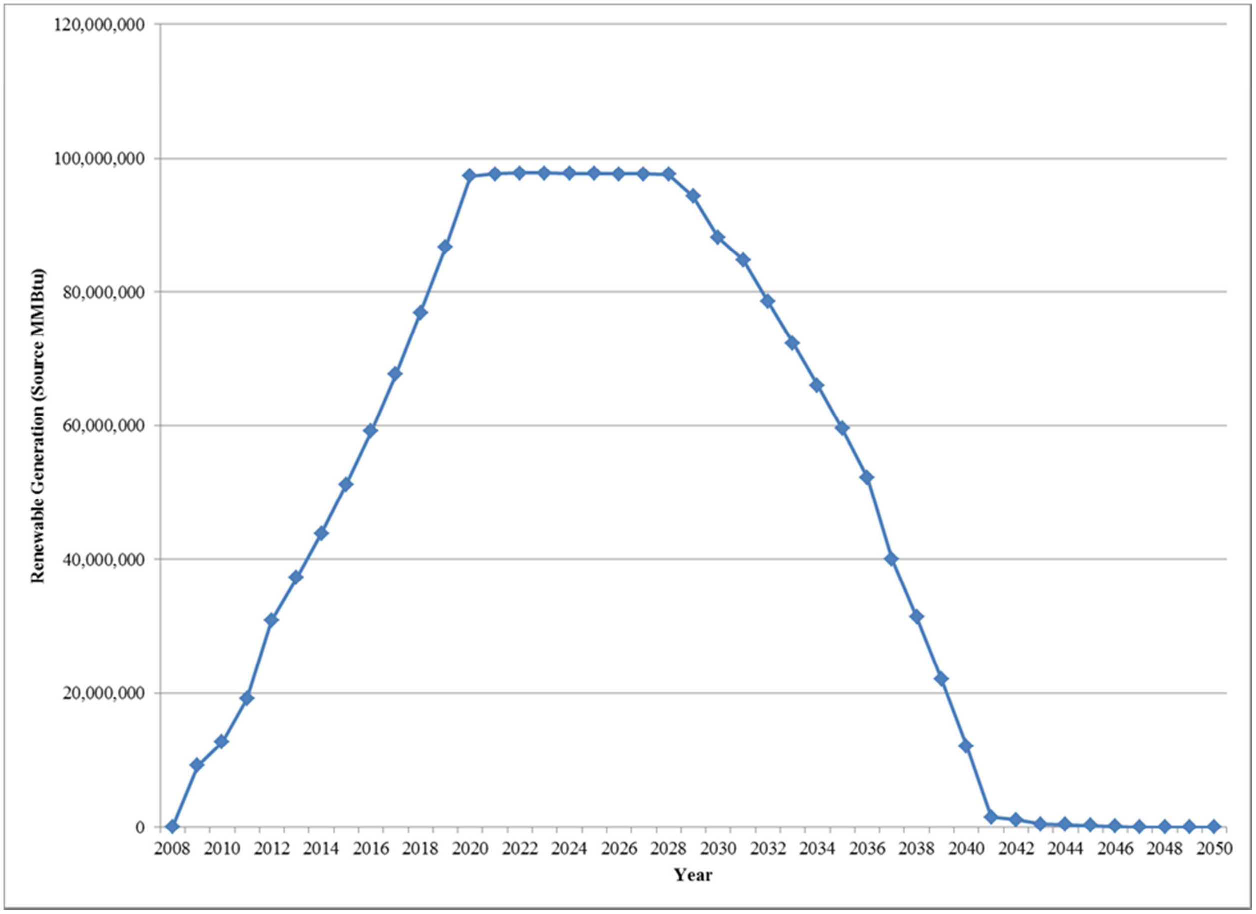

Figure 5-2: SEP-Attributable cumulative renewable generation for ARRA-period activities by year (Source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.1.1.2 Energy impacts by fuel type (ARRA-period)

Table 5-2and **Table 5-3** show the SEP-attributable energy savings and renewable generation over time by fuel type in Source MMBtu for the ARRA-period BPACs.

Table 5-2shows SEP-attributable energy savings of around 566 million source MMBtu of electricity and 104 million source MMBtu of natural gas between 2009 and 2050. The ARRA-period BPACs also resulted in SEP-attributable energy savings for oil (16.1 million source MMBtu), propane (2.1 million source MMBtu), and wood (2 thousand source MMBtu).

Table 5-3 shows that the electric renewable generation amounted to around 2.1 billion source MMBtu during the study period. Generation of digester gas amounted to about 810 thousand source MMBtu and about 15 thousand source MMBtu of biodiesel was produced.

Table 5-2: SEP-attributable cumulative energy savings for ARRA-period activities over time by fuel type (Source MMBtu)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	161,734	3,690,999	9,287,713	15,133,07	16,522,35	147,437,89	231,047,68	125,435,11	17,662,08	566,378,65
Natural Gas	284,225*	446,592	1,658,902	3,013,380	3,279,393	25,574,863	42,105,658	23,973,406	3,217,714	103,554,13
Oil	309*	66,935*	376,608	430,629	499,451	4,319,142	6,937,896	3,034,267	466,907*	16,132,145
Propane	2,498*	15,234	47,324	59,005	61,908	540,375	881,131	401,963	93,030*	2,102,469
Kerosene	-	-	-	-	-	-	-	-	-	-
Wood	-	-	73*	73*	73*	508*	733*	243	-	1,703*
Diesel	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-
Total	**448,766**	**4,219,761**	**11,370,620**	**18,636,162**	**20,363,176**	**177,872,783**	**280,973,104**	**152,844,989**	**21,439,737**	**688,169,099**

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

Table 5-3: SEP-attributable cumulative renewable generation for ARRA-period activities by fuel type over time (Source MMBtu)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	9,200,370*	12,732,891*	19,167,37	30,824,08	37,234,22	482,762,922	963,722,10	519,022,468	4,010,267	2,078,676,705
Methane	-	-	-	-	-	-	-	-	-	-
Landfill Gas	-	-	-	-	-	-	-	-	-	-
Digester Gas	-	-	3,350*	6,700*	10,049*	164,141*	368,480*	247,887*	10,049*	810,656*
Biodiesel	-	-	-	430*	451*	3,859*	8,388*	2,227*	-	15,355*
Ethanol	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-
Total	**9,200,370***	**12,732,891***	**19,170,72**	**30,831,21**	**37,244,72**	**482,930,922**	**964,098,97**	**519,272,58**	**4,020,317**	**2,079,502,716**

Note:

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"*" 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.

5.1.1.3 Energy impacts by sector (ARRA-period)

Figure 5-3 displays the SEP-attributable energy savings by sector during the 2009 through 2050 study period. Energy savings occurred in all five sectors, with the most occurring in the residential sector.

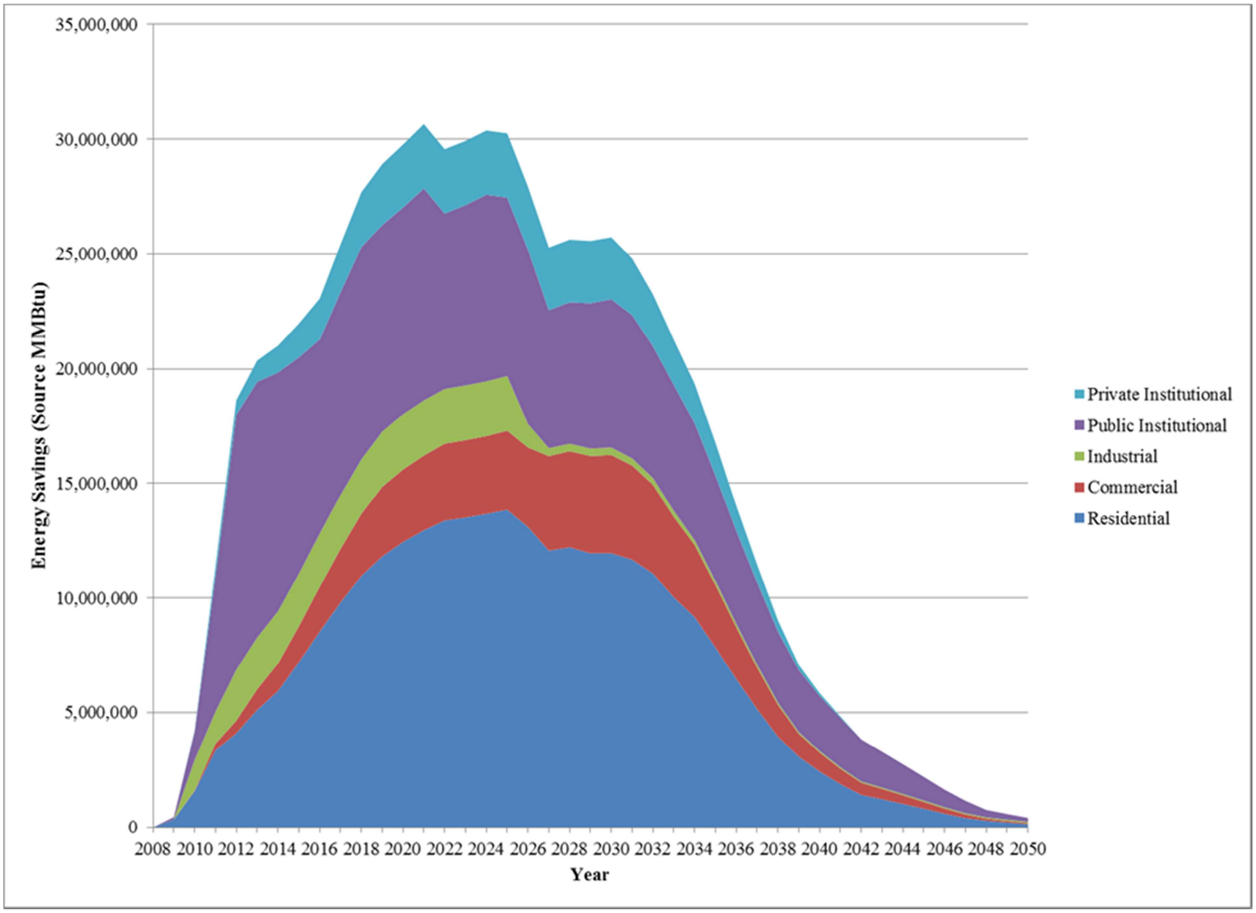

Figure 5-3: SEP-attributable cumulative energy savings for ARRA-period activities by sector by year (Source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 5-4 shows the total SEP-attributable energy savings by sector in source MMBtu for the 2009 through 2050 period. The energy savings were distributed across all sectors, with the highest energy savings occurring in the residential (289 million source MMBtu), followed by the public institutional sector (220 million source MMBtu).

Table 5-4: SEP-attributable cumulative energy savings for ARRA-period activities by sector (Source MMBtu)

	SEP-Attributable Energy Savings 2009-2050
Residential	288,668,122
Commercial	82,540,084
Industrial	40,181,766
Public Institutional	220,324,442
Private Institutional	56,454,685
Total	**688,169,099**

Note:
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Figure 5-4 displays the SEP-attributable renewable generation by sector over time. The majority of the renewable generation occurred in the industrial sector. Renewable generation in all other sectors exist, but were too small in comparison to be seen in **Figure 5-4**.

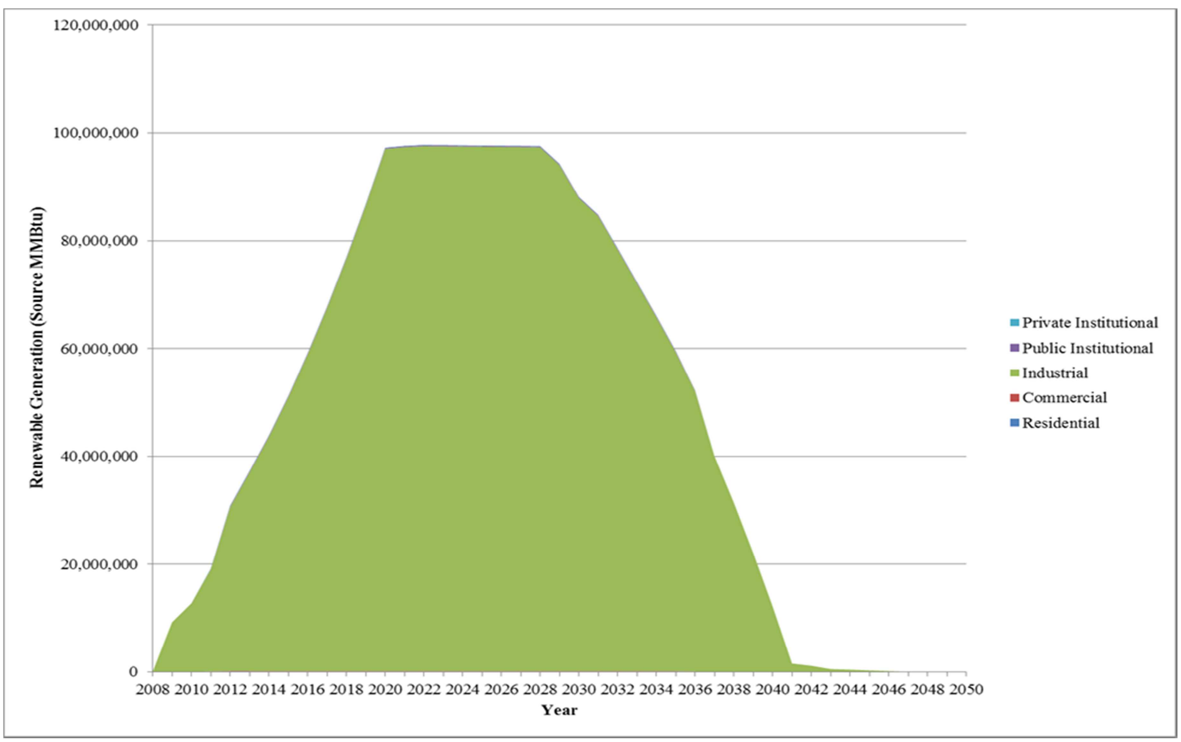

Figure 5-4: SEP-attributable cumulative renewable generation for ARRA-period activities by sector over time (Source MMBtu)
A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.
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Table 5-5 shows the total SEP-attributable renewable generation during the 2009 through 2050 study period by sector in source MMBtu. The industrial sector had the majority of the renewable generation at around 2.1 billion source MMBtu. The public institutional sector had the next highest levels of renewable generation (4.6 million source MMBtu). The renewable generation for the residential, commercial and private institutional sectors ranged between 1.2 and 2.5 million source MMBtu.

Table 5-5: SEP-attributable cumulative renewable generation for ARRA-period activities by sector (Source MMBtu)

	SEP-Attributable Renewable Generation 2009-2050
Residential	2,543,526
Commercial	1,674,207
Industrial	2,069,385,143
Public Institutional	4,638,131
Private Institutional	1,261,710*
Total	**2,079,502,716**

Note:
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5.1.2 Labor impacts (ARRA-period)

For an understanding of how the Labor analysis results are achieved, refer to **Section 4.1.2**.

While all four BPACs do not extend to the same end point (Codes and Standards to 2041, Building Retrofits to 2035, and Loans, Grants, and Incentives and Renewable Energy Market Development to 2050), the cumulative total job changes – that is job changes inclusive of the REMI model's dynamic adjustments and economic multiplier effects – for the overall interval are more than 135 thousand job-years (**Table 5-6**), and approximately $13,858 per job created based on $1.9 billion in funding for the evaluated ARRA period BPACs.

Table 5-6: Direct, indirect, and induced jobs created in the U.S. from ARRA-period SEP activities

	Direct, Indirect, and Induced Jobs (2009-2050)									
	2009	**2010**	**2011**	**2012**	**2013**	**2014-2020**	**2021-2030**	**2031-2040**	**2041-2050**	**Total**
Building Retrofits	2,487	3,356	4,828	3,374	1,853	7,018	1,914	-418	-	24,413
Building Codes and Standards	74	116	56	61	218	11,639	29,392	6,962	-339	48,178
Loans, Grants, and Incentives	1,626	3,129	4,974	3,750	1,868	2,115	-721	1,072	1,438	19,251
Renewable Energy Market Development	1,955	1,651	4,719	6,480	4,571	21,915	2,262	250	-152	43,651
Total	**6,142**	**8,252**	**14,576**	**13,665**	**8,511**	**42,688**	**32,847**	**7,865**	**947**	**135,493**

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

Over time, the job impacts are greatest within the ARRA-period (2012 experiences the maximum job impact) but positive job impacts persist until 2045 as shown in **Figure 5-5**.

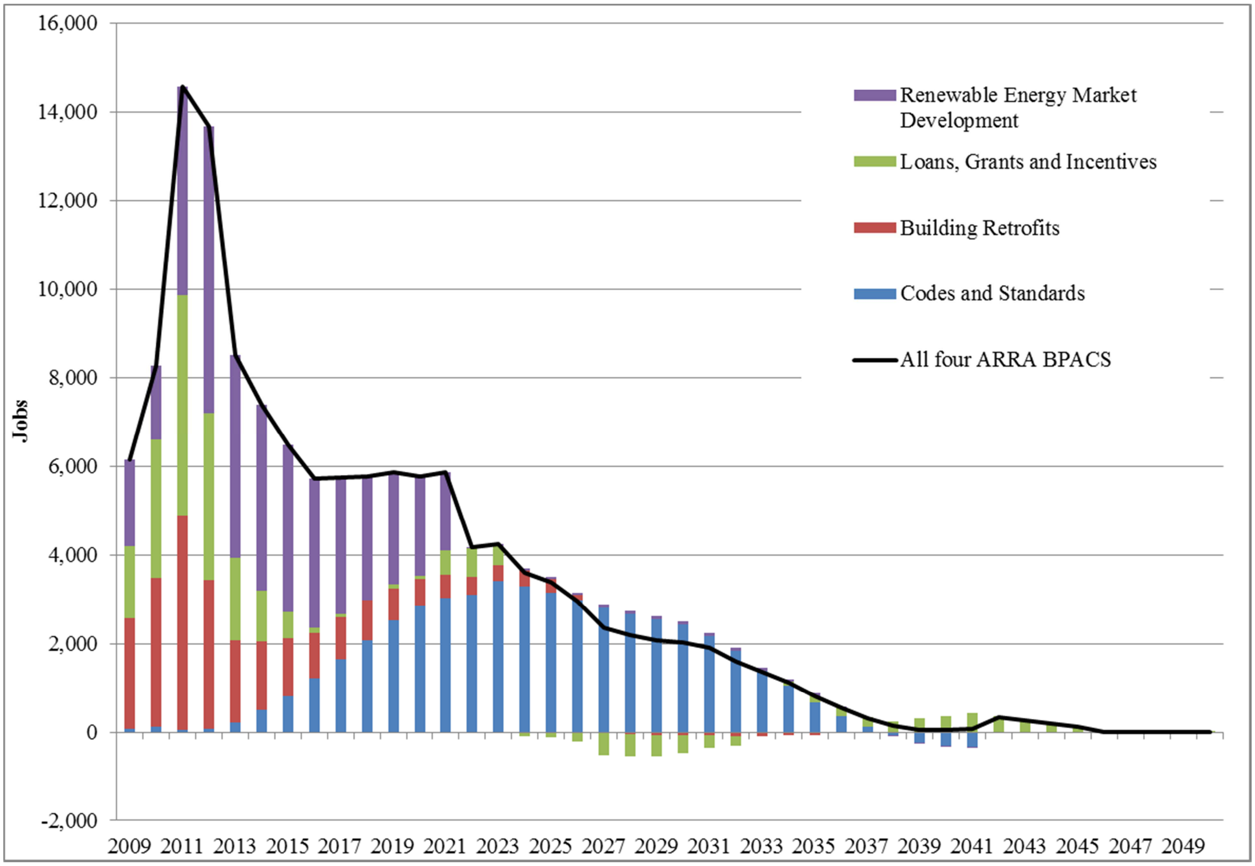

Figure 5-5: Direct, indirect, and induced job changes created in the U.S. from ARRA-period SEP activities

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.
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As shown in **Figure 5-6**, 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.

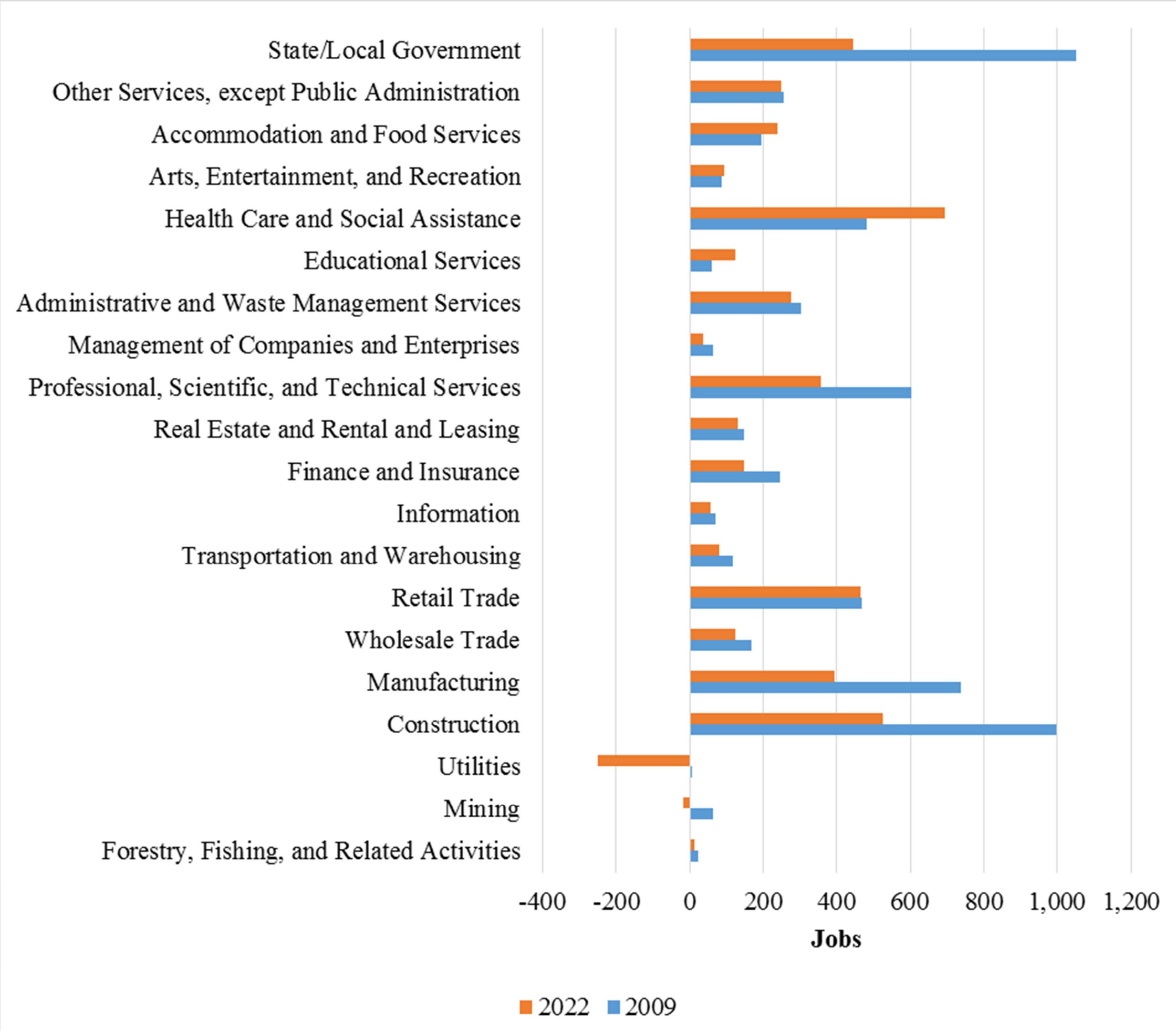

Figure 5-6: Job impact of ARRA-period SEP activities, by NAICS sector

The direct job effects, shown in **Table 5-7**, are over 13,936 job-years in the U.S. for the short-term interval related to ARRA SEP program administration (that is, through 2013). However, for all BPACs except Building Retrofits, there are installation or technical services contracts, or on-going loan administration support, some prolonged equipment purchases, and manufacturing jobs supported through market development incentives that extend beyond 2013, and those direct jobs are shown above in the total job changes of **Table 5-6**. Cumulative direct job-years are 26,856 through 2022.

Table 5-7: Direct jobs created in the U.S. from ARRA-period activities

Year	2009	2010	2011	2012	2013	2014-2022	Job-years
Building Retrofits	688	2633	2439	939	108	-	6,808
Building Codes and Standards	35	61	383	516	684	4,794	6,472
Loans, Grants, and Incentives	88	597	902	416	17	2,929	4,949
Renewable Energy Market Development	504	446	574	1,083	824	5,197	8,627
Total	**1,314**	**3,737**	**4,297**	**2,954**	**1,633**	**12,920**	**26,856**

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

5.1.3 Avoided carbon emissions and avoided social cost estimates (ARRA-period)

This section addresses avoided carbon emissions and avoided social cost impacts for all four ARRA-period BPACs studied in this evaluation. The impacts are all reported in million metric tons of carbon equivalent (MMTCE). The avoided social costs are reported in 2009 dollars.

Avoided carbon emissions from ARRA-period BPAC activities total approximately 163.5 MMTCE and are derived from energy displaced from renewable generation and energy savings (**Table 5-8**). Energy displaced from renewable generation had the higher avoided carbon emissions at 122 MMTCE, followed by 42.4 MMTCE from energy savings.

Table 5-8: Cumulative avoided carbon emissions from ARRA-period activities, by BPAC and program mechanism (MMTCE)

	Avoided Carbon From Energy Savings 2009-2050	Avoided Carbon From Renewable Generation 2009-2050
Building Retrofits	5.88	-
Building Codes and Standards	19.40	-
Loans, Grants, and Incentives	17.04	17.78
Renewable Energy Market Development	0.05	104.00
Total	**42.36**	**121.78**

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.

5.1.3.1 Avoided carbon emissions (ARRA-period)

Avoided carbon emissions from the ARRA-period BPACs are derived from energy savings and renewable generation. As shown in **Figure 5-7**, avoided carbon emissions from ARRA-period BPAC activities total approximately 163.5 MMTCE and are derived from energy displaced from renewable generation and energy savings. Energy displaced from renewable generation had a higher proportion of avoided carbon emissions at 121 MMTCE, followed by 42.4 MMTCE from energy savings.

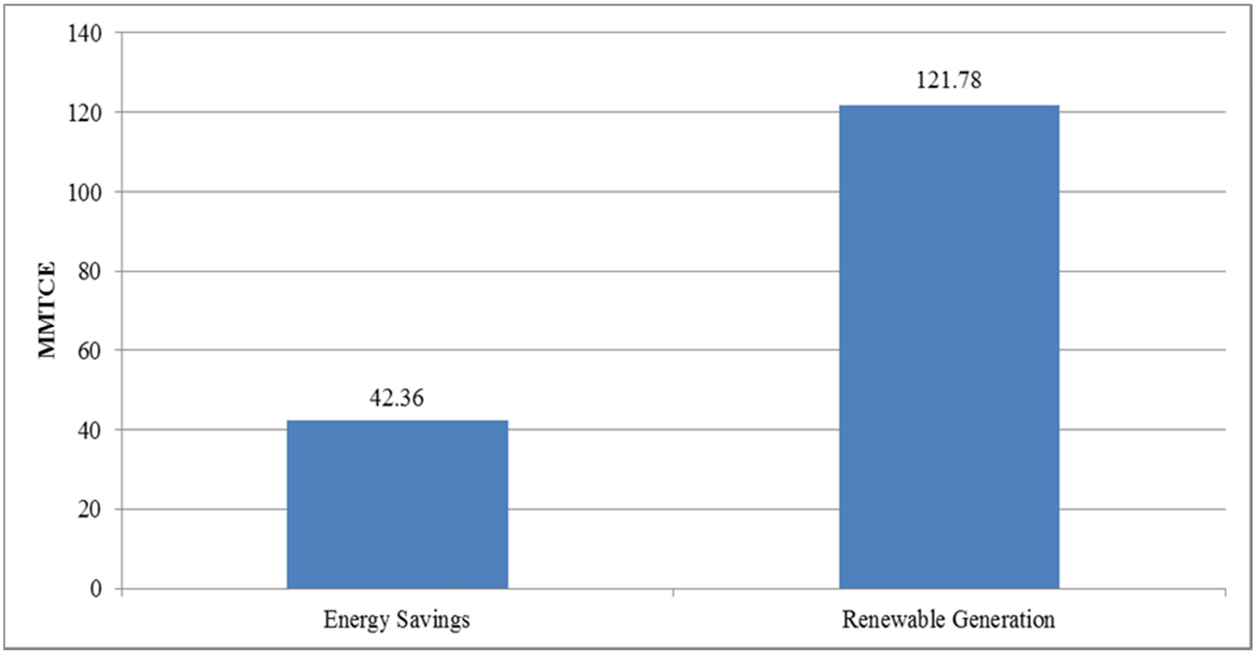

Figure 5-7: Cumulative avoided carbon emissions for ARRA-period activities by program mechanism (MMTCE)

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Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-8 shows SEP-attributable avoided carbon emissions over time from 2009 programmatic activities in MMTCE. Avoided carbon emissions follow a similar trajectory to energy savings and renewable generation, rising steadily from 2009 through 2025, when avoided carbon emissions peak. The avoided carbon emissions then begin to decline through 2050, when less than 1 MMTCE of avoided carbon emissions still persist due to residual impacts of revolving loan programs.

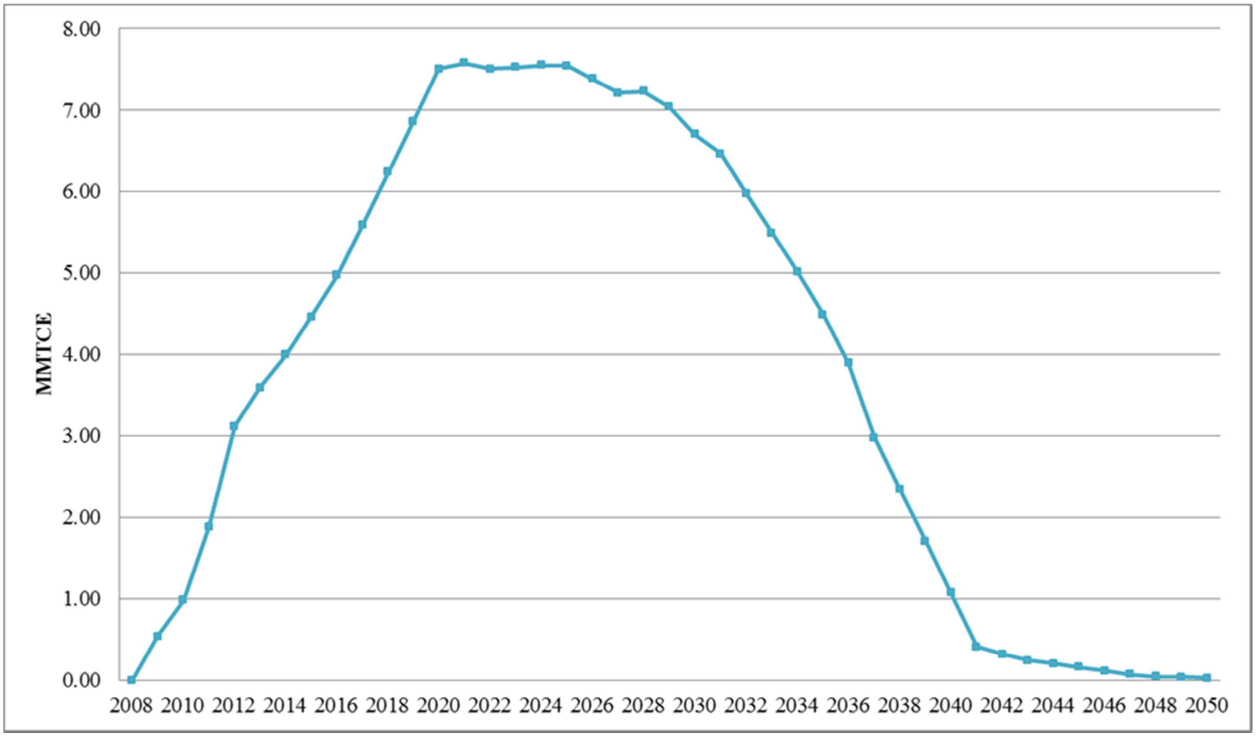

Figure 5-8: Cumulative avoided carbon emissions over time from ARRA-period activities (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided carbon emissions over the lifetime of energy impacts, by sector, are presented in **Figure 5-9**. The industrial sector accounts for the largest amount of avoided MMTCE (127), followed by the residential sector with 18.4 avoided MMTCE, and the public institutional sector with 14.5 avoided MMTCE. The private institutional sector had 3.7 avoided MMTCE, followed by the commercial sector with 5.3 avoided MMTCE.

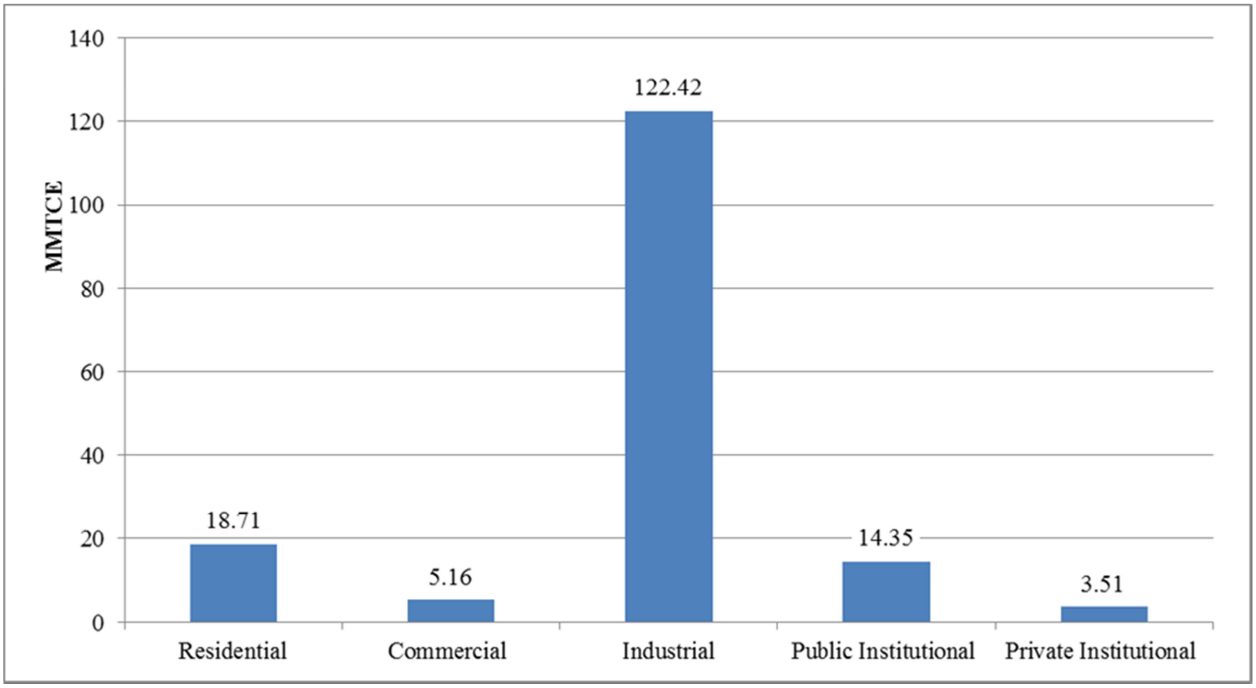

Figure 5-9: Cumulative avoided lifetime carbon emissions by sector from ARRA-period activities (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.1.3.2 Avoided social costs of carbon (ARRA-period)

Total avoided social costs of carbon are $11.9 billion. As shown below in **Figure 5-10**, energy displaced from renewable generation accounts for the majority of the avoided social costs at $8.9 billion. Energy savings accounted for $3.1 billion in avoided social costs.

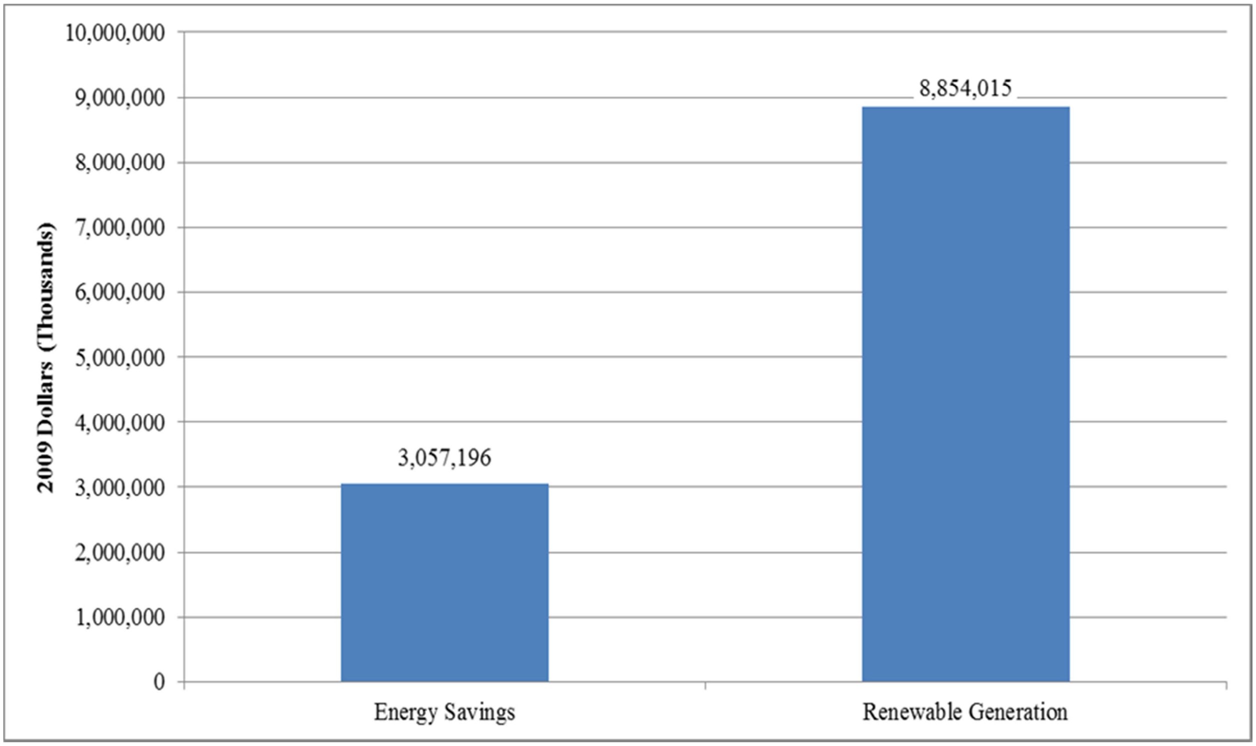

Figure 5-10: Cumulative avoided social costs of carbon emissions for ARRA-period activities by program mechanism (Thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided social costs of carbon over time are presented in **Figure 5-11** for the four ARRA-period BPACs. Similar to the pattern of avoided carbon emissions, the associated avoided social costs rise through 2025 when they reach their peak. Avoided social costs then decline through 2050, when some associated avoided social costs of carbon persist through 2050, the end of the period covered by this program evaluation.

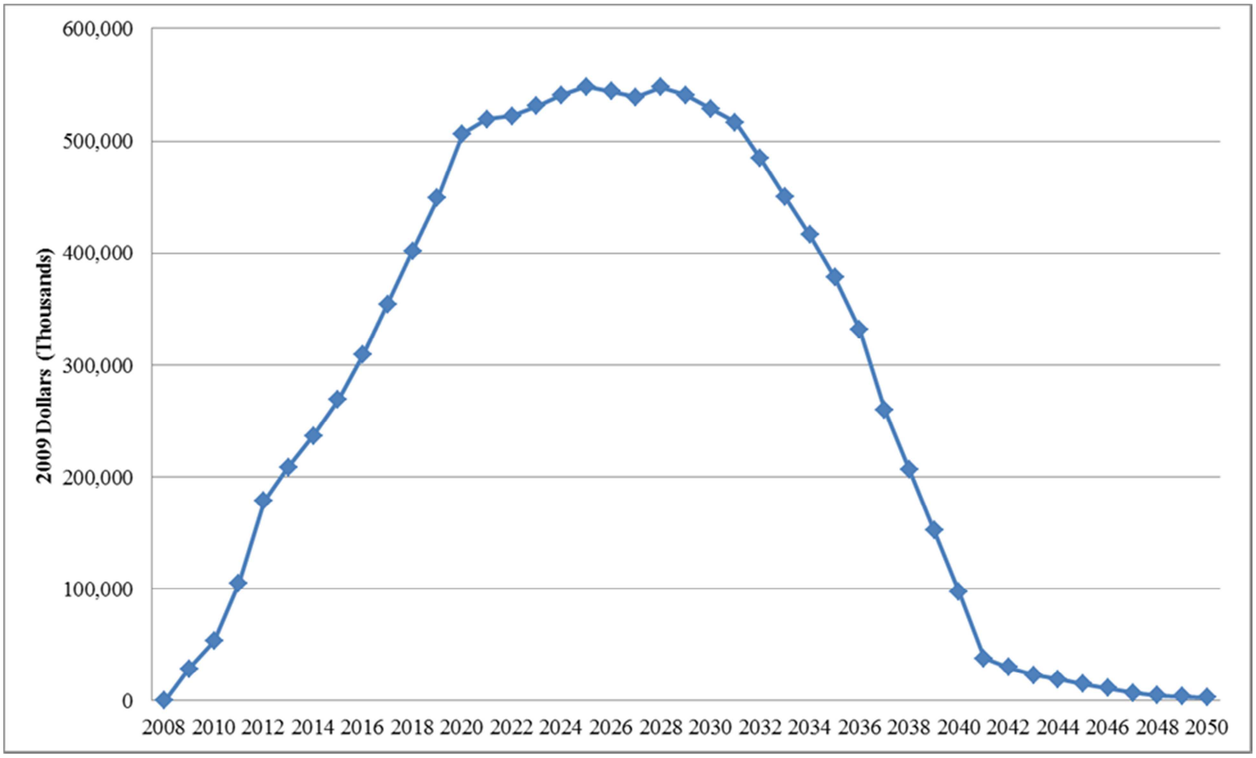

Figure 5-11: Cumulative avoided social costs of carbon over time from ARRA-period activities (Thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-12 shows how those avoided social costs of carbon distribute across sectors. The industrial sector realizes the most avoided costs at $9.3 billion. The other sectors' avoided costs ranged from $396 million (commercial) to $1.3 billion (residential).

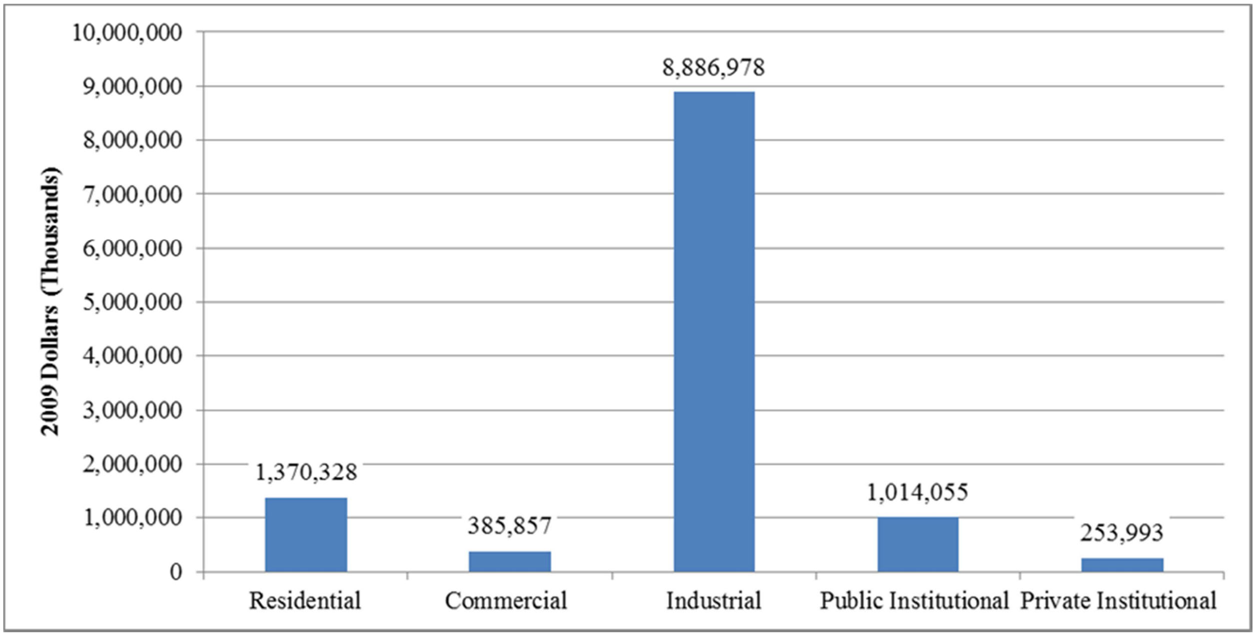

Figure 5-12: Cumulative avoided lifetime social costs of carbon by sector from ARRA-period activities (Thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.1.4 Bill savings and cost-effectiveness (ARRA-period)

This section presents findings on bill savings and cost-effectiveness indicators for all studied SEP activities during the ARRA-period. Bill savings are presented in 2009 dollars, and include direct customer savings from energy efficiency and on-site renewable generation, as well as indirect customer bill savings related to utility-scale renewable generation. For cost-effectiveness, two indicators are presented in this report: the SEP RAC test result and a ratio of SEP-attributable bill savings to SEP expenditures in present value terms.

Total bill savings attributable to SEP from energy savings and renewable generation associated with the ARRA-period BPAC activities are shown in **Table 5-10**. Bill savings for this BPAC peak about half way through the study period, with cumulative bill savings totaling $7.8 billion through year 2050, compared to estimated program funding of $1.9 billion for these BPACs in the ARRA period.[85]

Table 5-9: Cumulative bill savings for ARRA-period studied BPACs

BPAC	Bill Savings ($Thousands)
Building Retrofits	$835,684
Building Codes and Standards	$4,018,704
Loans, Grants, and Incentives	$2,772,906
Renewable Energy Market Development	$130,165*
Total	**$7,757,459**

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

Figure 5-13 shows how bill savings are distributed across different sectors over the entire period of analysis, with most coming from the residential sector, followed by the public institutional sector, then the commercial, industrial and private institutional sectors.

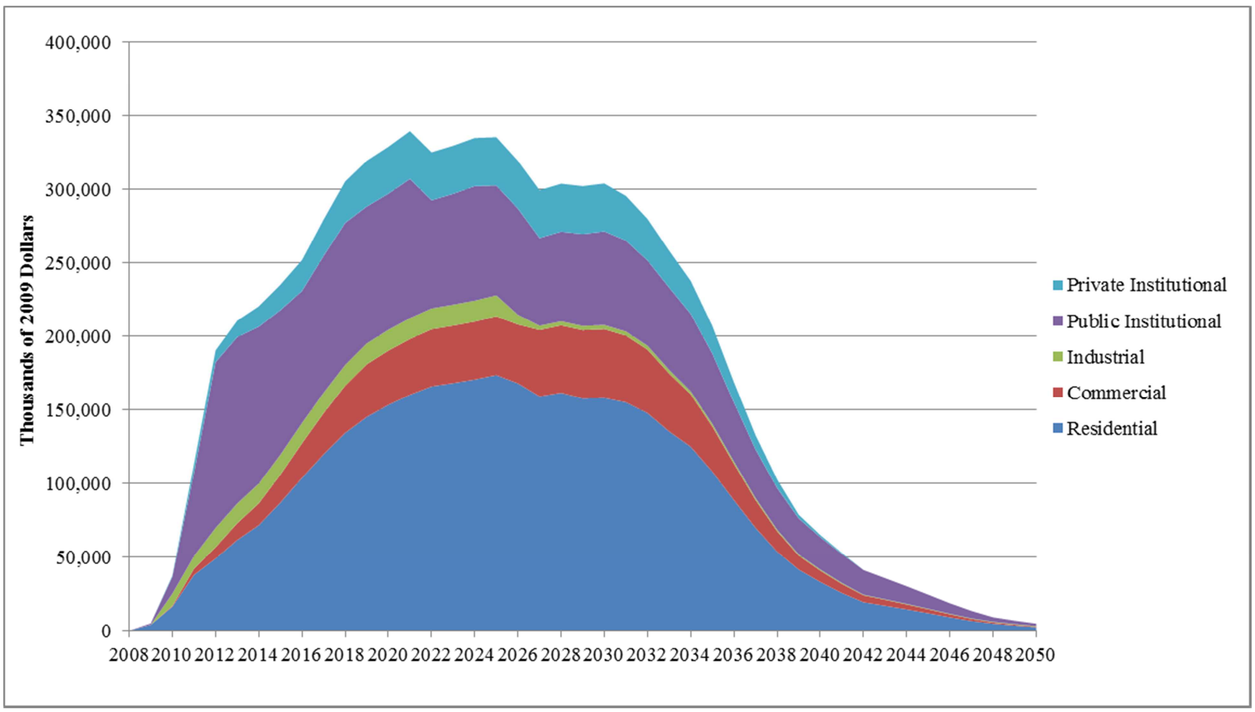

Figure 5-13: Cumulative bill savings for ARRA-period Building Retrofits by sector by year (Thousands of $2009)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

85 Customer bill savings related to on-site generation are included in total bill savings for the Loans, Grants, and Incentives and Renewable Energy Market Development BPACS. All on-site renewable generation evaluated in this study is customer-owned and therefore the savings accrue to the customer.

Table 5-10 shows SEP-attributable bill savings by fuel and sector. The majority of bill savings are accounted for in the residential customer sector—mostly related to electricity savings—followed by the public institutional sector, where most of the bill savings also involve electricity savings.

Table 5-10: SEP-attributable cumulative bill savings for PY 2008 activities by fuel type by sector (thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	$2,945,699	$768,789	$226,762	$1,749,540	$545,133	$6,235,923
Natural Gas	$563,247	$115,931	$18,483	$376,434	$92,703	$1,166,798
Oil	$142,525*	$43,401	$4,058	$71,590	$39,663	$301,237
Propane	$46,058	$532	$15*	$1,814	$2,230	$50,650
Kerosene	n/a	-	-	-	-	-
Wood	n/a	-	-	$11*	-	$11*
Diesel	n/a	$801*	$392*	$1,118*	-	$2,311
Ethanol	n/a	-	-	-	-	-
Gasoline	n/a	$529*	-	-	-	$529*
Other	n/a	-	-	-	-	-
Total	$3,697,528	$929,984	$249,710	$2,200,508	$679,730	$7,757,459

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

5.1.4.1 Cost-effectiveness (ARRA-period)

Table 5-11 shows the SEP RAC test result for all four PY 2008 BPACs studied. SEP RAC test results are presented from a building perspective, which combines energy savings and renewable generation, and from a system perspective, which combines energy savings with energy displaced by renewable generation.[86]

The SEP RAC test result for all studied BPACs was 74.9 from the building perspective and 75.5 from the system perspective with loans. Without loans, the SEP RAC test result was 92.0 from the building perspective and 92.8 from the system perspective. This substantially exceeded the ARRA-period benchmark of 10. All four BPACs exceed the SEP RAC test's benchmark, with the cumulative value being a savings weighted average of all of them based on the size of the savings and PA funding. The Building Codes and Standards BPAC generated the largest SEP RAC test result (1,562), but had the smallest budget and weight. This was offset by the Building Retrofits BPAC that had the lowest SEP RAC test result (16.7).

The SEP RAC test results are presented both with and without the initial loan disbursements for the Loans, Grants, and Incentives BPAC, which includes loans that are included as program expenditures. As these loans are eventually repaid by borrowers, however, they can alternatively be viewed as not being a program expenditure, which is why it is presented with and without loans.

86 The substantive distinction between the SEP RAC test from the building perspective and the SEP RAC test from the system perspective 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 5-11: SEP RAC test result for ARRA-period studied BPACs

Metrics	SEP RAC Test Result (Building)	SEP RAC Test Result (System)
Building Retrofits	16.7	16.7
Building Codes and Standards	1,562.4	1,562.4
Loans, Grants, and Incentives (with loans)	20.6	21.5
Loans, Grants, and Incentives (without loans)	35.1	36.6
Renewable Energy Market Development	227.1	228.1
Total (with loans)	**74.9**	**75.5**
Total (without loans)	**92.0**	**92.8**

Under all three discount scenarios these ARRA-period BPACs produce positive present value ratios. Present value ratios ranged from 2.3 to 3.7 under different discount rate scenarios when loans were included. When loans were excluded, present value ratios ranged from 2.8 to 4.6.[87]

Table 5-12: Lifetime present value ratio for ARRA-period studied BPACs

Discount Rate	0.7%	2.7%	4.7%
Building Retrofits	1.3	1.2	1.1
Building Codes and Standards	333.8	250.3	191.6
Loans, Grants, and Incentives (with loans)	2.9	2.2	1.7
Loans, Grants, and Incentives (without loans)	4.9	3.7	3.0
Renewable Energy Market Development	0.3	0.2	0.2
Total (with loans)	**3.7**	**2.9**	**2.3**
Total (without loans)	**4.6**	**3.5**	**2.8**

The SEP RAC test results and PV ratios for the same BPACs (i.e., Building Retrofits; Loans, Grants, and Incentives) were found to vary from PY 2008 to the ARRA period. For Building Retrofits, the cost-effectiveness numbers were lower under ARRA than in PY 2008. This can largely be explained by differences in the nature of the programs in the two periods, with the ARRA-funded activities often involving larger projects and covering a greater share of total costs. The state leveraging requirement for PY 2008, which did not apply under ARRA, also contributed to the greater SEP-attributable savings per SEP dollar because that state investment would not have occurred in the absence of SEP. For Loans, Grants, and Incentives, the PY 2008 RAC test results and PV ratios are lower than for the ARRA period because PY 2008 included more programmatic activities that focused on carbon reduction, especially in the transportation and alternative fuel areas, where energy savings were lower than those achieved by other types of activities. As explained in **Sections 3.4.4** and **3.5.4**, cost-effectiveness is calculated by dividing SEP-attributable savings by SEP funding only.

5.2 Energy savings/renewable generation (ARRA-period)

This section presents the following findings related to energy savings and renewable generation for each ARRA-period BPAC:

- 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

Energy impacts are originally calculated in site energy, but are reported in source MMBtu. This means that energy savings and renewable generation at a consumer site is converted to the equivalent

[87] Customer costs associated with switching electricity service for on-site generation technologies are not considered in the PV ratios for the Loans, Grants, and Incentives and the Renewable Energy Manufacturing BPACs.

amount of raw fuel consumed at the fuel source. Ratio adjustments from EPA's ENERGY STAR© PortfolioManager® account for loss of energy from transmission and production of heat and electricity not combusted on-site.[88] These ratio adjustments are provided in Appendix J.

5.2.1 Building retrofits (ARRA-period)

The Building Retrofits BPAC encompasses programmatic activities that provide financial incentives for building retrofit and equipment replacement projects in nonresidential and residential buildings. The ARRA-period Building Retrofits BPAC did not have any renewable generation impacts over the 2009 through 2050 period; therefore, this section will only discuss energy savings impacts.

> ARRA Building Retrofits programs cover a broad range of energy efficient projects in the residential and nonresidential sectors, including programs that used the funds to retrofit lighting and HVAC systems in state-owned buildings.

5.2.1.1 Energy impacts for all fuel types and sectors combined (building retrofits)

The ARRA-period Building Retrofits BPAC resulted in SEP-attributable energy savings of 89.2 million source MMBtu over the 2009 to 2050 period. SEP-attributable energy savings start in 2009, peak in 2012, and gradually decline through 2035 as the effective useful lifetimes of the associated efficiency technologies expire. **Figure 5-14** shows the impacts over time.

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

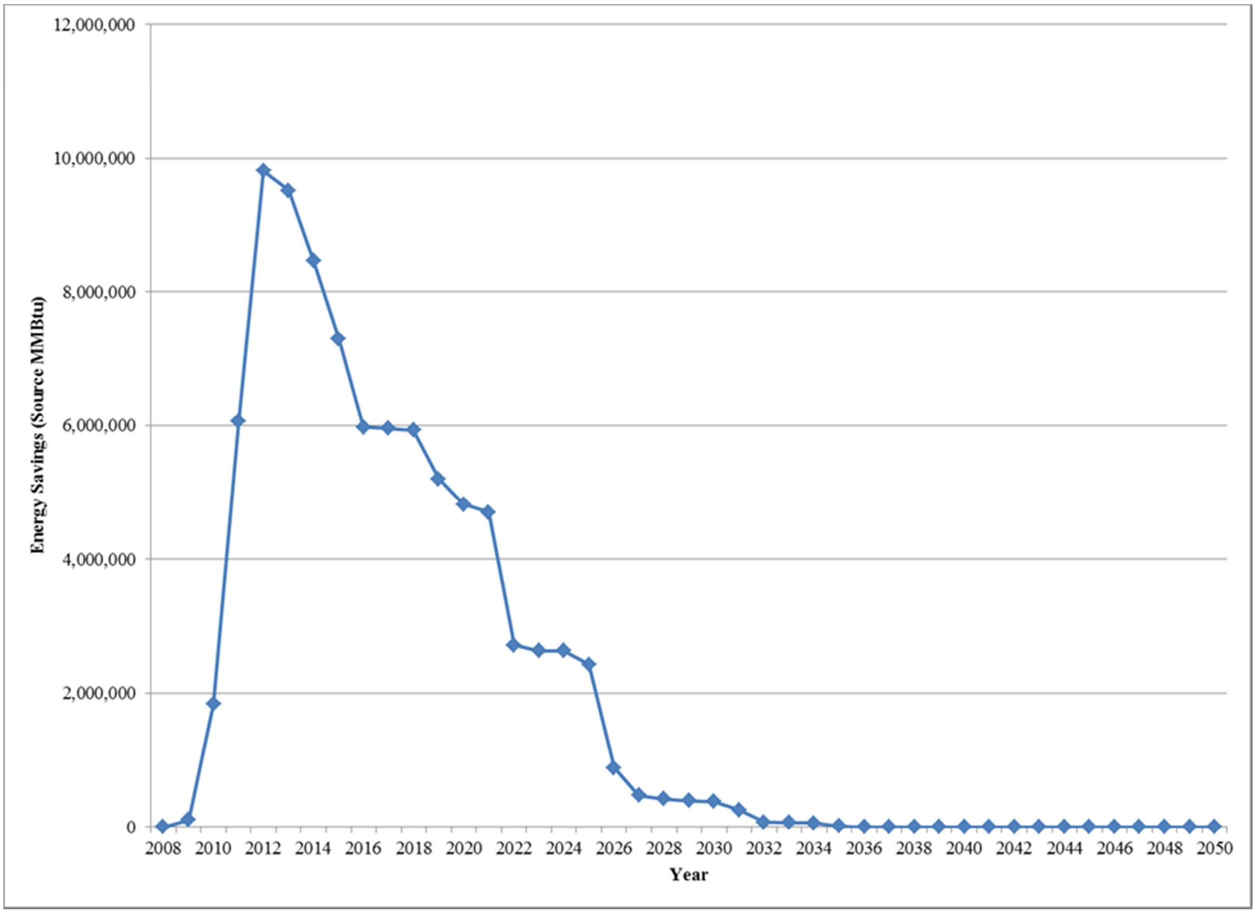

Figure 5-14: SEP-attributable energy savings for building retrofits activities by year (Source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.2.1.2 Energy impacts by fuel type (building retrofits)

Table 5-13 shows the SEP-attributable energy savings and renewable generation over time by fuel type in source MMBtu. Electricity savings amounted to 75.7 million source MMBtu over the 2009 to 2050 study period. Natural gas savings amounted to 12.3 million source MMBtu.

Table 5-13: SEP-attributable energy savings for building retrofits activities by fuel type over time (Source MMBtu)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	106,877*	1,801,613	5,094,677	8,033,786	7,746,241	37,361,015	15,179,65	369,955	-	75,693,820
Natural Gas	-	28,967	917,224	1,720,415*	1,716,424*	5,896,293	1,993,327	42,012	-	12,314,663
Oil	-	4,081*	45,088*	47,665*	47,665*	333,658*	444,167*	40,779*	-	963,104*
Propane	-	3,872*	8,814*	8,814*	8,814*	61,701*	86,788*	21,000*	-	199,805*
Kerosene	-	-	-	-	-	-	-	-	-	-
Wood	-	-	73*	73*	73*	508*	733*	243*	-	1,703*
Diesel	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-
Total	**106,877***	**1,838,533**	**6,065,875**	**9,810,754**	**9,519,217**	**43,653,176**	**17,704,67**	**473,990**	**-**	**89,173,094**

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

5.2.1.3 Energy impacts by sector (building retrofits)

Figure 5-15 displays the energy savings in source MMBtu by sector over time.

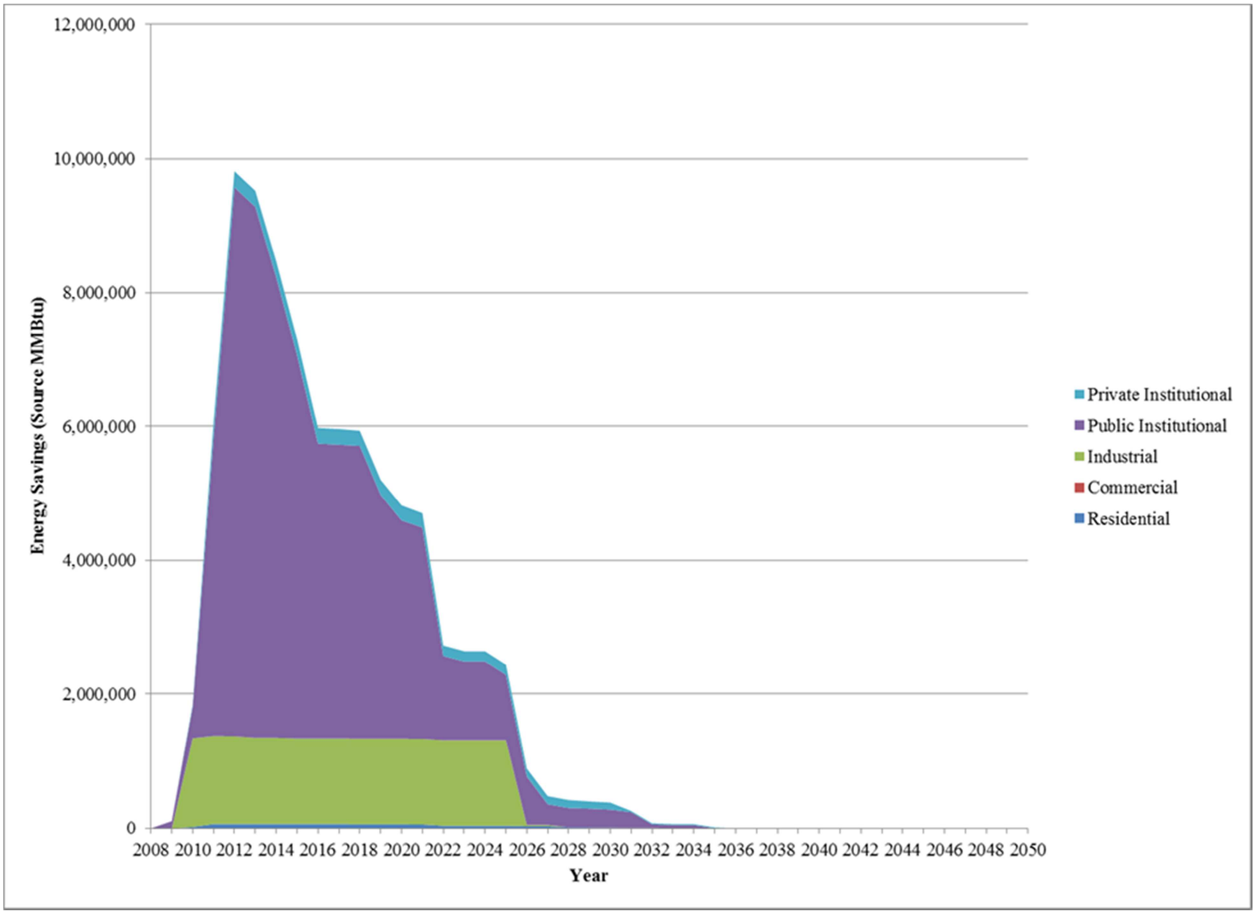

Figure 5-15: SEP-attributable energy savings for building retrofits activities by sector by year (Source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 5-14 shows the total SEP-attributable energy savings by sector in source MMBtu for the 2009 through 2050 period. The majority of the energy savings occur in the public institutional sector (63.8 million source MMBtu), followed by the industrial sector (20.5 million source MMBtu). The private institutional sector and residential sector showed energy savings of four million and one million source MMBtu respectively.

Table 5-14: SEP-attributable energy savings for building retrofits activities by sector (Source MMBtu)

	SEP-Attributable Energy Savings 2009-2050
Residential	1,001,076
Commercial	-
Industrial	20,512,760*
Public Institutional	63,815,140
Private Institutional	3,844,119
Total	**89,173,094**

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

5.2.2 Building codes and standards (ARRA-period)

The Building Codes and Standards BPAC encompasses programmatic activities designed to provide technical and administrative support for the development of more energy-efficient appliance/equipment standards and building codes as well as training and technical services to strengthen enforcement of energy efficiency building codes. However, this analysis examines only building codes activities and does not incorporate standards programs because the funding for those programmatic activities fell below the minimums set up for this evaluation. The ARRA-period Building Codes and Standards BPAC did not have any renewable generation impacts over the 2009 to 2050 period, therefore, this section will only discuss energy savings impacts.

> Typical PAs in the Building Codes and Standards BPAC include funding to help increase awareness of, and compliance with, the International Energy Conservation Code. In one state, the funding provided training of both code officials and the general public.

5.2.2.1 Energy impacts for all fuel types and sectors combined (codes and standards)

The ARRA-period Codes and Standards BPAC resulted in SEP-attributable energy savings of 326 million source MMBtu over the 2009 to 2050 period. **Figure 5-16** shows the SEP-attributable impacts over time. Energy savings for codes ramp up as the codes come into effect in 2010 through 2020. The energy savings peak from 2022 through 2030, after that they gradually diminish as new codes are introduced to the market that were not influenced by ARRA-period funding.

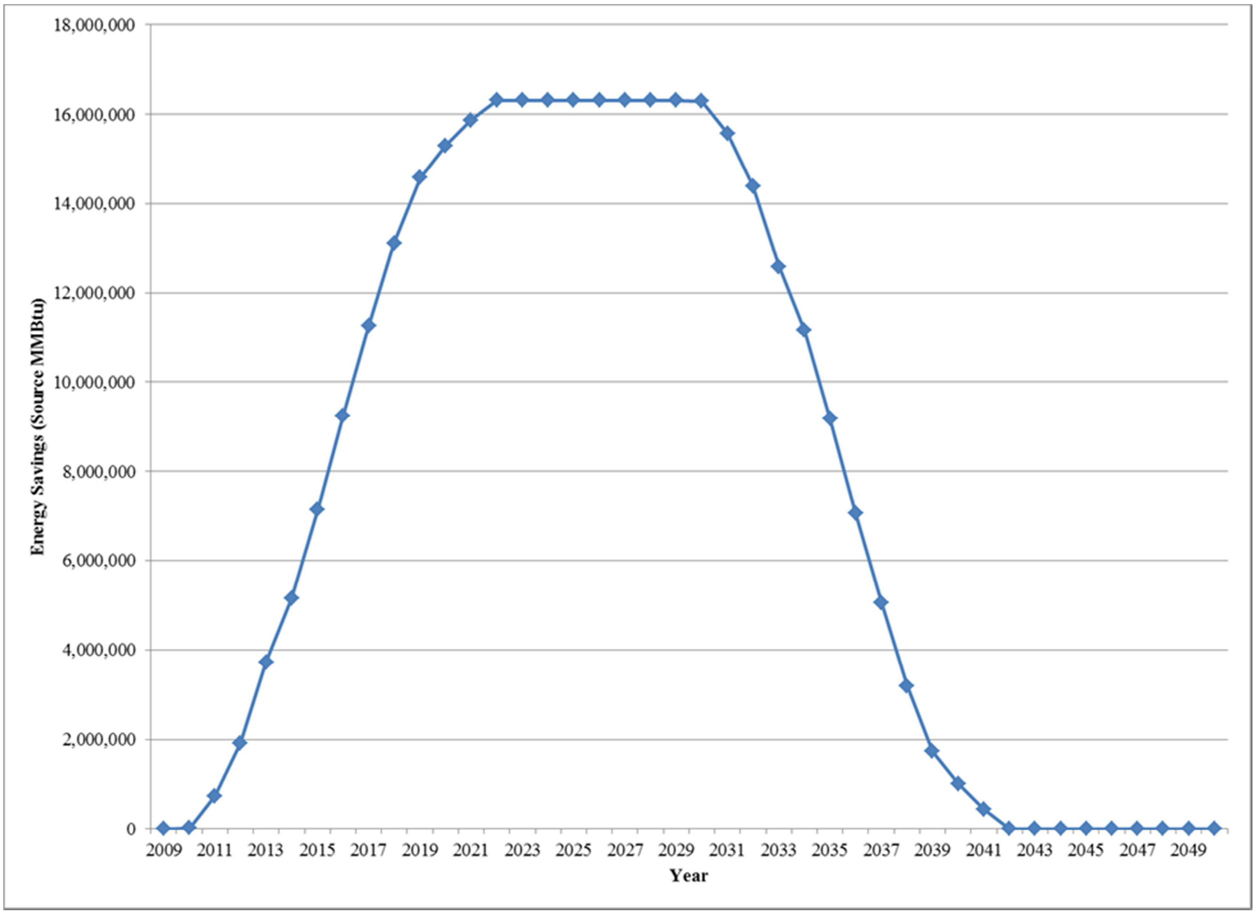

Figure 5-16: SEP-attributable energy savings for codes and standards activities by year (Source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.2.2.2 Energy impacts by fuel type (codes and standards)

Table 5-15 shows the SEP-attributable energy savings over time by fuel type. The data suggest SEP-attributable energy savings of 273 million source MMBtu of electricity and 47.7 million source MMBtu of natural gas between 2009 and 2050. The Codes and Standards BPAC also resulted in SEP-attributable energy savings for oil and propane.

Table 5-15: SEP-attributable energy savings for codes and standards activities by fuel type over time (Source MMBtu)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	-	19,281*	633,488	1,648,796	3,202,775	63,912,173	136,167,61	67,141,52	351,864	273,077,509
Natural Gas	-	2,994	83,092	228,616	448,609	10,589,783	23,777,566	12,513,262	82,801	47,726,725
Oil	-	529*	14,977	36,882	69,453	1,166,075	2,449,343	1,170,038	7,552	4,914,849
Propane	-	-	1,407	3,623	6,683	132,913	259,741	115,369	253	519,989
Kerosene	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-
Total	**-**	**22,805**	**732,965**	**1,917,917**	**3,727,519**	**75,800,944**	**162,654,26**	**80,940,19**	**442,471**	**326,239,072**

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

5.2.2.3 Energy impacts by sector (codes and standards)

Figure 5-17 displays the energy savings associated with Codes activities by sector over time. All five sectors follow a similar pattern to the overall pattern for the BPAC as shown in **Figure 5-16**. Energy savings occurred across all five sectors, with the most energy savings occurring in the residential sector, followed by the commercial and private institutional sectors.

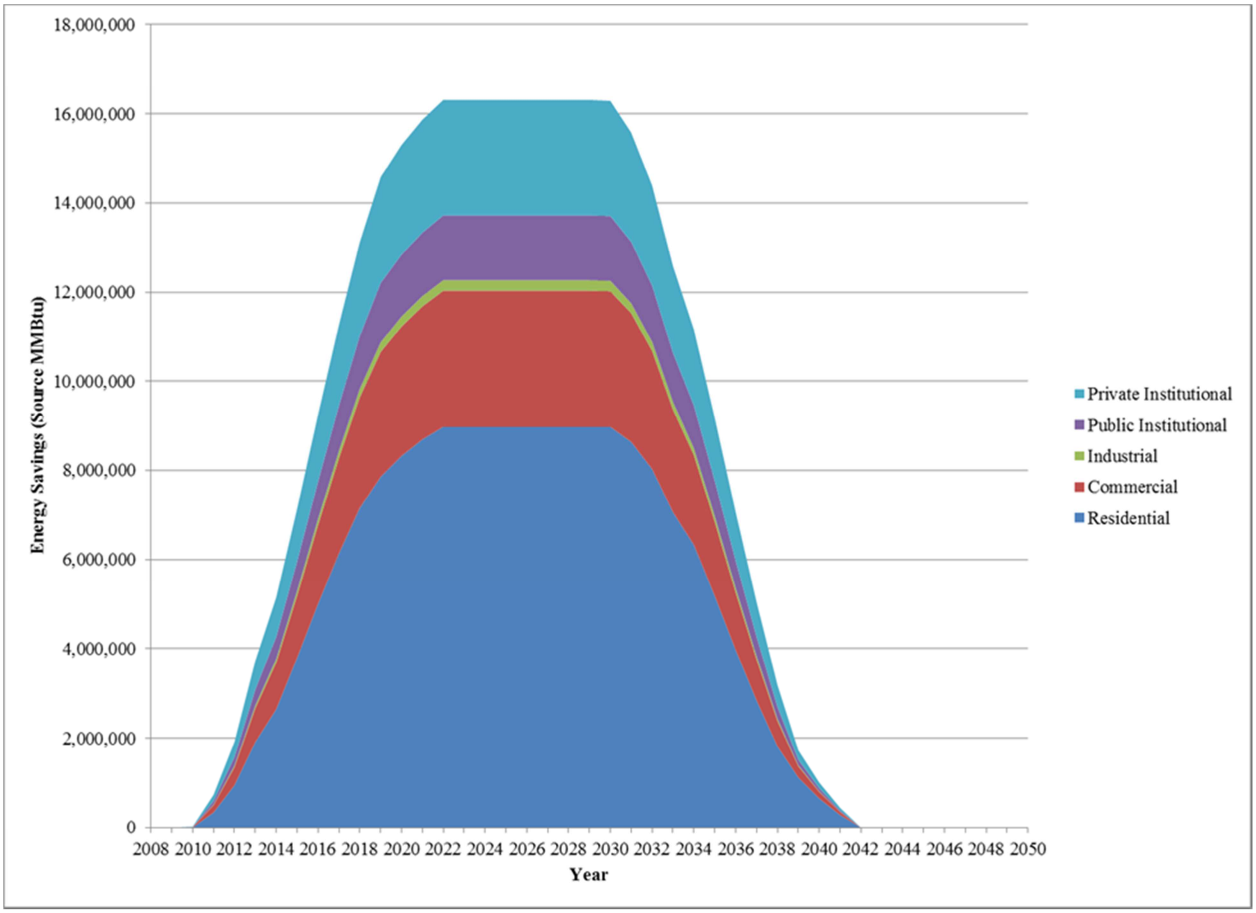

Figure 5-17: SEP-attributable energy savings for codes and standards activities by sector by year (Source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 5-16 shows the total Codes-related energy savings by sector in source MMBtu for the 2009 through 2050 period. The residential sector made up almost half of the energy savings with about 180 million source MMBtu of energy savings.

Table 5-16: SEP-attributable energy savings for codes and standards activities by sector (Source MMBtu)

	SEP-Attributable Energy Savings 2009-2050
Residential	179,528,365
Commercial	61,088,802
Industrial	4,709,477
Public Institutional	29,143,954
Private Institutional	51,768,473
Total	**326,239,072**

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

5.2.3 Loans, grants, and incentives (ARRA-period)

The Loans, Grants, and Incentives BPAC encompasses programmatic activities aimed to provide financial incentives for building retrofit and equipment replacement projects across all sectors. During the ARRA-period this BPAC encompassed both increased energy efficiency and the introduction of renewable technologies.

ARRA Loans, Grants, and Incentives programs included funding for rebate programs, such as lighting and HVAC upgrades for municipal buildings. It also included revolving loan fund programs, such as one that allowed households to get financing for on-site solar photovoltaic, solar thermal, or wind systems.

5.2.3.1 Energy impacts for all fuel types and sectors combined (loans, grants, and incentives)

The ARRA-period Loans, Grants, and Incentives BPAC resulted in SEP-attributable energy savings of 272 million source MMBtu over the 2009 to 2050 period. **Figure 5-18** shows the energy savings impacts over time. The energy savings rise quickly through 2012, increase gradually to the peak in 2025, and then decline sharply at first, then gradually. Energy savings persist through 2050, the end of the studied evaluation period. The majority of the later impacts occur as a result of revolving loan programs.

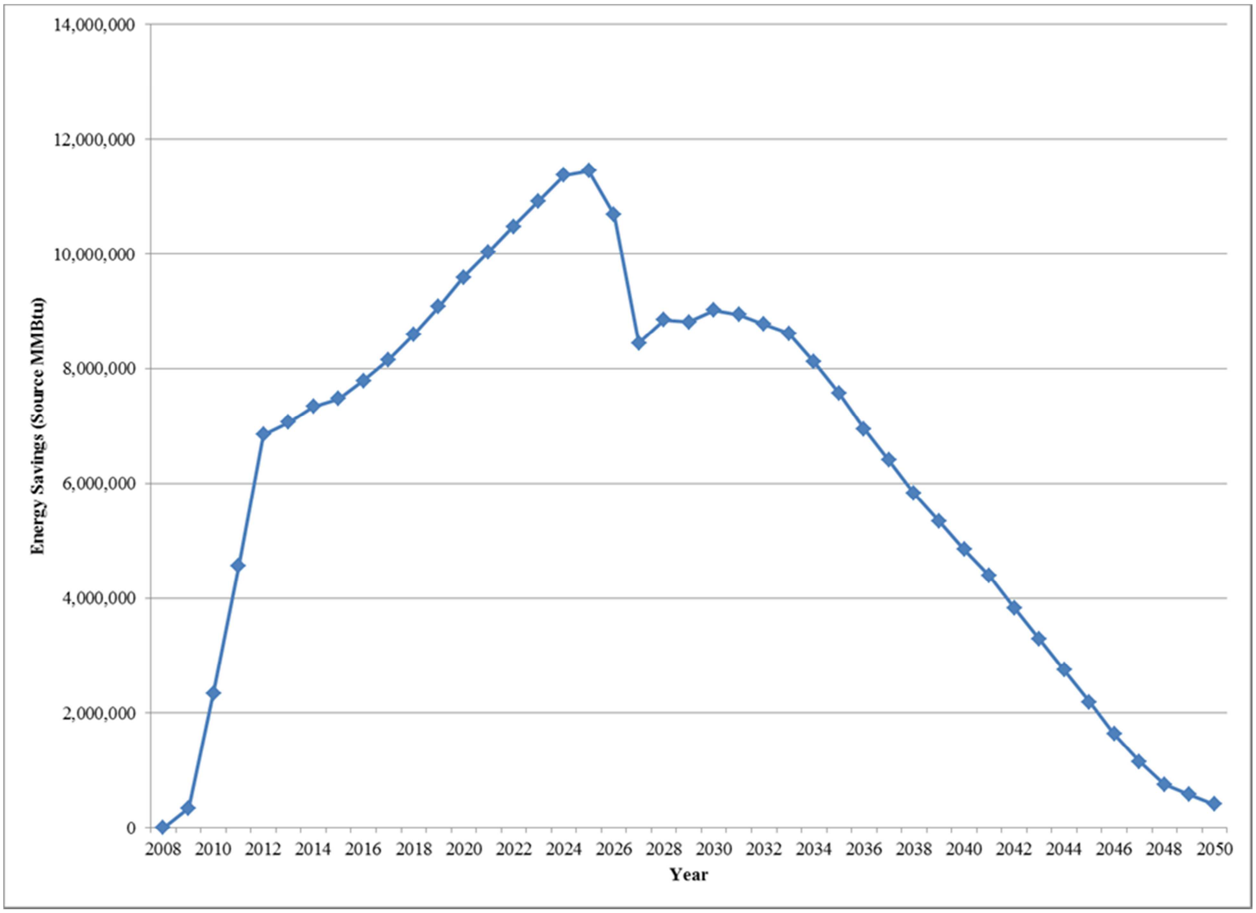

Figure 5-18: SEP-attributable energy savings for loans, grants, and incentives activities by year (source MMBtu)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

The studied portion of the ARRA-period Loans, Grants, and Incentives BPAC resulted in 232 million source MMBtu of SEP-attributable renewable generation over the 2009 to 2050 period. **Figure 5-19** shows the impacts over time. The graph shows early variability in the 2010 to 2013 ARRA-period, but after this time the renewable generation rises steadily as all program impacts begin to accumulate until renewable generation peaks in 2031. At the end of the evaluation's study period in 2050, savings persist at about 4,000 source MMBtu.

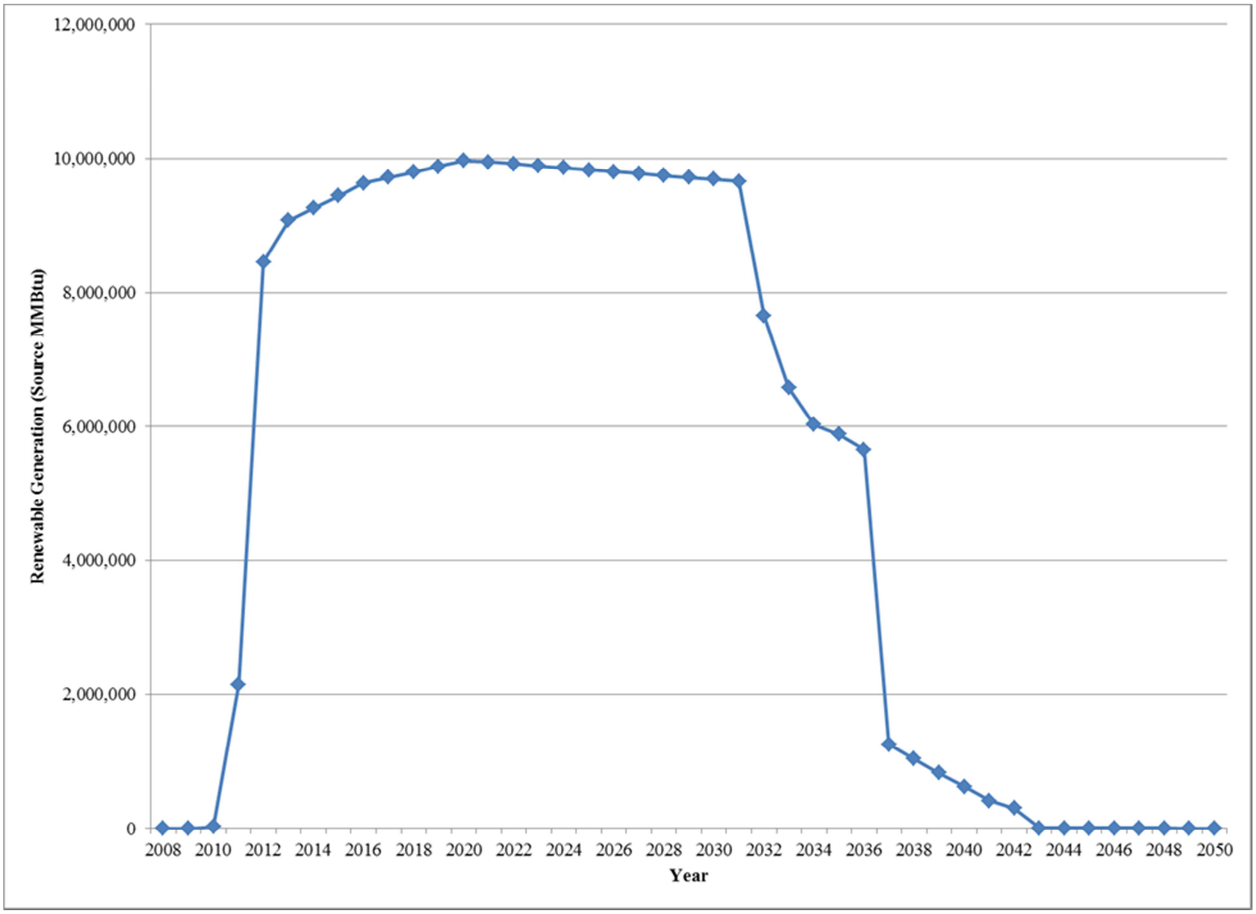

Figure 5-19: SEP-attributable renewable generation for loans, grants, and incentives activities by year (source MMBtu)
A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.2.3.2 Energy impacts by fuel type (loans, grants, and incentives)

Table 5-17 and **Table 5-18** show the SEP-attributable energy savings and renewable generation over time by fuel type. **Table 5-17** shows energy savings of 217 million source MMBtu from electricity followed by 43.4 million source MMBtu from natural gas, 10.3 million source MMBtu from oil and 1.4 million source MMBtu from propane. Table 5-18 shows that activities in this BPAC generated 232 million source MMBtu from renewable electricity, with 15 thousand source MMBtu provided by biodiesel.

Table 5-17: SEP-attributable energy savings for loans, grants, and incentives activities by fuel type over time (source MMBtu)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	54,857*	1,864,949	3,544,756	5,399,443	5,522,286	45,810,589	79,209,716	57,888,533	17,310,222	216,605,350
Natural Gas	284,225*	411,473	654,994	1,059,124	1,109,136	9,052,220	16,285,684	11,416,499	3,134,913	43,408,267
Oil	309*	62,325*	316,543	346,082	382,332	2,819,409	4,044,387	1,823,450	459,355*	10,254,192
Propane	2,498*	11,363	37,103	46,568	46,411	345,761	534,602*	265,594*	92,777*	1,382,675*
Kerosene	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-
Total	**341,890***	**2,350,109**	**4,553,395**	**6,851,217**	**7,060,165**	**58,027,979**	**100,074,388**	**71,394,076**	**20,997,267**	**271,650,484**

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

Table 5-18: SEP-attributable renewable generation for loans, grants, and incentives activities by fuel type over time (source MMBtu)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Renewable Electricity	2,661	26,105	2,144,973*	8,454,439*	9,079,019*	67,732,493	98,213,800	45,196,184	757,429	231,607,105
Methane	-	-	-	-	-	-	-	-	-	-
Landfill Gas [50% CH4/ 50% CO2]	-	-	-	-	-	-	-	-	-	-
Digester Gas [Sewage or Biogas]	-	-	-	-	-	-	-	-	-	-
Biodiesel	-	-	-	430*	451*	3,859*	8,388*	2,227*	-	15,355*
Ethanol	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-
Total	**2,661**	**26,105**	**2,144,973***	**8,454,869***	**9,079,470***	**67,736,352**	**98,222,188**	**45,198,411**	**757,429**	**231,622,460**

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

5.2.3.3 Energy impacts by sector (loans, grants, and incentives)

Figure 5-20 graphically displays the energy savings by sector over time.

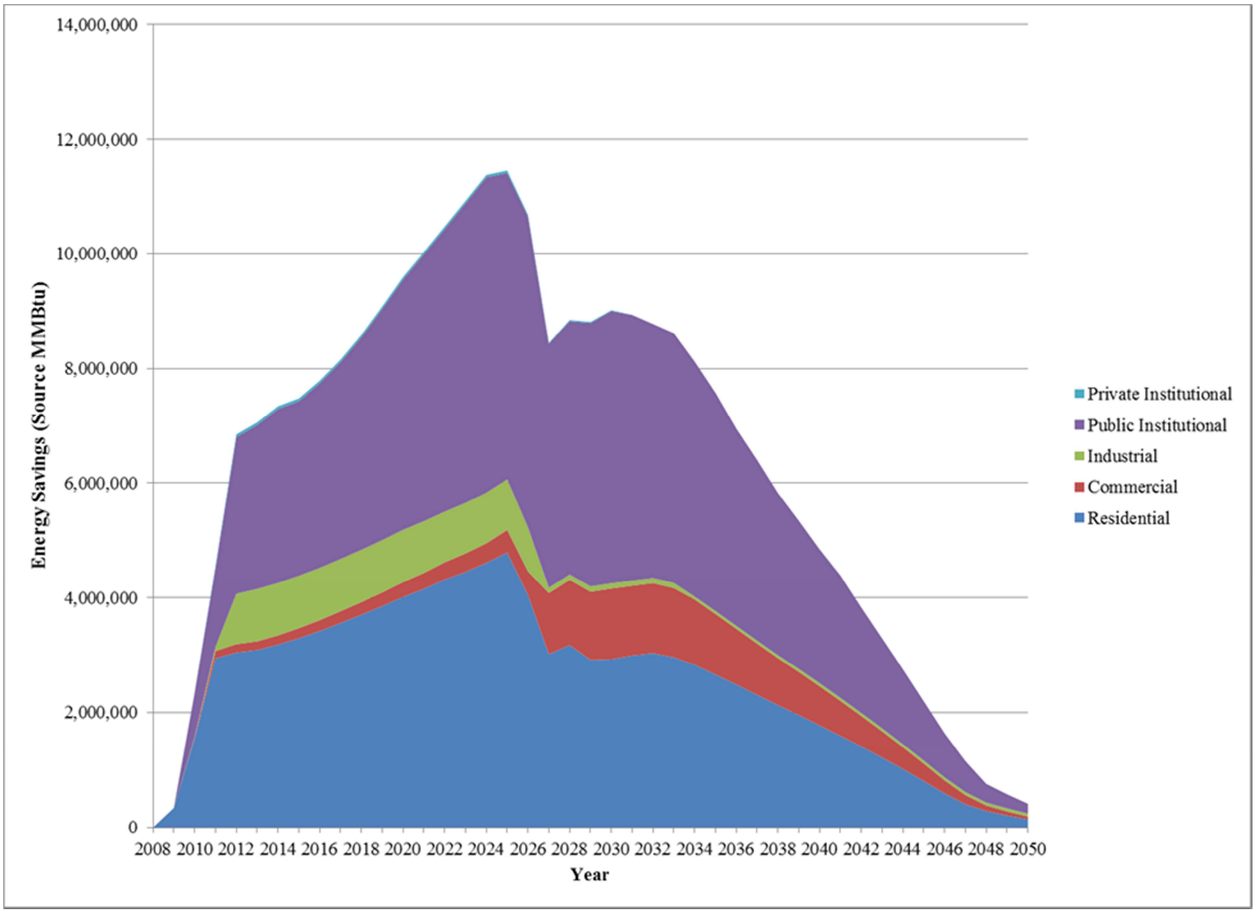

Figure 5-20: SEP-attributable energy savings for loans, grants, and incentives activities by sector by year (source MMBtu)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 5-19 shows the total energy savings by sector in source MMBtu for the 2009 through 2050 period. The public institutional sector had about half of the energy savings with 127 million source MMBtu of energy savings, followed by the residential sector with around 107 million source MMBtu of energy savings. The commercial sector saved 21.5 million source MMBtu followed by the industrial sector with 15.0 million source MMBtu and the private institutional sector with 748 thousand source MMBtu saved.

Table 5-19: SEP-attributable energy savings for loans, grants, and incentives activities by sector (source MMBtu)

	SEP-Attributable Energy Savings 2009-2050
Residential	107,198,508
Commercial	21,451,282*
Industrial	14,959,529*
Public Institutional	127,293,054
Private Institutional	748,112
Total	**271,650,484**

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

Figure 5-21 displays the renewable generation by sector over time. The industrial sector had the large majority of the renewable generation.

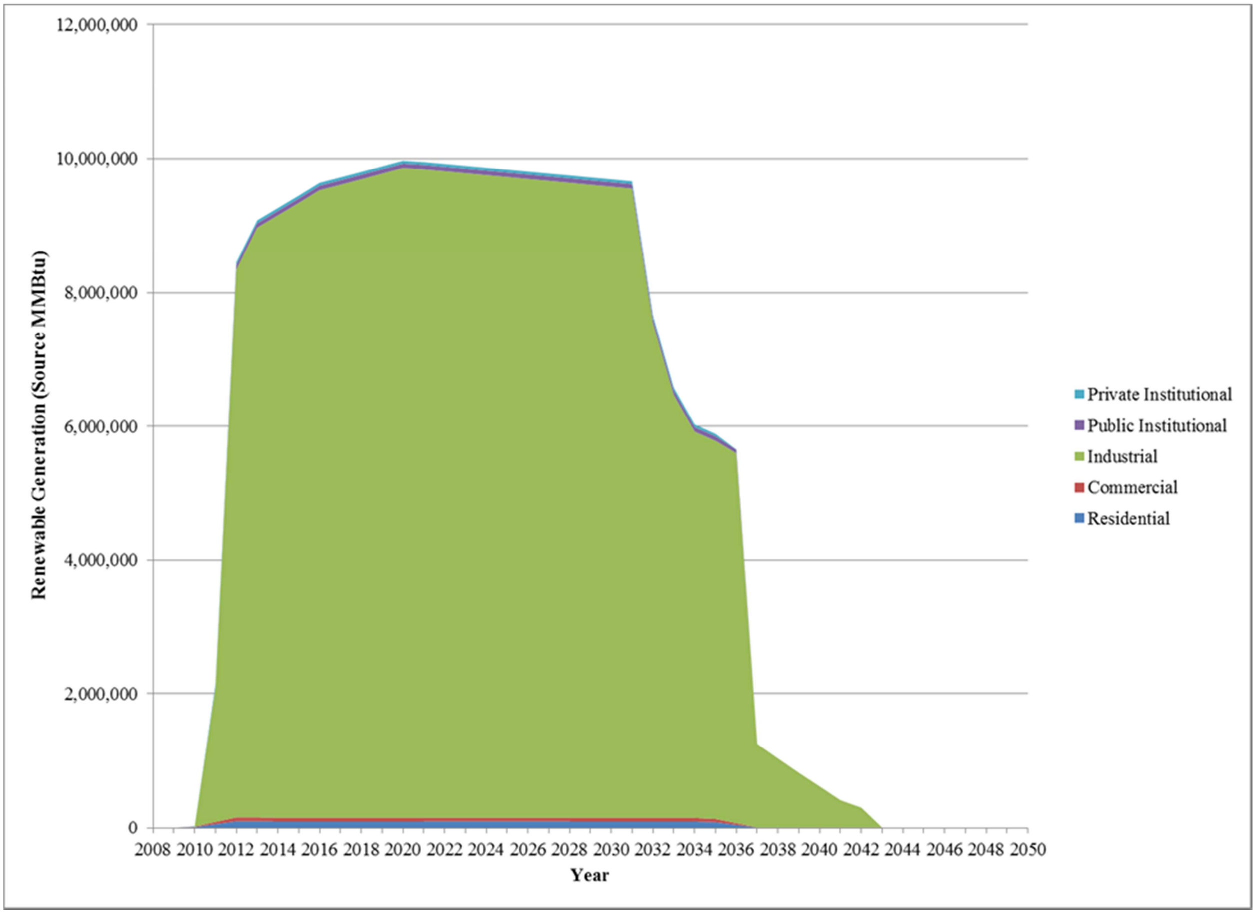

Figure 5-21: SEP-attributable renewable generation for loans, grants, and incentives activities by sector over time (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 5-20 shows total renewable generation by sector in source MMBtu. As previously noted, the industrial sector accounted for the large majority of the renewable generation, with about 225 million source MMBtu. The residential sector had around 2.5 million source MMBtu of renewable generation, followed by the public institutional, commercial and private institutional sectors with 1.0 through 1.7 million source MMBtu of renewable generation each.

Table 5-20: SEP-attributable renewable generation for loans, grants, and incentives activities by sector (source MMBtu)

	SEP-Attributable Renewable Generation 2009-2050
Residential	2,543,526
Commercial	1,405,404
Industrial	224,931,532
Public Institutional	1,702,812*
Private Institutional	1,039,185*
Total	**231,622,460**

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

5.2.4 Renewable energy market development (ARRA-period)

The Renewable Energy Market Development BPAC encompasses programmatic activities that aimed to develop or expand existing manufacturing capacity for renewable energy equipment or components, or to provide financial or technical assistance to support the development of renewable energy facilities including solar, wind, biomass and small hydro. This BPAC included renewable energy projects, which focused on support of renewable energy facilities and renewable energy manufacturing. The goal of this BPAC is renewable generation; however, a relatively small amount of energy savings also exist for this BPAC because the quantifiable impact for two renewable technologies, solar thermal and geothermal, are based on energy reductions of existing technologies (i.e., electric water heater, gas heat) rather than direct renewable generation.

PAs in the Renewable Energy Market Development BPAC ranged from small residential programs where solar water heating was installed directly on eligible households' rooftops across the region to large-scale industrial programs that increased efficiency of wind turbines through changes to hub and blade dimensions during the manufacturing process.

5.2.4.1 Energy impacts for all fuel types and sectors combined (renewable energy market development)

The ARRA-period Renewable Energy Market Development BPAC resulted in SEP-attributable energy savings of 1.1 million source MMBtu over the 2009 to 2050 period. **Figure 5-22** shows the impacts over time. The energy savings peak in the 2012 through 2029 period, and then begin to drop off as the effective useful lifetimes of the associated technologies expire.

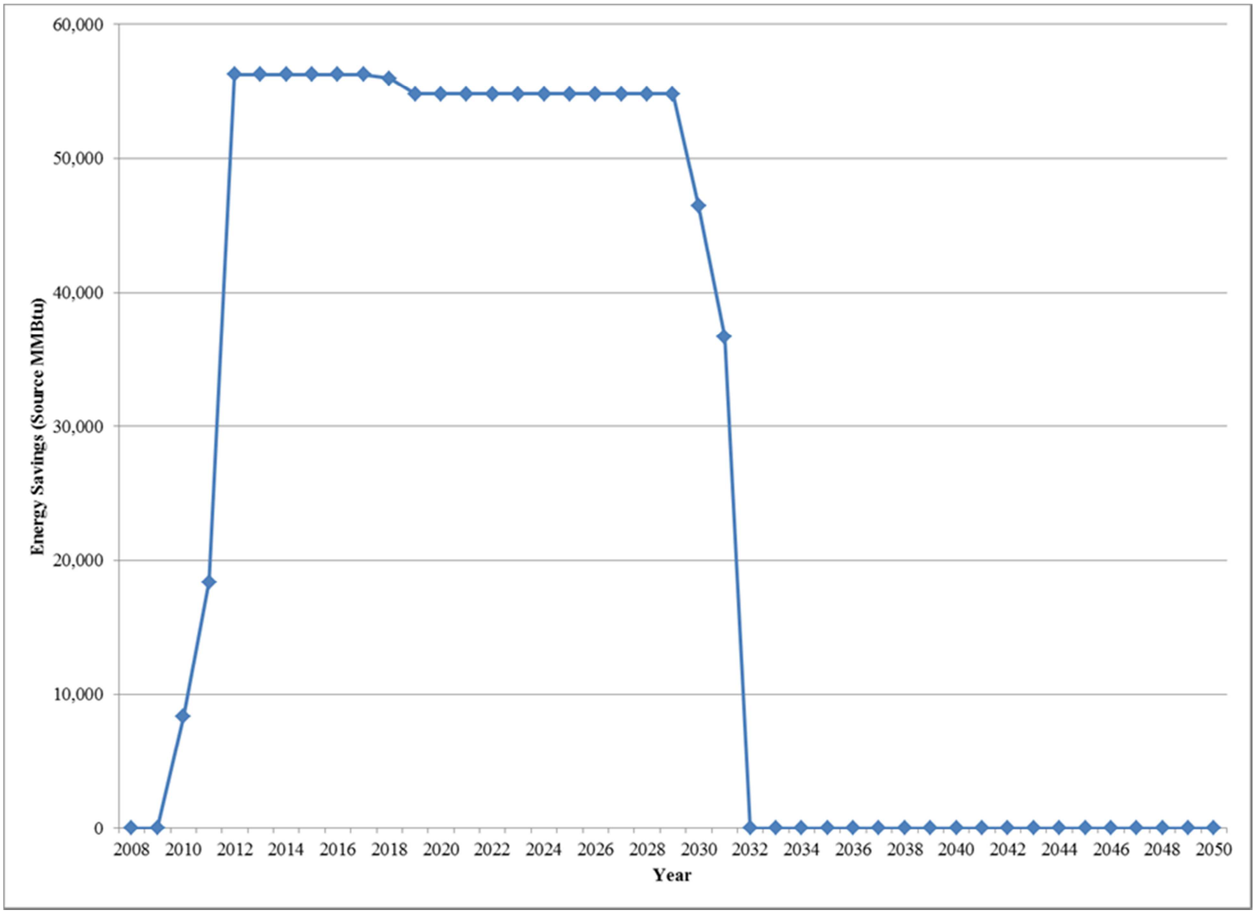

Figure 5-22: SEP-attributable energy savings for renewable energy market development activities by year (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

The studied portion of the ARRA-period Renewable Energy Market Development BPAC resulted in 1.8 billion source MMBtu of SEP-attributable renewable generation over the 2009 to 2050 period. **Figure 5-23** shows the impacts over time. The renewable generation rises steadily, peaking from 2020 through 2028, and finally declining as measure lives of renewable technologies begin to expire. At the end of the evaluation's study period in 2050, savings persist at about one thousand source MMBtu.

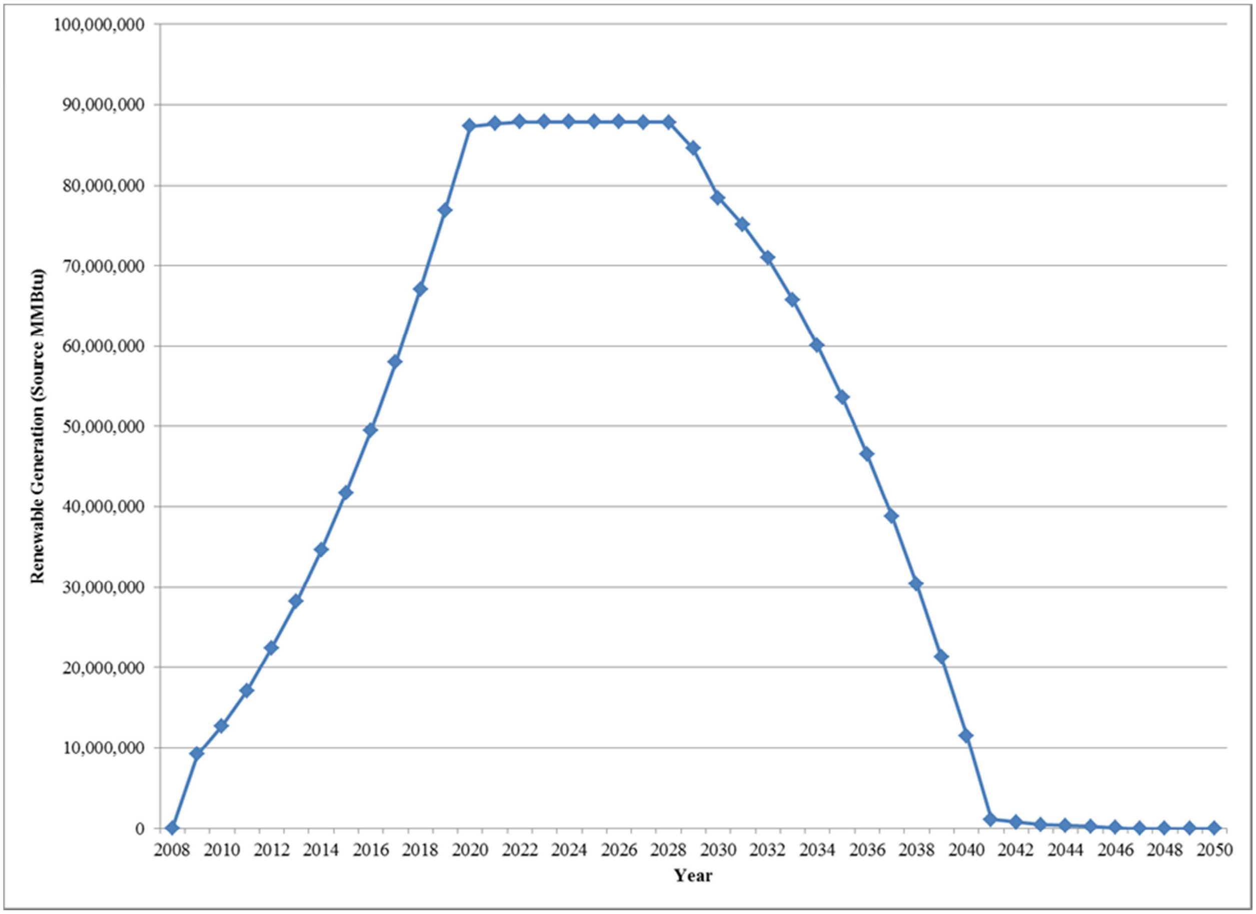

Figure 5-23: SEP-attributable renewable generation for renewable energy market development activities by year (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.2.4.2 Energy impacts by fuel type (renewable energy market development)

Table 5-21 and **Table 5-22** show the SEP-attributable energy savings and renewable generation over time by fuel type. **Table 5-21** shows there were about one million source MMBtu of electricity saved and about 104 thousand source MMBtu of natural gas. **Table 5-22** shows that there were 1.8 billion source MMBtu of renewable electricity generated and 810 thousand source MMBtu of digester gas generated.

Table 5-21: SEP-attributable energy savings for renewable energy market development activities by fuel type over time (source MMBtu)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Electricity	-	5,155*	14,793	51,051*	51,051*	354,117*	490,703*	35,100*	-	1,001,970*
Natural Gas	-	3,158*	3,592*	5,224	5,224	36,567	49,081	1,632*	-	104,478
Oil	-	-	-	-	-	-	-	-	-	-
Propane	-	-	-	-	-	-	-	-	-	-
Kerosene	-	-	-	-	-	-	-	-	-	-
Wood	-	-	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-
Gasoline	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-
Total	**-**	**8,314***	**18,385**	**56,274***	**56,274***	**390,684***	**539,784***	**36,732***	**-**	**1,106,448***

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

Table 5-22: SEP-attributable renewable generation for renewable energy market development activities by fuel type over time (source MMBtu)

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Renewable Electricity	9,197,709*	12,706,786*	17,022,401*	22,369,650*	28,155,202*	415,030,429*	865,508,303*	473,826,283*	3,252,838*	1,847,069,600*
Methane	-	-	-	-	-	-	-	-	-	-
Landfill Gas [50% CH4/ 50% CO2]	-	-	-	-	-	-	-	-	-	-
Digester Gas [Sewage or Biogas]	-	-	3,350*	6,700*	10,049*	164,141*	368,480*	247,887*	10,049*	810,656*
Biodiesel	-	-	-	-	-	-	-	-	-	-
Ethanol	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-
Total	**9,197,709***	**12,706,786***	**17,025,751***	**22,376,350***	**28,165,251***	**415,194,570***	**865,876,783***	**474,074,170***	**3,262,887***	**1,847,880,257***

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

5.2.4.3 Energy impacts by sector (renewable energy market development)

Figure 5-24 displays the energy savings by sector over time. The residential sector had the most energy savings, followed by the private institutional and public institutional sectors.

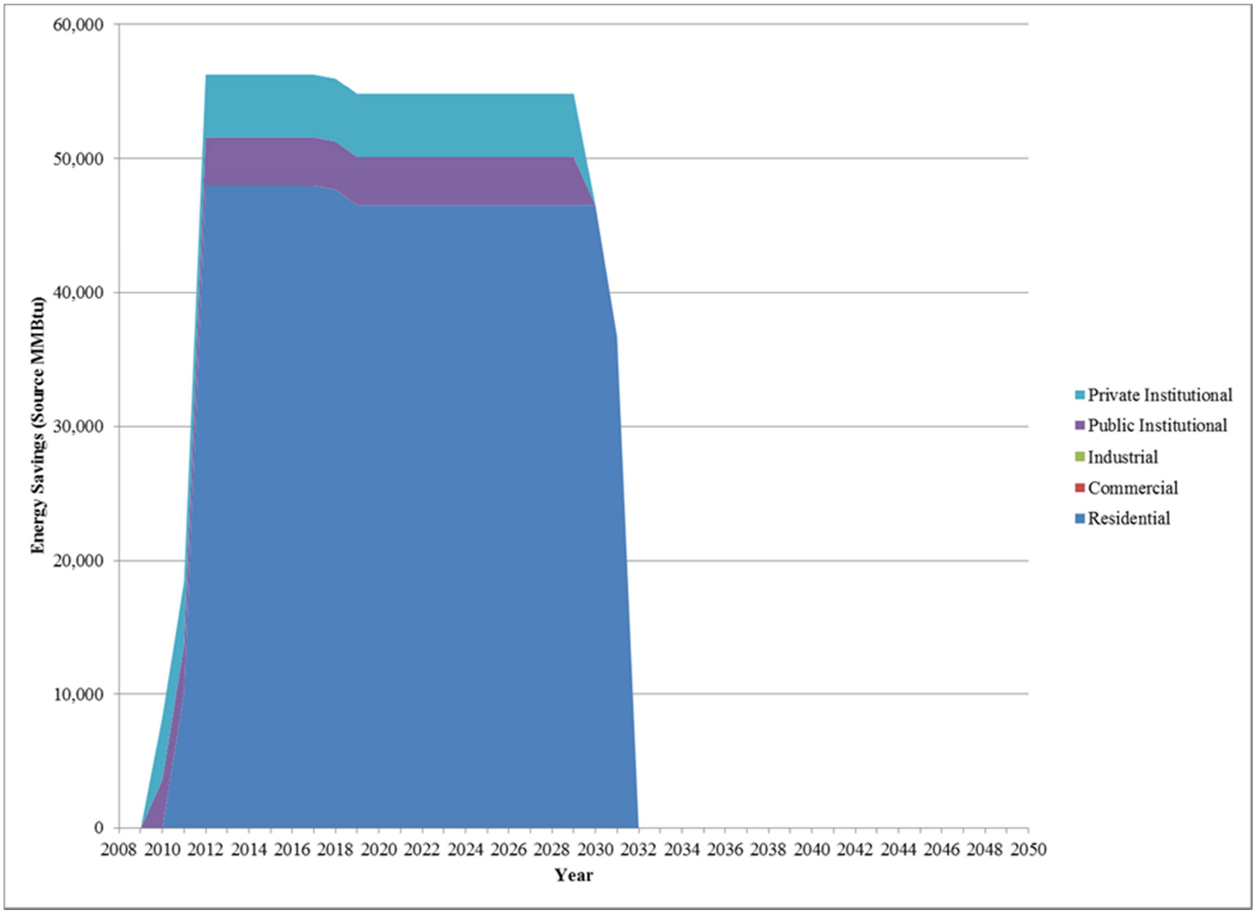

Figure 5-24: SEP-attributable energy savings for renewable energy market development activities by sector by year (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 5-23 shows the total energy savings by sector in source MMBtu for the 2009 through 2050 period. The residential sector had the majority of the energy savings with 940 thousand source MMBtu of energy savings, followed by the private institutional and public institutional sectors with around 94 thousand and 72 thousand source MMBtu of energy savings respectively.

Table 5-23: SEP-attributable energy savings for renewable energy market development activities by sector (source MMBtu)

	SEP-Attributable Energy Savings 2009-2050
Residential	940,174*
Commercial	-
Industrial	-
Public Institutional	72,293*
Private Institutional	93,981*
Total	**1,106,448***

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

Figure 5-25 displays the renewable generation by sector over time. The industrial sector had the large majority of the renewable generation, which prevents the other sectors from showing in this figure.

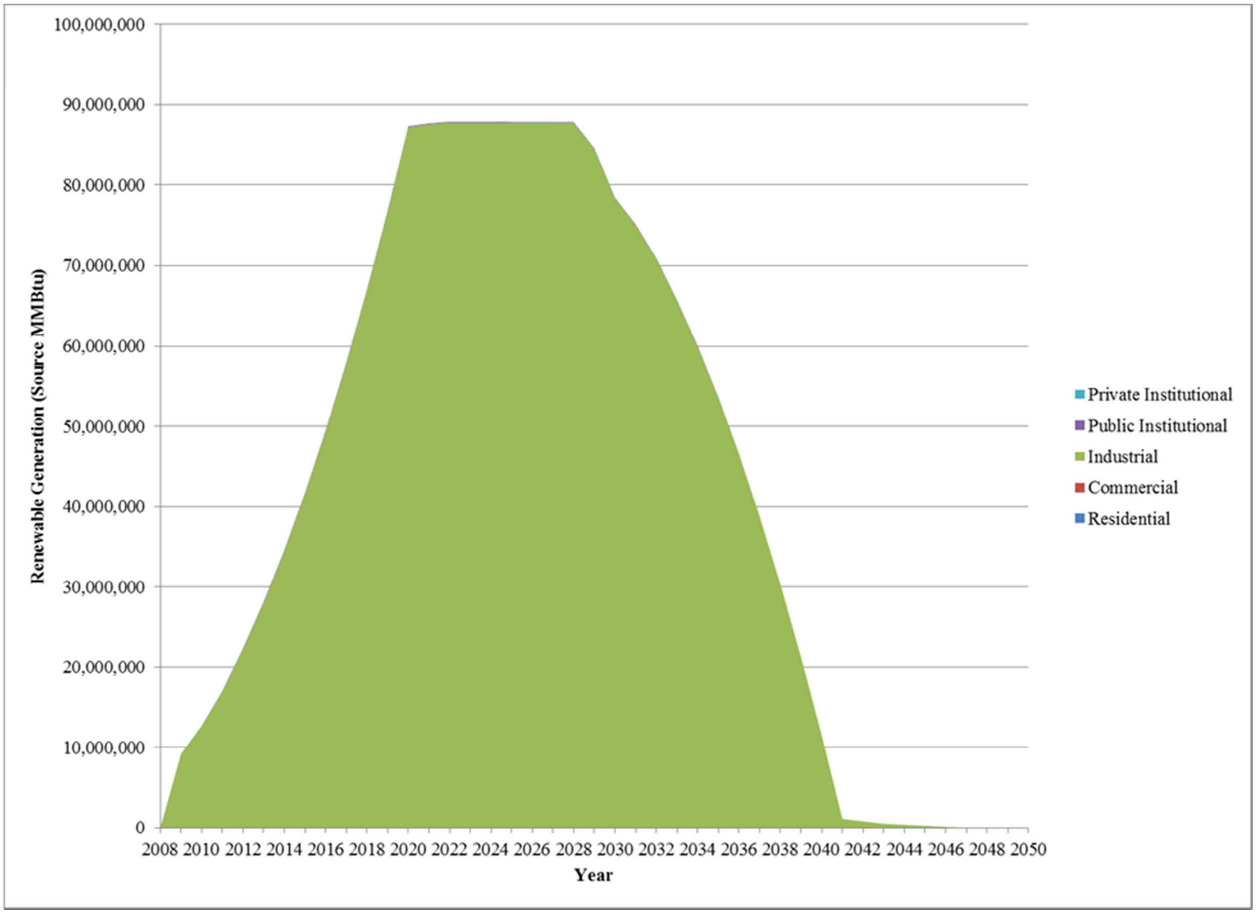

Figure 5-25: SEP-attributable renewable generation for renewable energy market development activities by sector over time (source MMBtu)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 5-24 shows total renewable generation by sector in source MMBtu. The industrial sector had the majority of the renewable generation with about 1.8 billion source MMBtu. The public institutional sector had around 2.9 million source MMBtu of renewable generation, followed by the commercial and private institutional sectors with over 200 thousand source MMBtu of renewable generation.

Table 5-24: SEP-attributable renewable generation for renewable energy market development activities by sector (source MMBtu)

	SEP-Attributable Renewable Generation 2009-2050
Residential	-
Commercial	268,802*
Industrial	1,844,453,611*
Public Institutional	2,935,318*
Private Institutional	222,525*
Total	**1,847,880,257***

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

5.3 Labor (ARRA-period)

This section addresses the labor impacts for each of the four ARRA period BPACs studied in this evaluation. Labor impacts are presented in terms of jobs created by ARRA period SEP activities.[89]

5.3.1 Building retrofits (ARRA-period)

This section presents ARRA-attributable job impact results for the Building Retrofits BPAC for the ARRA-period. The following BPAC characteristics influence the pattern and magnitude of job impacts observed:

- All sectors except commercial participated in the program.
- Through 2012, project activity required $466 million for U.S. manufactured goods and $266 million in installer contracts
- The public institutional sector is awarded with the largest net bill savings ($272 million through 2035) followed by the industrial sector ($98 million through 2027)

Table 5-25 shows the total employment impact over the life of ARRA-period Building Retrofit SEP activities studied in this evaluation. 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. The table shows that there are 24,413 job-years created through 2035.

Table 5-25: Direct, indirect, and induced jobs created in the U.S. from ARRA-period building retrofits SEP activities

	Direct, Indirect, and Induced Jobs (2009-2050)									
	2009	**2010**	**2011**	**2012**	**2013**	**2014-2020**	**2021-2030**	**2031-2040**	**2041-2050**	**Total**
Total	2,487	3,356	4,828	3,374	1,853	7,018	1,914	-418	-	24,413

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

89 Labor impacts vary over time because REMI models economic impacts from sometimes variable evaluation input data, and responds dynamically to public expenditures and related events in the labor and capital markets across regions and over time, including feedbacks from regional changes to the business environment and the cost-of-living relative to surrounding regions. See Section 3.1.2 and Appendix H for more detailed information on the REMI model and the labor impacts methodology.

This section presents the longer-term job generation effects of ARRA-period funding for Building 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. **Figure 5-26** shows the direct, indirect, and induced job-years created from ARRA supported SEP Building Retrofit activities over time. The early job impact spike is related to project deployment activities and the fact that the residential and the institutional sectors (public and private) were more than compensated for their project outlays in 2009. From 2014 onward, we see the job impact trajectory from bill savings and lower utility demand. The taper to the positive job impacts is a function of the eventual decay of bill savings.

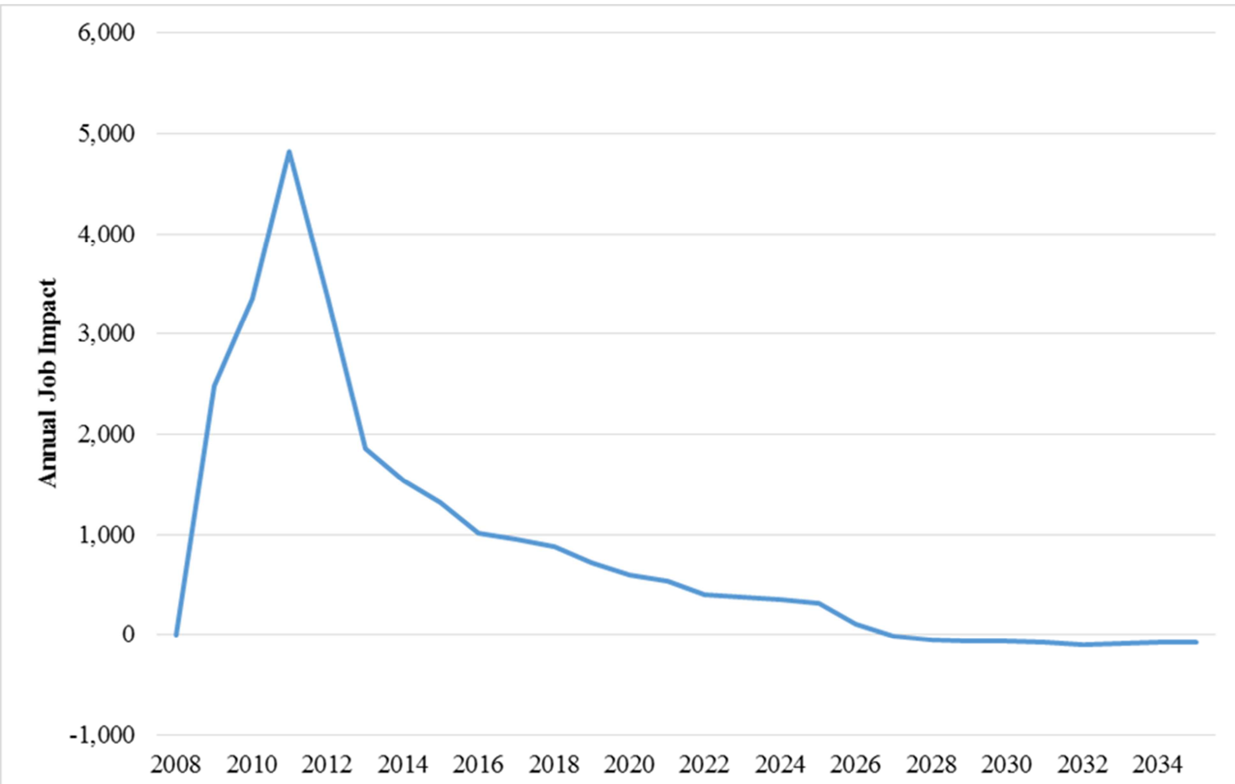

Figure 5-26: Direct, indirect, and induced job changes created in the U.S. from ARRA-period building retrofits SEP activities

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-27 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 projects in 2009 do not ramp up until 2010 and 2011(e.g. construction labor, professional and technical services, 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 sector was heavily-incented and, as a result, added to public budgets which require more staff;
- Sectors that are affected when energy consumers redirect some of their budget away from general household or business expenditures and into making energy improvements; and,
- Sectors that are affected when customers redirect their bill savings 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 lower cost-of-doing-business. In 2022 all participating sectors 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.

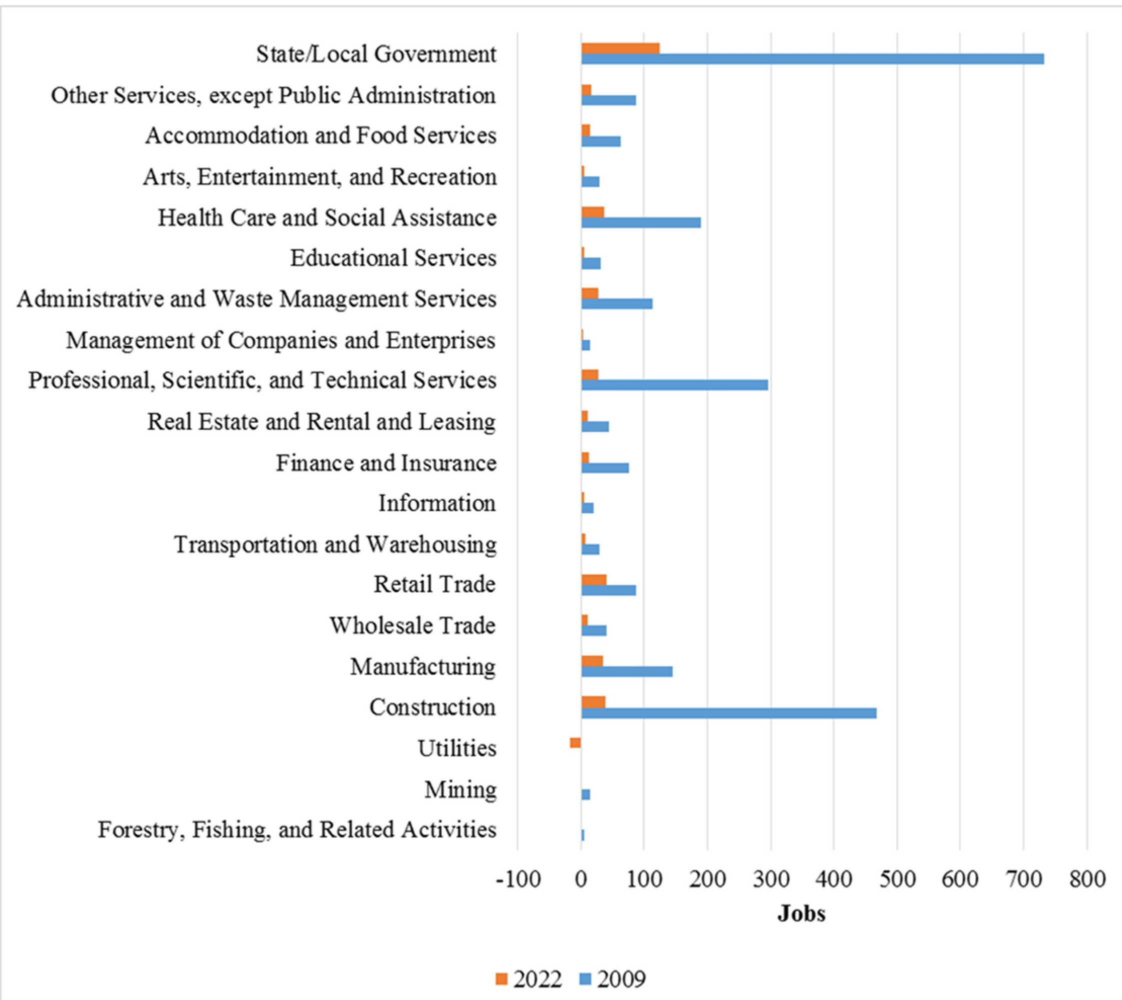

Figure 5-27: Job Impact of ARRA-period funding into building retrofits SEP activities, by NAICS sector

Jobs increase within a private-sector business (whether it is commercial, industrial or private institutional) from a gain in their relative competitiveness. This gain is the result of lower business costs (specifically, bill savings after paying for any portion of the improvement) which triggers a market share expansion for each type of business. These initial job increases then trigger subsequent 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. The private sector may also see an increase in jobs as a result of households having more discretionary income to spend, and then there are multiplier effects. The state and local sector (synonymous with the public institutional sector) increase jobs as a result of redirecting saved energy budget into other forms of public spending.

Table 5-26 presents the direct job effects occurring in the short-term project deployment activities as a result of ARRA-period funding for Building Retrofit activities. The values reported are annual impacts within the interval that funds were to be disbursed. Approximately 6,800 job-years will be required in the U.S. for this interval.

Table 5-26: Direct jobs created in the U.S. from ARRA-period building retrofits funded activities

Year	2009	2010	2011	2012	2013	2014-2022	Job-years
Total	688	2,633	2,439	939	108	-	6,808

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

5.3.2 Codes and standards (ARRA-period)

This section presents ARRA-attributable job impact results for the Codes and Standards BPAC for the ARRA-period. The following BPAC characteristics influence the pattern and magnitude of job impacts observed:

- All five customer sectors participated.
- Participant outlays to make improvements extended to 2022 even though the administration of the program ended in 2012.
- These outlays created about $466 million worth of orders for U.S. manufactured goods and another $318 million of business related to installations and technical services. Additionally, another $12.1 million covered wages and salaries in the State and Local government sector related to program administration.
- Bill savings persist through 2041.
- The value of cumulative bill savings to each customer sector (after accounting for up-front outlays to make improvements) is:
  - $3.1 billion residential
  - $0.7 billion commercial
  - $0.6 billion private institutional
  - $0.03 billion industrial, and
  - $0.35 billion public institutional.

Table 5-27 shows the total employment impact over the life of ARRA-period funding for Codes and Standards SEP activities studied in this evaluation. 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 48,178 job-years created through 2041.

Table 5-27: Direct, indirect, and induced jobs created in the U.S. from ARRA-period codes & standards SEP activities

	Direct, Indirect, and Induced Jobs (2009-2041)									
	2009	**2010**	**2011**	**2012**	**2013**	**2014-2020**	**2021-2030**	**2031-2040**	**2041-2050**	**Total**
Total	74	116	56	61	218	11,639	29,392	6,962	-339	48,178

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

This section presents the longer-term job generation effects of ARRA-period funding into Codes and Standards 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. Figure 5-28 shows the direct, indirect, and induced job-years created from the ARRA supported SEP Codes and Standards activities over time. After 2014, the annual job impacts increases until its peak in 2023 and then moderates while remaining positive until 2038.

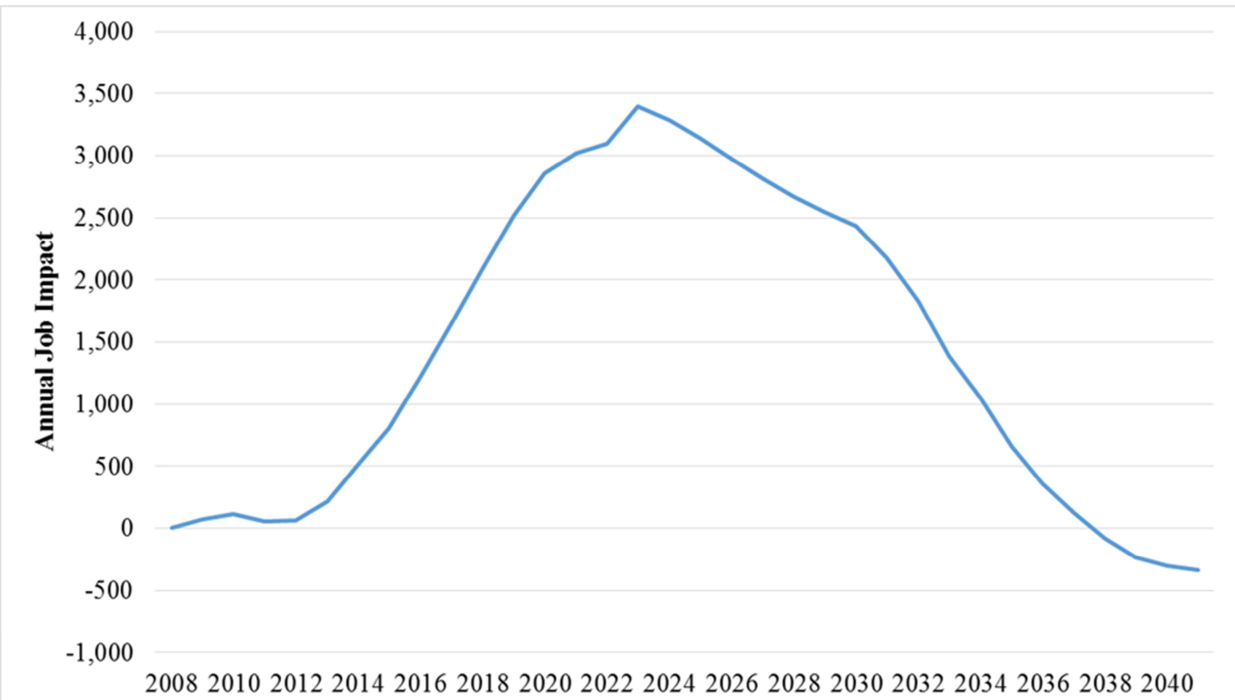

Figure 5-28: Direct, indirect, and induced job changes created in the U.S. from ARRA-period codes & standards SEP activities

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.3.2.1 Composition of incremental employment by industry sector

Figure 5-29 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, manufacturing); in 2009 there is just 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,
- Jobs 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 year 2022 is close to the peak year of energy savings and the sector profile of total job change by NAICs sector demonstrates what customer bill savings does for an economy.

Jobs increase within a private-sector business (whether it is commercial, industrial or a private institutional) from a gain in their relative competitiveness (this is displayed for the pervasive job gains showing in 2022). This gain is the result of lower business costs (specifically, bill savings after paying for any portion of the improvement) which triggers a market share expansion for each type of business. These initial job increases then trigger subsequent 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, and then there are multiplier effects. The state and local sector (synonymous with the public institutional sector) increase jobs as a result of redirecting saved energy budget into other forms of public spending.

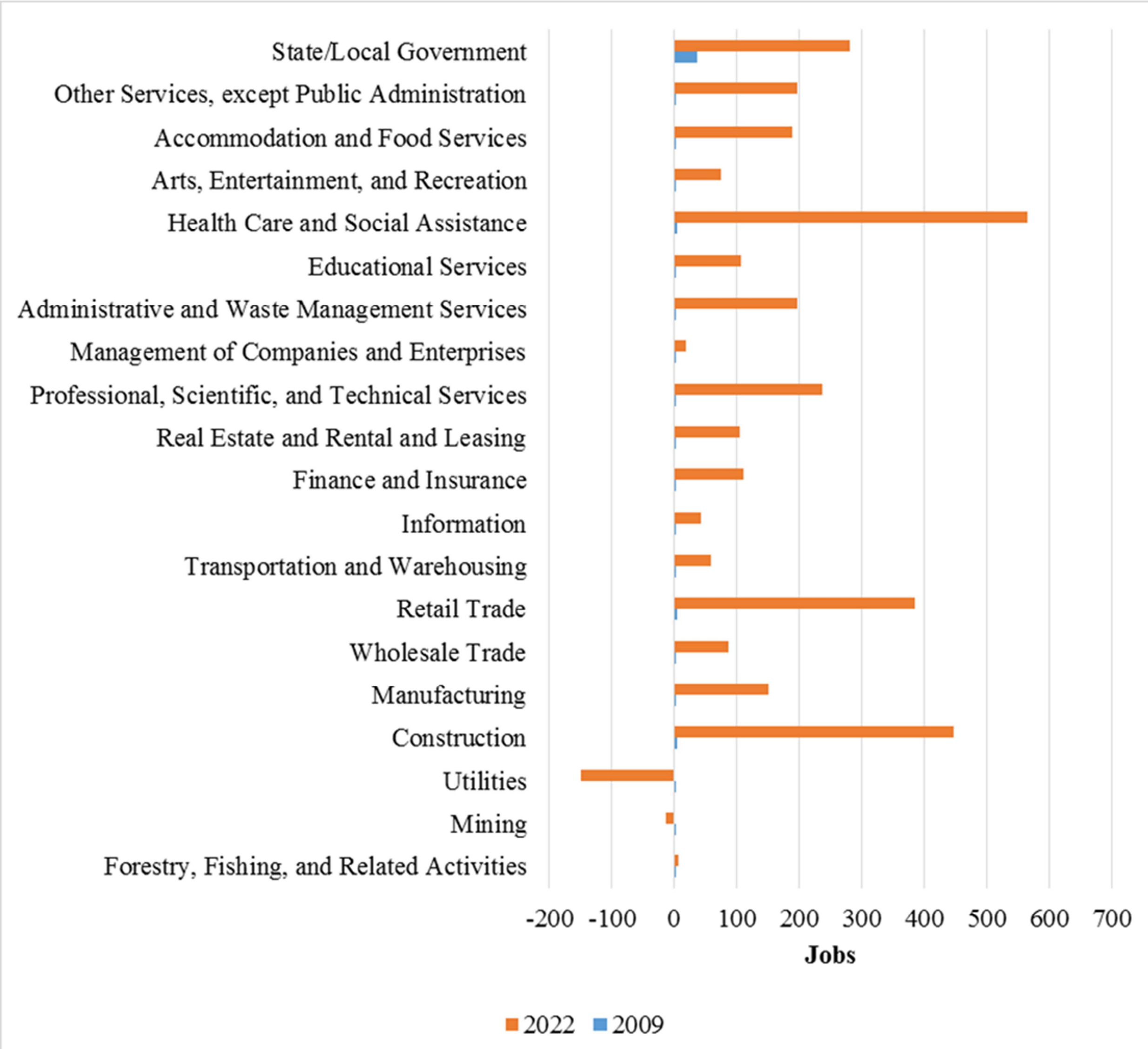

Figure 5-29: Job Impact of ARRA-period funding into codes & standards SEP activities, by NAICS sector

Table 5-28 presents the direct job effects occurring in the short-term project deployment activities as a result of ARRA-period funding for Codes and Standards activities. The values reported are annual impacts within the 2009 to 2022 time interval that funds were to be disbursed. Some 6,472 job-years will be required in the U.S. for this interval.

Table 5-28: Direct jobs created in the U.S. from ARRA-period codes and standards funded activities

Year	2009	2010	2011	2012	2013	2014-2022	Job-years
Total	35	61	383	516	684	4,794	6,472

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

5.3.3 Loans, grants, and incentives (ARRA-period)

This section presents SEP-attributable job impact results for the Loans, Grants, and Incentives BPAC for the ARRA-period. The following BPAC characteristics influence the pattern and magnitude of job impacts observed:

- All customer sectors participated.
- Projects will require $493 million of U.S. manufactured equipment and $328 million of installation labor through the year 2032.
- Some 2,225 job-years (predominantly through 2024 but a small number of positions remain until 2032) will accrue to the manufacturing sector in the U.S. as incentives to firms to promote renewable energy market development cover new positions.
- There is a revolving loan structure in place (for all regions) through 2050, the end of the study period.
- Bill savings persist to 2050 for all sectors except private institutional (cease in 2041).
- Cumulative net bill savings (after participant project outlays and loan repayment costs) are $487 million for the residential sector, -$178 million for the public institutional sector (loans costs erode bill savings), $161 million for the industrial sector, $99 million for the Commercial sector, and $37 million for the private institutional sector.
- The private institutional sector incurs short interval of project expenses (2010 through 2012), while all other sectors have expenses through 2032.

Table 5-29 shows the total employment impact over the life of ARRA-period funding for Loans, Grants, and Incentives SEP activities studied in this evaluation. The main influences behind this trajectory of annual job changes are initial project deployment stimulus, the decay in the persistence of energy savings, the presence of new manufacturing hires related to renewable energy market development activities, and reduced demand for electricity and natural gas. Job-years through 2050 are more than 19,000.

Table 5-29: Direct, indirect, and induced jobs created in the U.S. from ARRA-period loans, grants, and incentives SEP activities

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Total	1,626	3,129	4,974	3,750	1,868	2,115	-721	1,072	1,438	19,251

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

This section presents the longer-term job generation effects of ARRA-period funding for Loans, Grants, and Incentives activities and it also presents job impacts inclusive of the multiplier effects (the indirect and induced effects). **Figure 5-30** shows the direct, indirect, and induced job-years created from the ARRA supported SEP Loans, Grants, and Incentives activities over time, which shows that after 2011, when the positive impacts are at a maximum, the job impacts will moderate. Equipment purchasing of U.S. manufactured goods is strong through 2023 along with the majority of the new market development positions within U.S. manufacturing firms. The weak impacts between 2024 and 2032 are the result of extra costs borne by the public institutional sector from loan programs. Job impacts return to a moderate positive impact after 2032 as all participating sectors (with the exception of the commercial sector) are no longer expending for new projects.

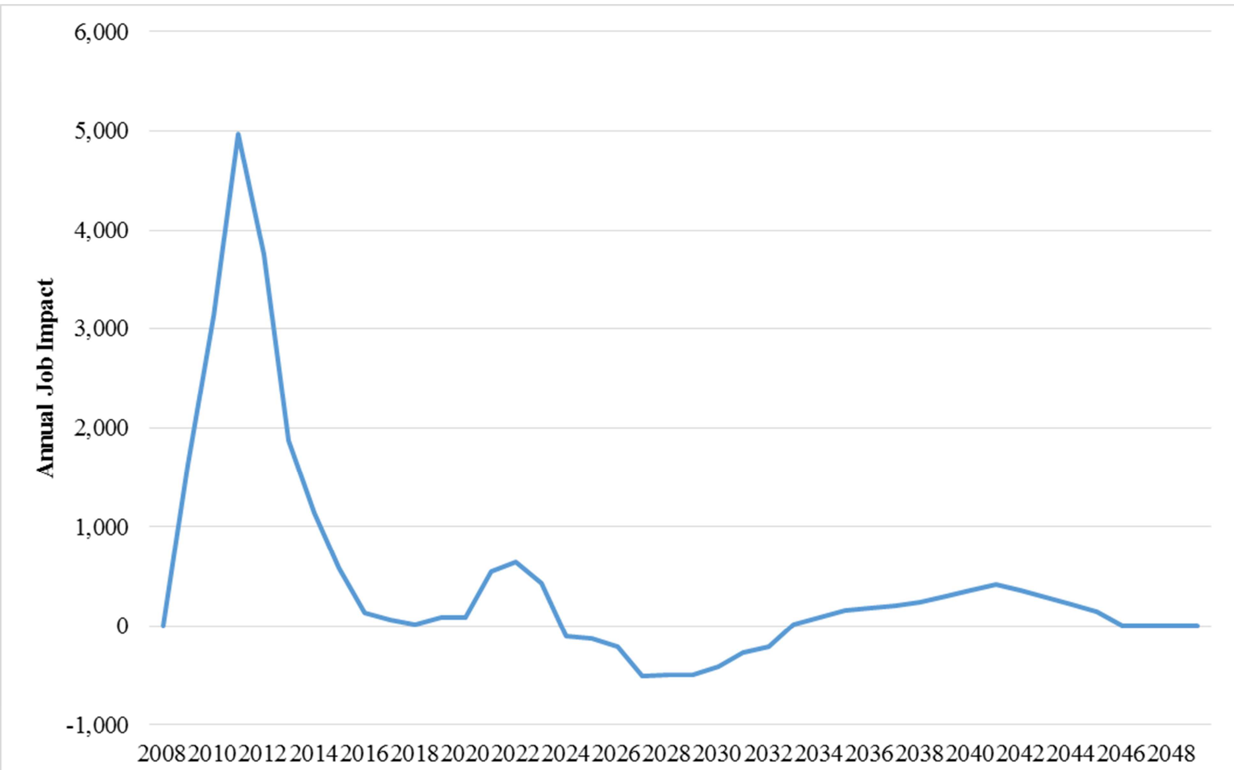

Figure 5-30: Direct, indirect, and induced job changes created in the U.S. from ARRA-period loans, grants, and incentives SEP activities

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-31 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:

- That in 2009, when project deployment activity is starting, almost every sector experiences positive job impacts except the public institutional sector.
- In 2022, most private-sector industries gain jobs as the result of some continued project deployment activities, the persistence of market development funds for additional manufacturing

jobs, and positive net savings for all segments except the S/L Government sector. The utilities sector also sheds some jobs in light of lower demand for electricity and natural gas.

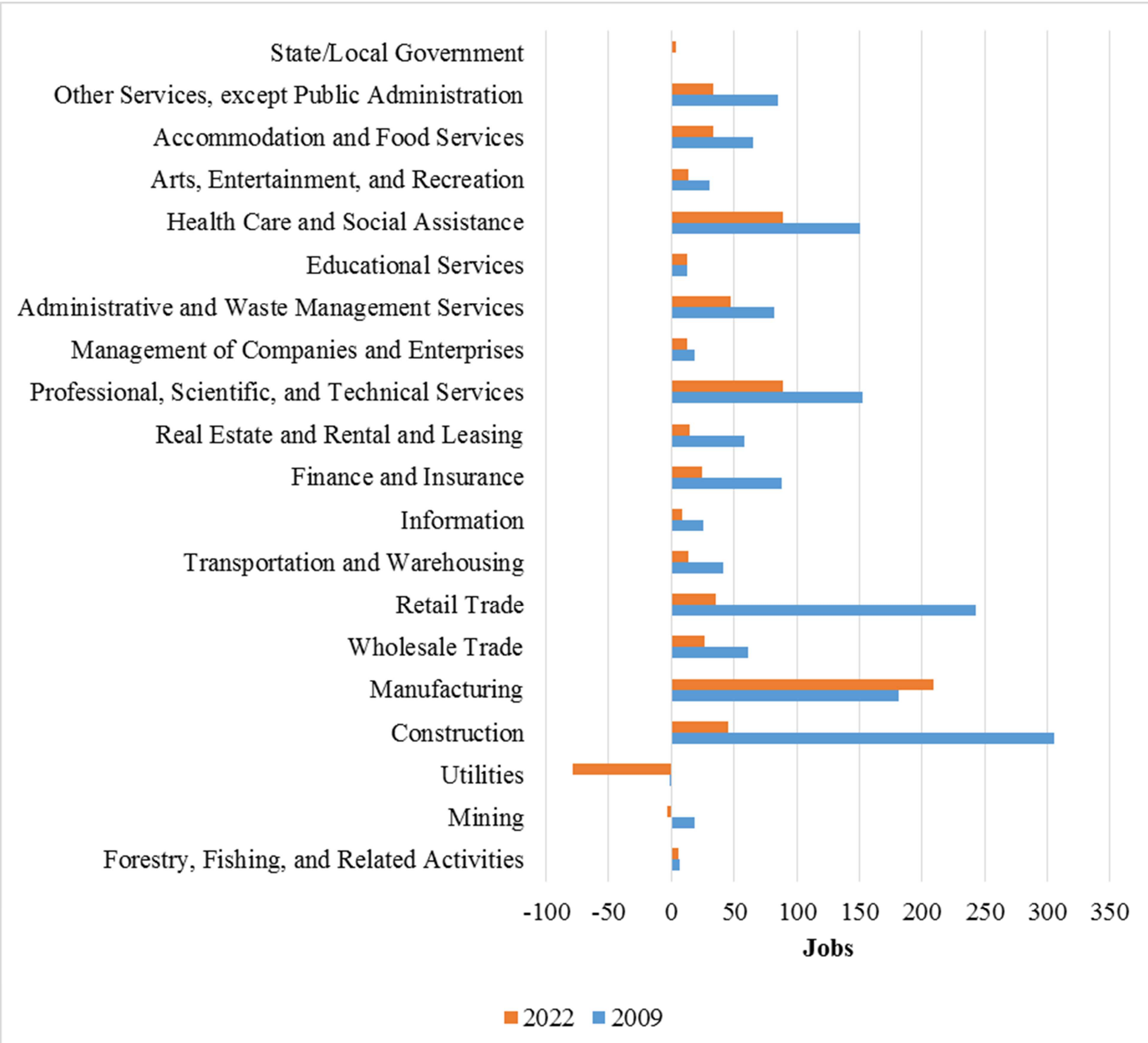

Figure 5-31: Job Impact of ARRA-period funding into loans, grants, and incentives SEP activities, by NAICS sector

Table 5-30 shows the direct job effects occurring in the short-term as a result of ARRA-period funding for Loans, Grants, and Incentives activities. About 4,900 job-years will be required in the U.S. for this interval.

Table 5-30: Direct jobs created in the U.S. from ARRA-period loans, grants, and incentives funded activities

Year	2009	2010	2011	2012	2013	2014-2022	Job-years
Total	88	597	902	416	17	2,929	4,949

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

5.3.4 Renewable energy market development (ARRA-period)

This section presents SEP-attributable job impact results for the Renewable Energy Market Development BPAC for the ARRA-period. The following BPAC characteristics influence the pattern and magnitude of job impacts observed:

- The residential sector did not participate.
- U.S. manufacturers, through incentives, add new positions (payroll additions) related to renewable energy market development efforts – some 7,521 job-years through 2022 across the Great Lakes region, the Plains region, the Southeast, and the Rocky Mountain regions. All other participating sectors expended funding through 2012, and administration of the program terminated in 2013.
- The commercial, public institutional and private institutional sectors have *negative* participant costs in 2011 and 2012 due to incentives that exceeded project costs.
- Project investments created about $125 million worth of orders for U.S. manufactured goods through 2012, and another $18 million of business related to installations and technical services through 2022. Additionally, another $28 million covered wages and salaries in the State and Local government sector related to program administration.
- Bill savings persist through 2041 for the industrial sector, and 2036 for all other participating sectors.
- The cumulative value of bill savings related to energy by customers' on-site renewable generation (after accounting for up-front outlays and rebate income to make improvements) is:
    - $0.009 billion gross ($0.022 billion net) commercial
    - $0.008 billion gross ($0.021 billion net) private institutional
    - $0.011 billion industrial (net savings equal the gross bill savings as there were no project costs)
    - $0.09 billion gross ($0.175 billion net) public institutional

Table 5-31 shows the total employment impact over the life of ARRA-period funding into Renewable Energy Market Development activities studied in this evaluation. There are almost 43,622 job-years added through 2050.

Table 5-31: Direct, indirect, and induced jobs created in the U.S. from ARRA-period funded renewable energy market development SEP activities

	2009	2010	2011	2012	2013	2014-2020	2021-2030	2031-2040	2041-2050	Total
Total	1,955	1,651	4,719	6,480	4,571	21,915	2,262	*250*	*-141*	43,662

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

This section presents the longer-term job generation effects of ARRA-period funding into Renewable Energy Market Development 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. **Figure 5-32** shows the direct, indirect, and induced job impacts created from the ARRA supported SEP Renewable Energy Market Development activities over time.

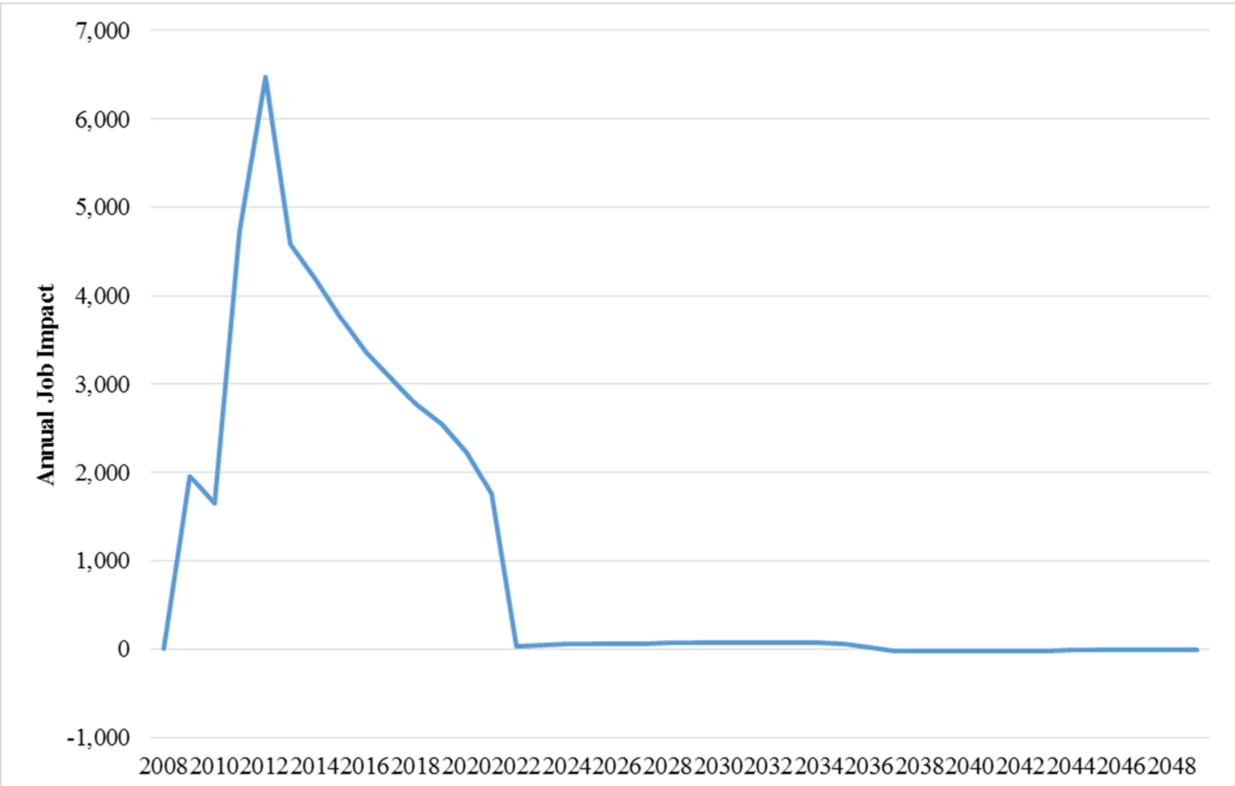

Figure 5-32: Direct, indirect, and induced job changes created in the U.S. from ARRA-period renewable energy market development SEP activities

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-33 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:

- Total job impacts for 2009 show stimulus across numerous sectors from project-related purchases both through program administration staffing and the purchase of RE equipment and installation contracts. The multiplier effect accounts for the jobs created across the different sectors (e.g. retail, general services, health care) associated with households (though not participating) benefitting as other segments of the economy expand from net savings effects, and from the business-to-business supplier effects (the indirect effect).
- The total jobs impacts for 2022 reflect the last year of some labor contracts (in the Construction sector and the Professional, Technical Services sector), fewer manufacturing jobs supported in the last year of market development efforts, and modest participants' savings (after outlays).

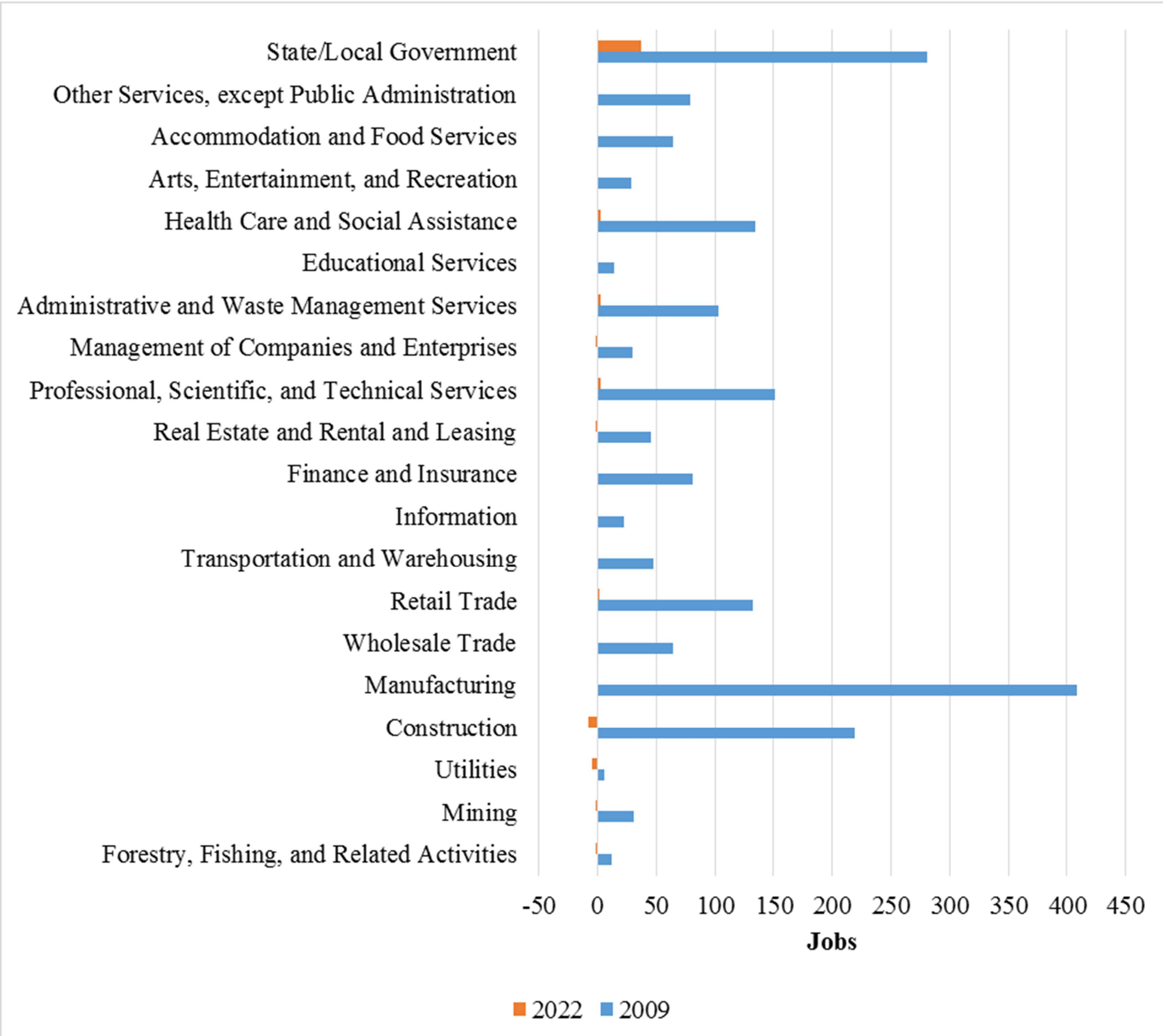

Figure 5-33: Job Impact of ARRA-period funding into renewable energy market development SEP activities, by NAICS sector

Table 5-32 shows the direct job effects occurring in the short-term as a result of ARRA-period funding for Renewable Energy Market Development activities. The values reported are annual impacts within the interval that funds were to be disbursed. Despite funding and project-deployment completing in 2012, the direct jobs shown for 2013 and 2014 are related to the incented market development manufacturing jobs (which will be supported at varying levels through 2022). Some 4,200 job-years will be required in the U.S. for this interval.

Table 5-32: Direct jobs created* in the U.S. from ARRA-period renewable energy market development funded activities

Year	2009	2010	2011	2012	2013	2014-2022	Job-years
Total	504	446	574	1,083	824	5,197	8,627

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

5.4 Avoided carbon emissions and avoided social cost estimates (ARRA-period)

This section addresses avoided carbon emissions and avoided social cost impacts for each of the four ARRA-period BPACs studied in this evaluation. The avoided emissions impacts are all reported in million metric tons of carbon equivalent (MMTCE). The avoided social costs are reported in 2009 dollars. Avoided carbon emissions from ARRA-period BPAC activities total approximately 164.1 MMTCE and are derived from energy displaced from renewable generation and energy savings (**Table 5-33**). Energy displaced from renewable generation had the higher avoided carbon emissions, at 122 MMTCE, followed by 42.4 MMTCE from energy savings.

Table 5-33: Cumulative avoided carbon emissions from ARRA-period activities, by BPAC and program mechanism (MMTCE)

	Avoided Carbon From Energy Savings 2009-2050	Avoided Carbon From Renewable Generation 2009-2050
Building Retrofits	5.88	-
Building Codes and Standards	19.40	-
Loans, Grants, and Incentives	17.04	17.78
Renewable Energy Market Development	0.05	104.00
Total	**42.36**	**121.78**

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.

As shown in **Table 5-34**, total avoided social costs of carbon are about $12.2 billion. Energy displaced from renewable generation accounts for the majority of the avoided social costs at $8.9 billion and energy savings account for $3.1 billion in avoided social costs.

Table 5-34: Cumulative avoided lifetime social costs of carbon from ARRA-period activities, by BPAC and program mechanism (thousands of 2009$)

	Avoided Social Costs From Energy Savings 2009-2050	Avoided Social Costs From Renewable Generation, 2009-2050
Building Retrofits	$368,371	-
Building Codes and Standards	$1,420,916	-
Loans, Grants, and Incentives	$1,264,824	$1,259,601
Renewable Energy Market Development	$3,085	$7,594,414
Total	**$3,057,196**	**$8,854,015**

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.

5.4.1 Building retrofits (ARRA-period)

5.4.1.1 Avoided carbon emissions (building retrofits)

Avoided carbon emissions from the Building Retrofits BPAC are derived from energy savings. As shown in **Figure 5-35**, avoided carbon emissions from Building Retrofits BPAC activities total 5.9 MMTCE, which are derived entirely from energy savings.

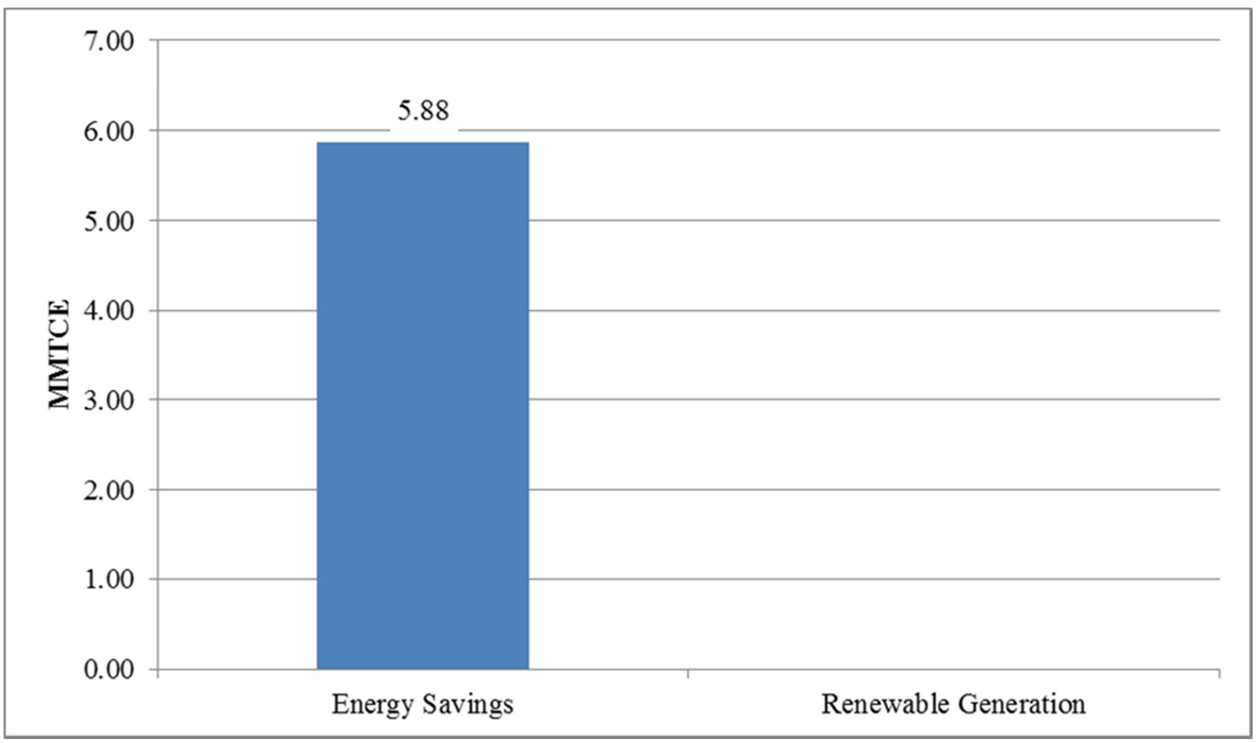

Figure 5-34: Avoided carbon emissions from building retrofit activities by program mechanism (MMTCE)
A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.

Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-35 shows SEP-attributable avoided carbon emissions over time from Building Retrofits programmatic activities in MMTCE. Avoided carbon emissions peak in 2012, fall quickly through 2016, and then gradually decline through 2035, after which time the impacts of all programmatic activities cease.

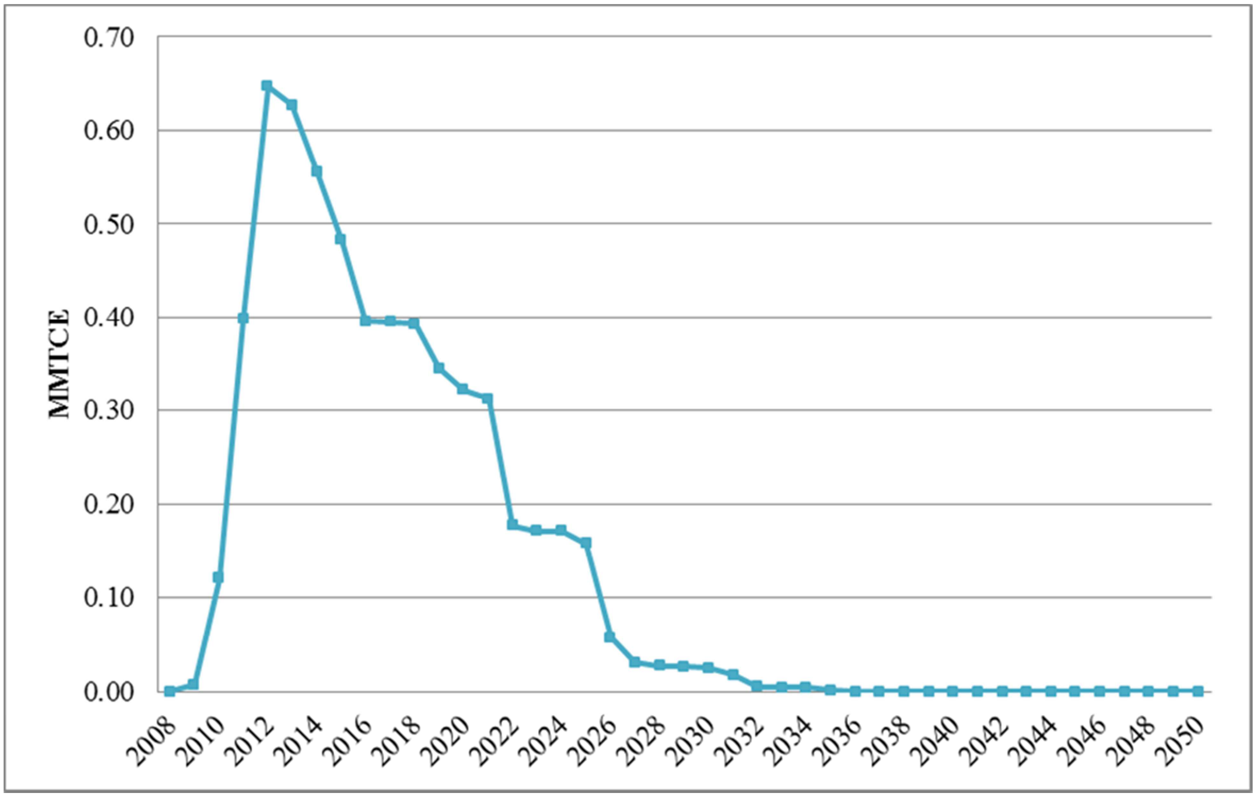

Figure 5-35: Avoided carbon emissions from building retrofit activities over time (MMTCE)
A zero indicates the estimate rounds to zero and is considered imprecise.
Appendix K provides precision for estimates used as primary inputs to this figure, such as energy impacts.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided carbon emissions over the lifetime of energy impacts, by sector, are presented in **Figure 5-36**. The public institutional sector accounts for the largest amount of avoided MMTCE (4.3 MMTCE). The industrial sector has 1.3 avoided MMTCE, followed by the private institutional sector (0.21 MMTCE), and the residential sector (0.05 MMTCE).

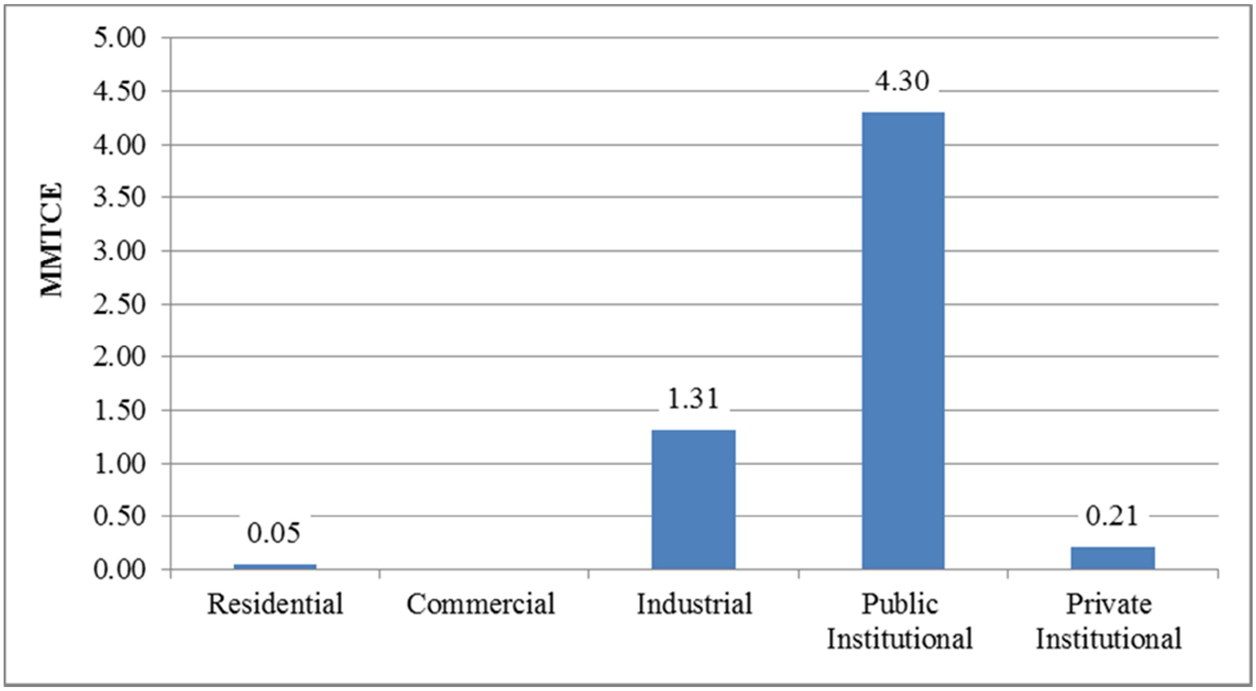

Figure 5-36: Avoided lifetime carbon emissions from building retrofit activities by sector (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.4.1.2 Avoided social costs of carbon (building retrofits)

As shown below in **Figure 5-37**, energy savings account for all the cumulative avoided social costs of $368 million.

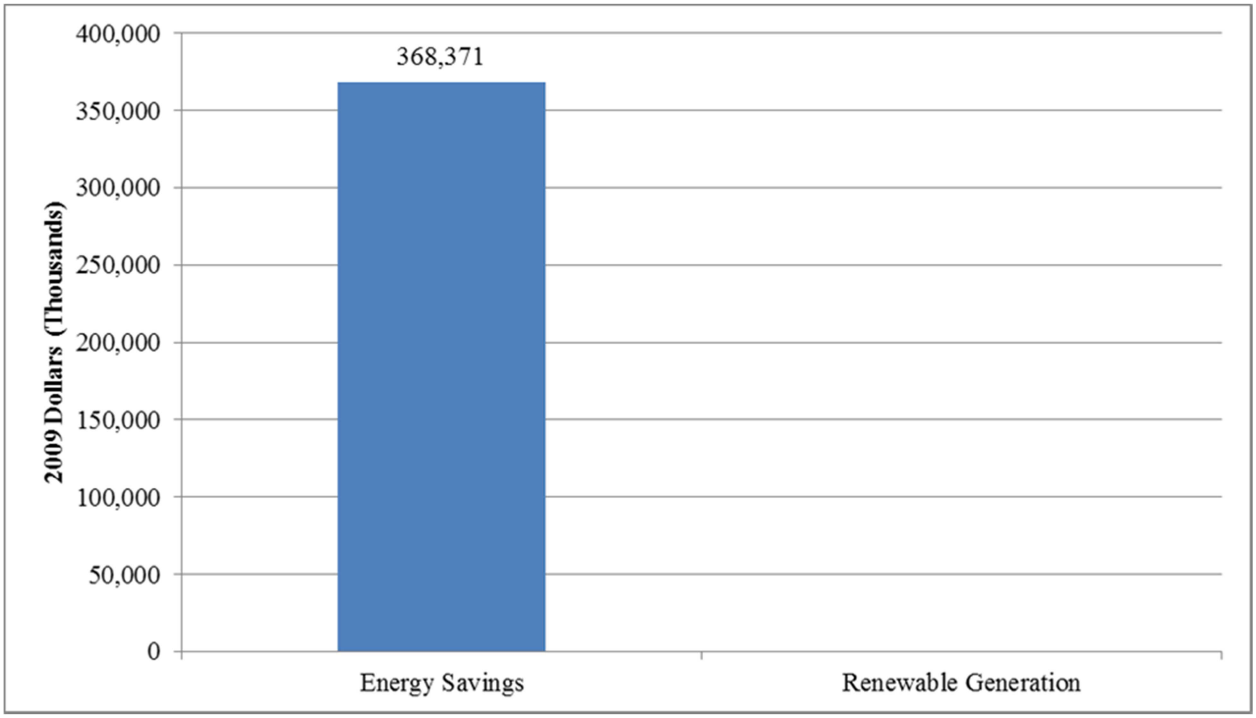

Figure 5-37: Avoided social costs of carbon emissions from building retrofit activities by program mechanism (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided social costs of carbon over time are presented in **Figure 5-38** for the Building Retrofits BPAC. Similar to the pattern of avoided carbon emissions, the associated avoided social costs peak in 2012, decline quickly through 2016, and then decline more gradually over time as various technologies' reach the end of their expected useful lives in 2035.

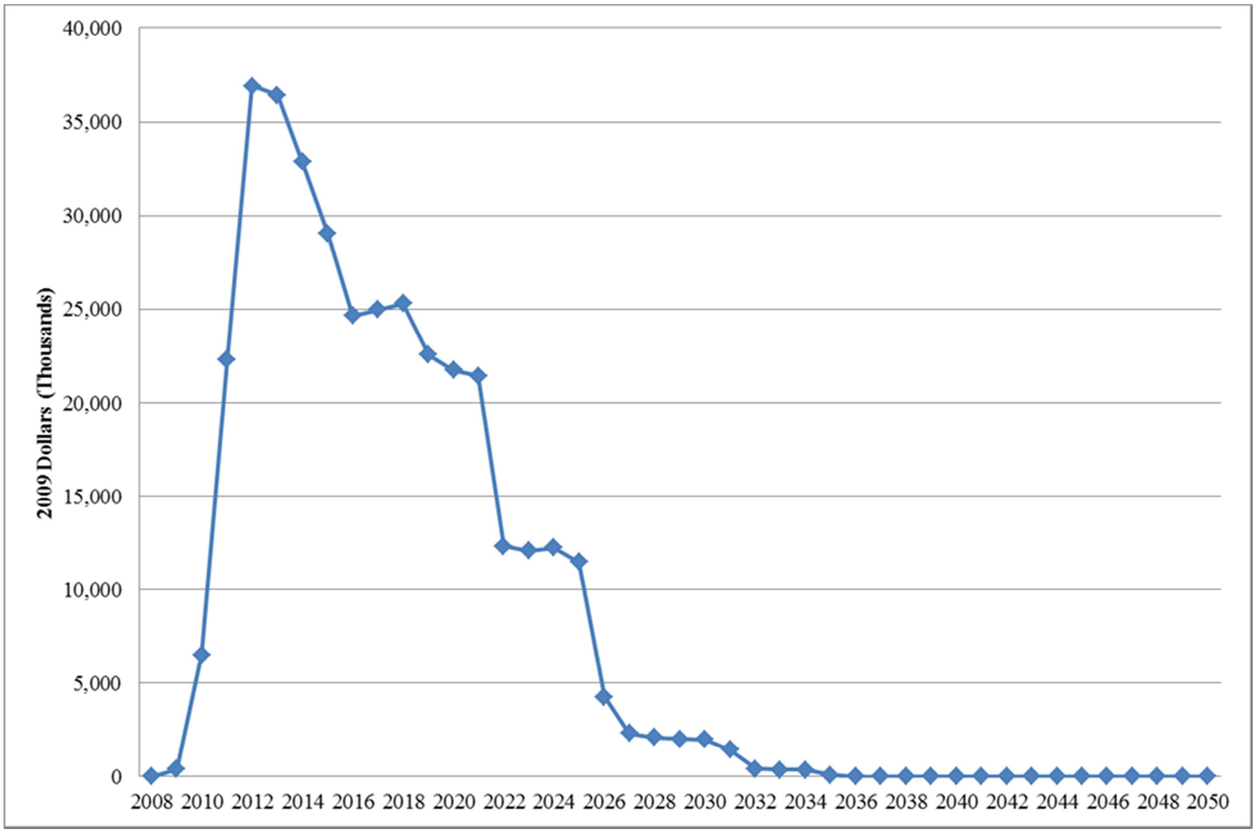

Figure 5-38: Avoided social costs of carbon from building retrofit activities over time (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-39 shows how those avoided social costs of carbon distribute across sectors. Similar to the distribution of avoided carbon emissions, the public institutional sector accounts for the largest amount of avoided social costs ($268 million), followed by the industrial sector ($83.7 million), the private institutional sector ($13.9 million), and the residential sector ($3.2 million).

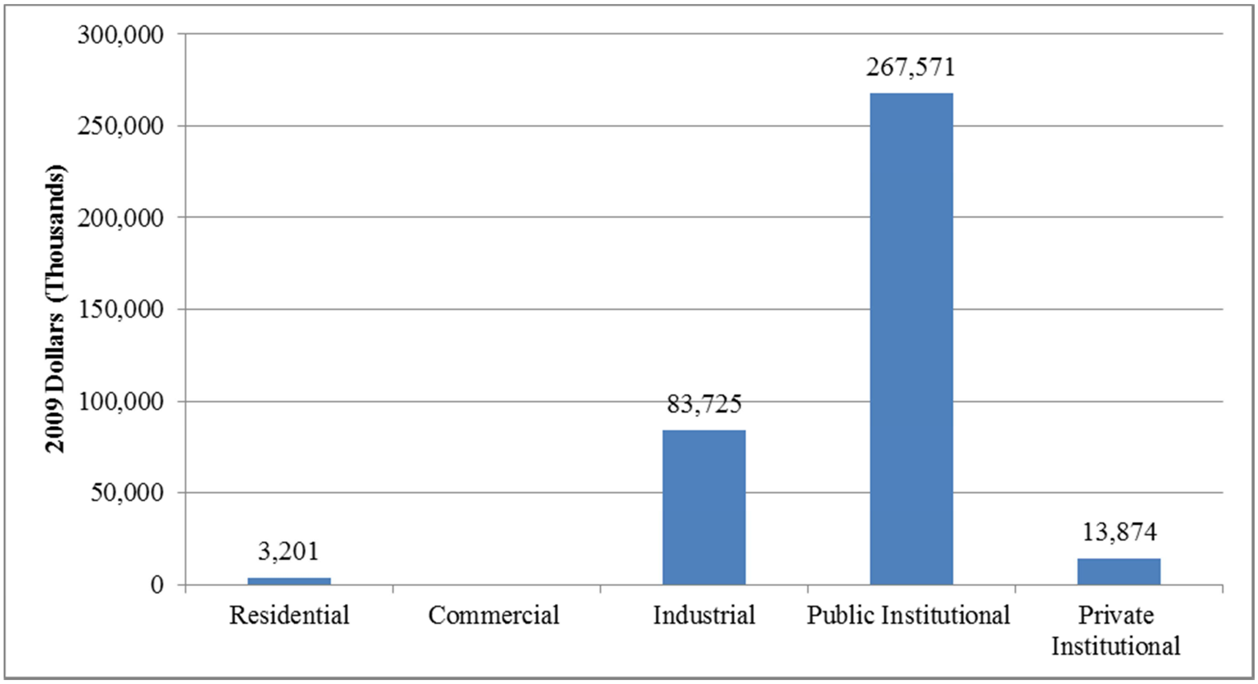

Figure 5-39: Avoided lifetime social costs of carbon from building retrofit activities by sector (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.4.2 Codes and standards (ARRA-period)

5.4.2.1 Avoided carbon emissions (codes and standards)

Avoided carbon emissions from the Codes and Standards BPAC are derived almost exclusively from energy savings. As shown in **Figure 5-40**, avoided carbon emissions from Codes and Standards BPAC activities total 19.4 MMTCE.

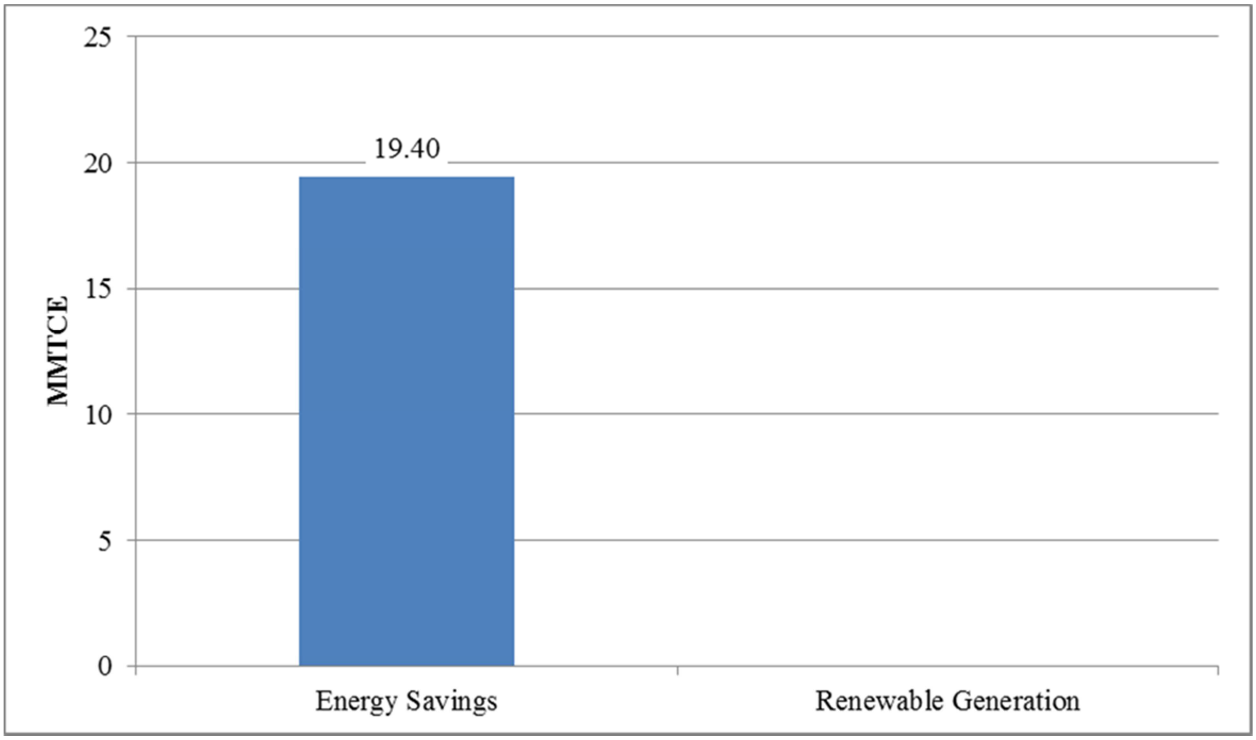

Figure 5-40: Avoided carbon emissions from codes and standards activities by program mechanism (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-41 shows SEP-attributable avoided carbon emissions over time from Codes and Standards programmatic activities in MMTCE. Avoided carbon emissions rise gradually from 2009, reach a peak from 2022 through 2030, and fall gradually over time to 2042, after the impacts of all programmatic activities have ceased.

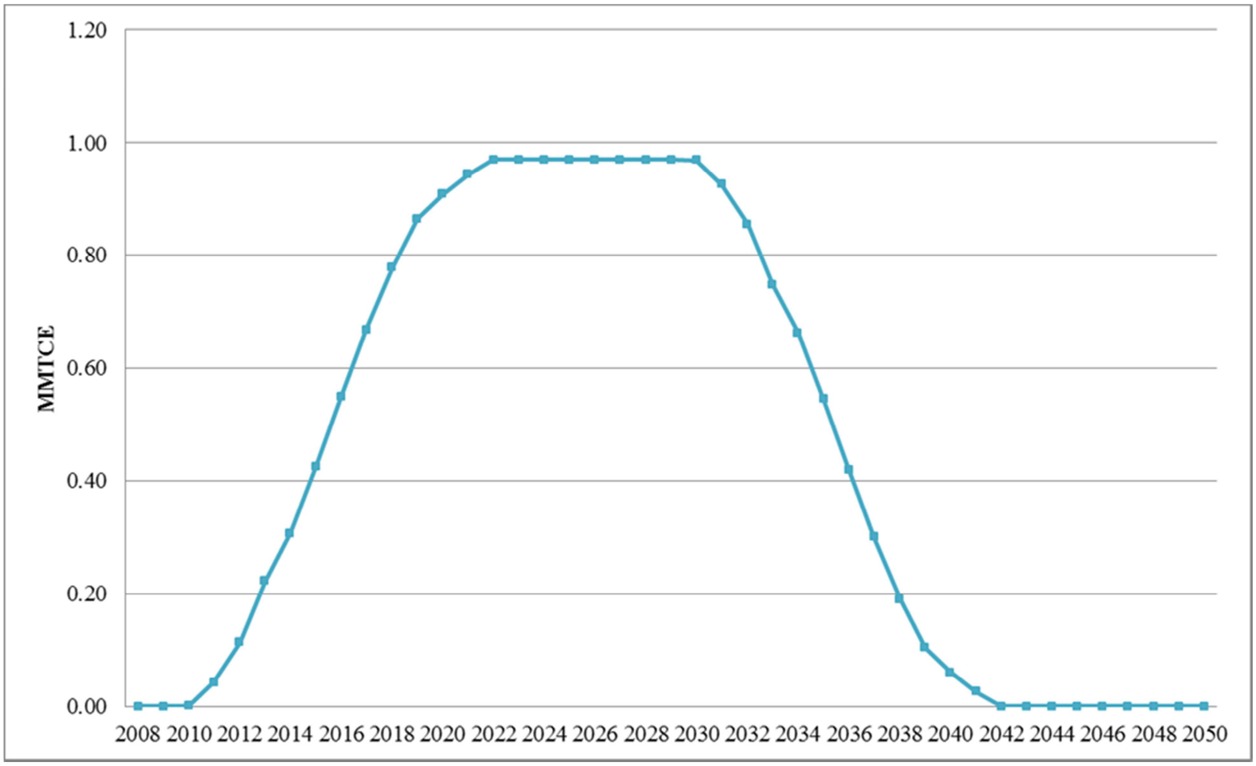

Figure 5-41: Avoided carbon emissions from codes and standards activities over time (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided carbon emissions over the lifetime of energy impacts, by sector, are presented in **Figure 5-42**. The residential sector accounts for the largest amount of avoided MMTCEs (10.9 MMTCE), followed by the commercial sector (3.6 MMTCE), the private institutional sector (3.0 MMTCE), the public institutional sector (1.7 MMTCE), and a small amount in the industrial sector (0.3 MMTCE).

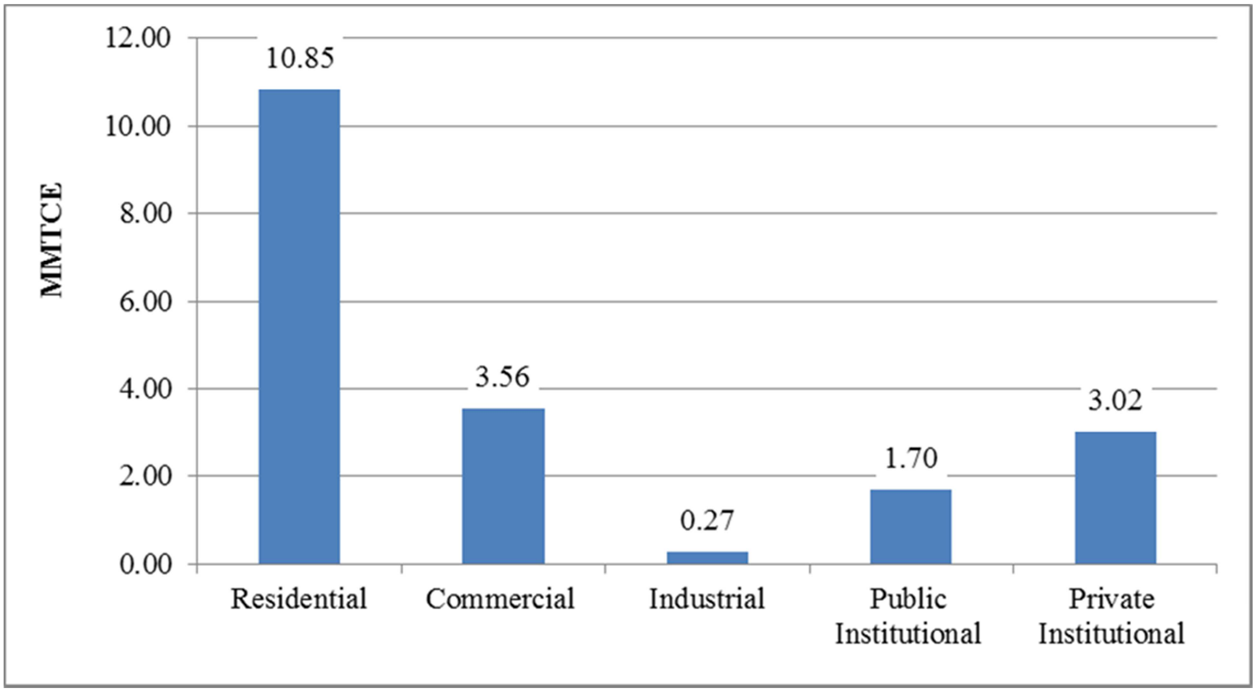

Figure 5-42: Avoided lifetime carbon emissions from codes and standards activities by sector (MMTCE)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

5.4.2.2 Avoided social costs of carbon (codes and standards)

As shown below in **Figure 5-43**, energy savings account for the cumulative avoided social costs of $1.4 billion.

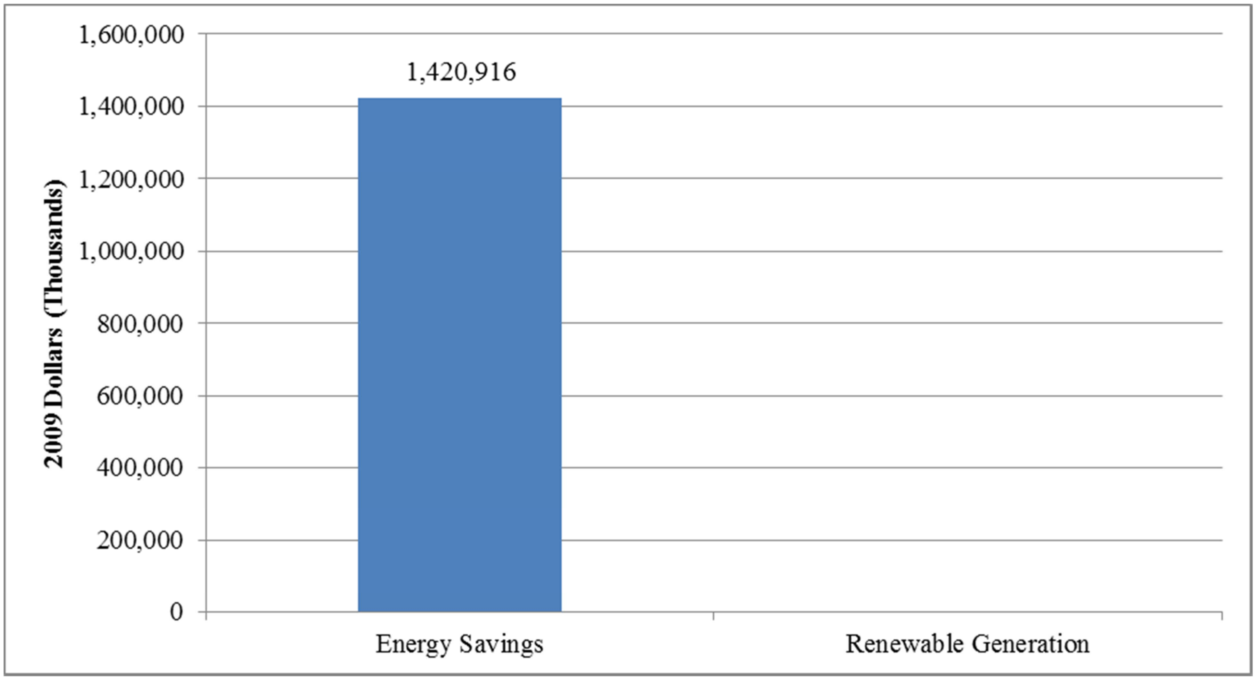

Figure 5-43: Avoided social costs of carbon emissions from codes and standards activities by program mechanism (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided social costs of carbon over time are presented in **Figure 5-44** for the Codes and Standards BPAC. Similar to the pattern of avoided carbon emissions, the associated avoided social costs rise gradually, peak in 2030, and decline gradually over time as various technologies' reach the end of their expected useful lives in 2042.

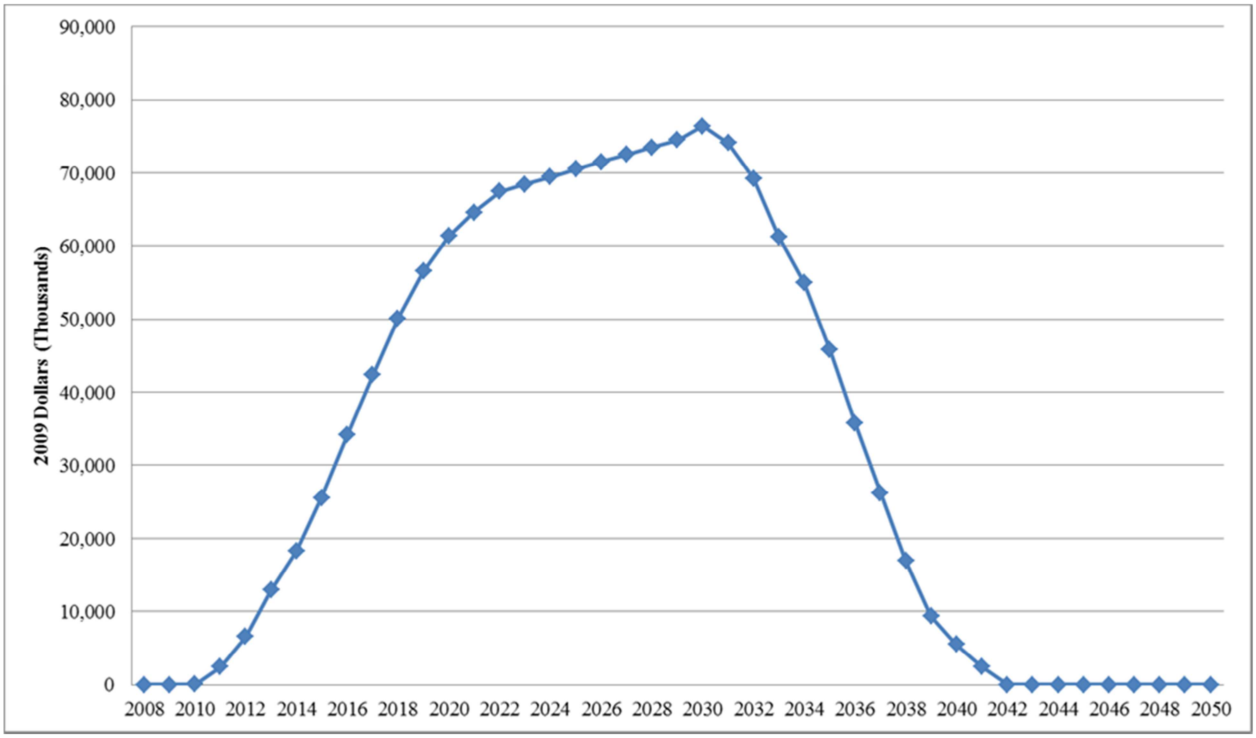

Figure 5-44: Avoided social costs of carbon from codes and standards activities over time (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-45 shows how those avoided social costs of carbon distribute across sectors. Similar to the distribution of avoided carbon emissions, the residential sector accounts for the largest amount of avoided social costs ($796 million), followed by the commercial sector ($260 million), the private institutional sector ($221 million), the public institutional sector ($124 million), and a small amount to the industrial sector ($20 million).

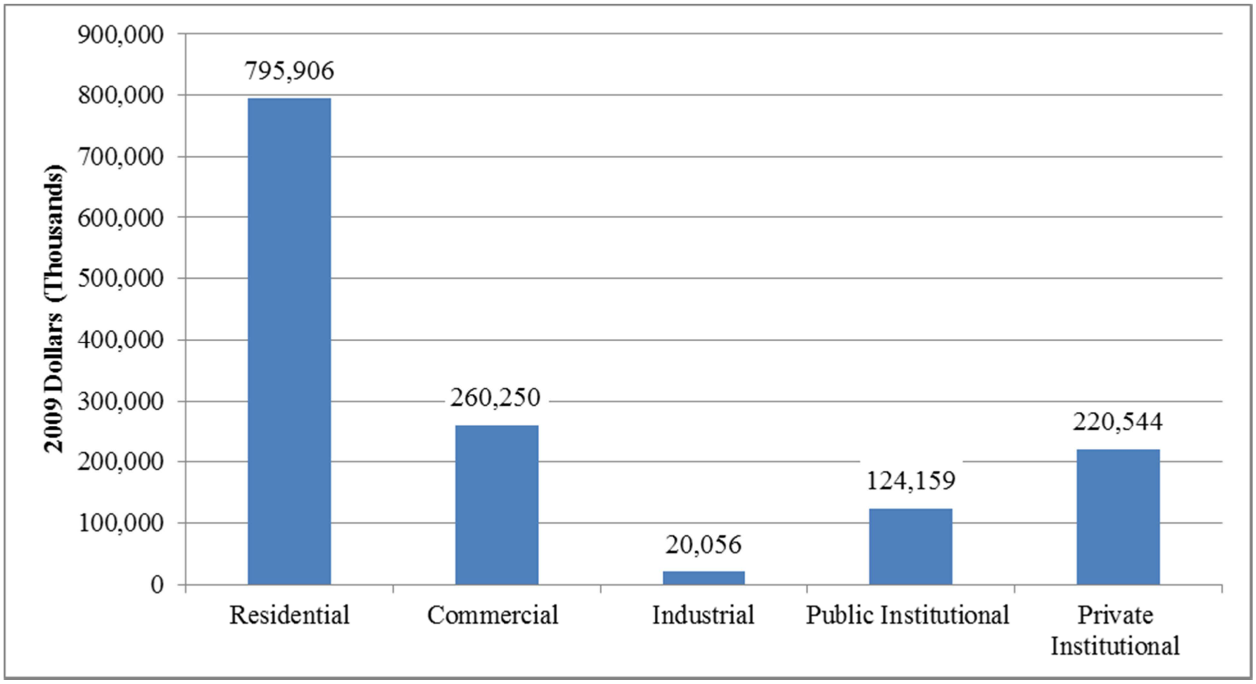

Figure 5-45: Avoided lifetime social costs of carbon from codes and standards activities by sector (thousands of 2009$)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

5.4.3 Loans, grants, and incentives (ARRA-period)

5.4.3.1 Avoided carbon emissions (loans, grants, and incentives)

Avoided carbon emissions from the Loans, Grants, and Incentives BPAC are derived from energy displaced from renewable generation and energy savings. As shown in **Figure 5-46**, avoided carbon emissions from Loans, Grants, and Incentives BPAC activities total 34.4 MMTCE. The largest avoided carbon emissions are derived from energy displaced from renewable generation (17.8 MMTCE), followed by energy savings (17.0 MMTCE).

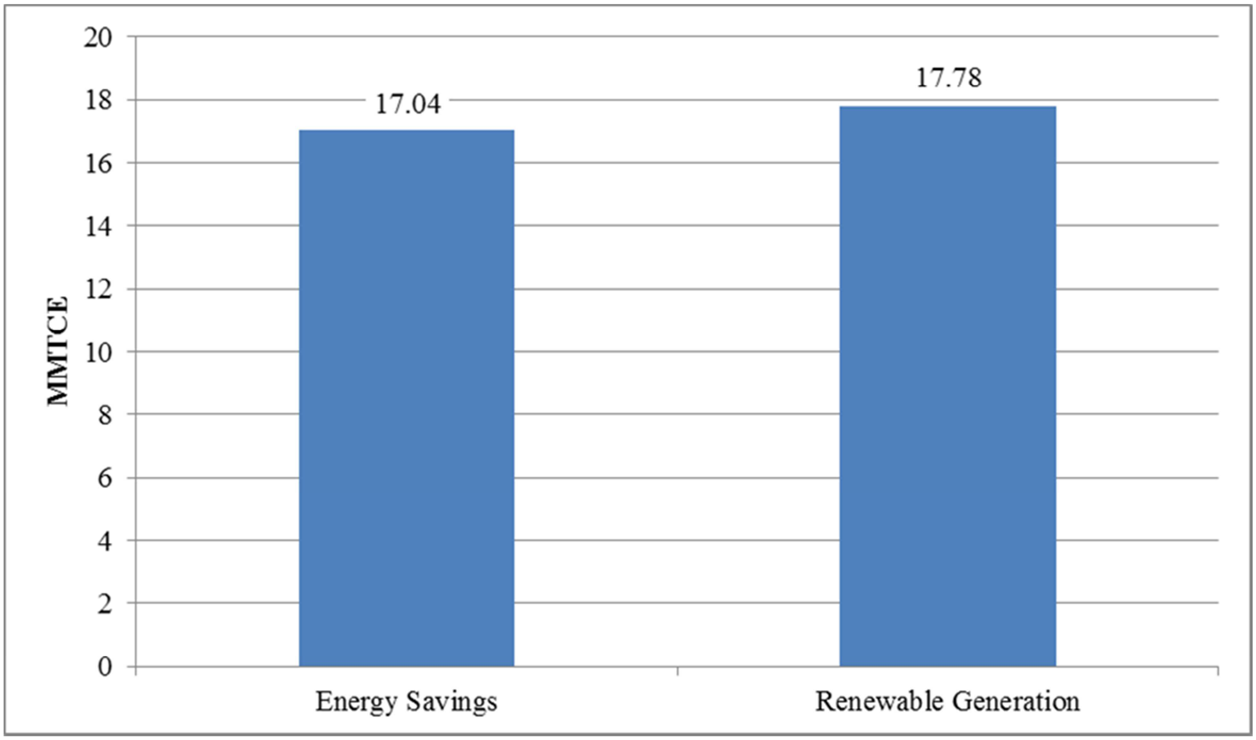

Figure 5-46: Avoided carbon emissions from loans, grants, and incentives activities by program mechanism (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-47 shows SEP-attributable avoided carbon emissions over time from Loans, Grants, and Incentives programmatic activities in MMTCE. Avoided carbon emissions rise steeply to 2012, increase gradually to a peak in 2025, and steadily decrease through 2050, when the evaluation period ends.

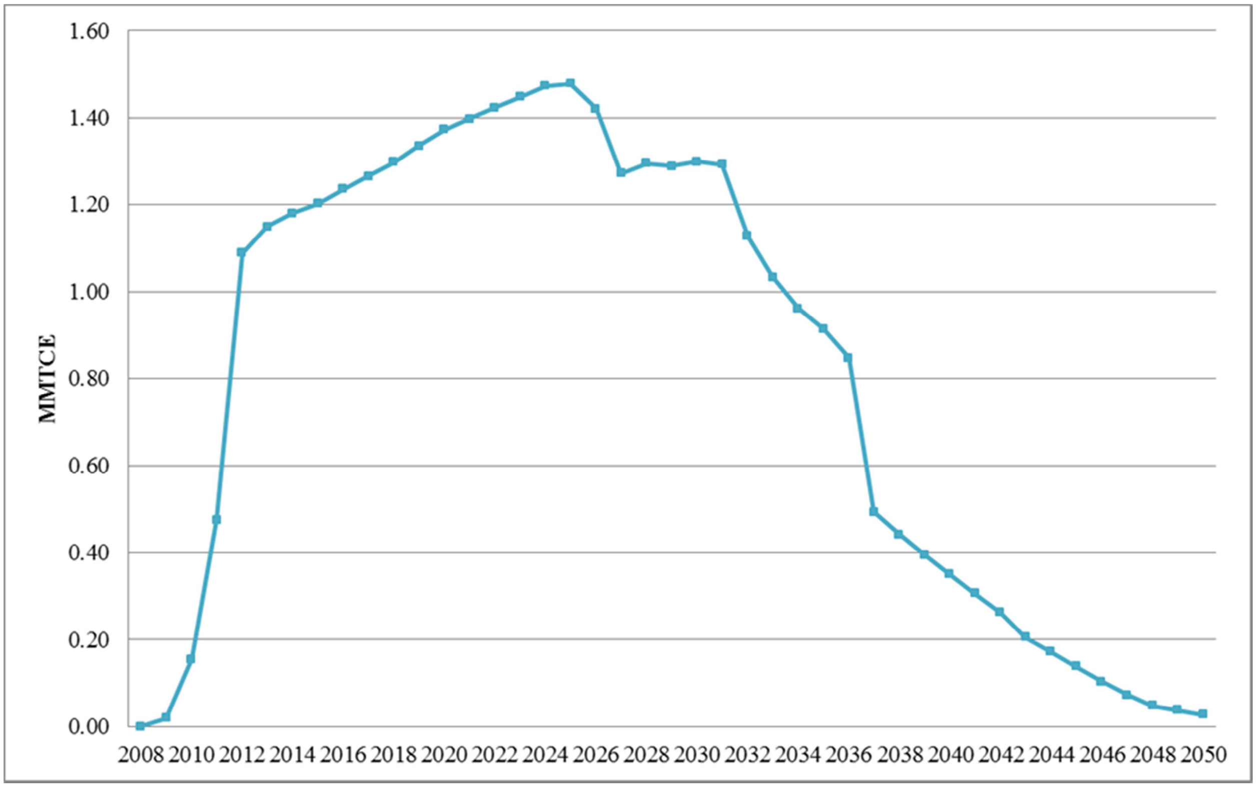

Figure 5-47: Avoided carbon emissions from loans, grants, and incentives activities over time (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided carbon emissions over the lifetime of energy impacts, by sector, are presented in **Figure 5-48**. The industrial sector accounts for the largest amount of avoided MMTCE (17.5 MMTCE), followed by the residential sector (7.8 MMTCE), the public institutional sector (7.7 MMTCE), the commercial sector (1.5 MMTCE), and finally the private institutional sector (0.2 MMTCE).

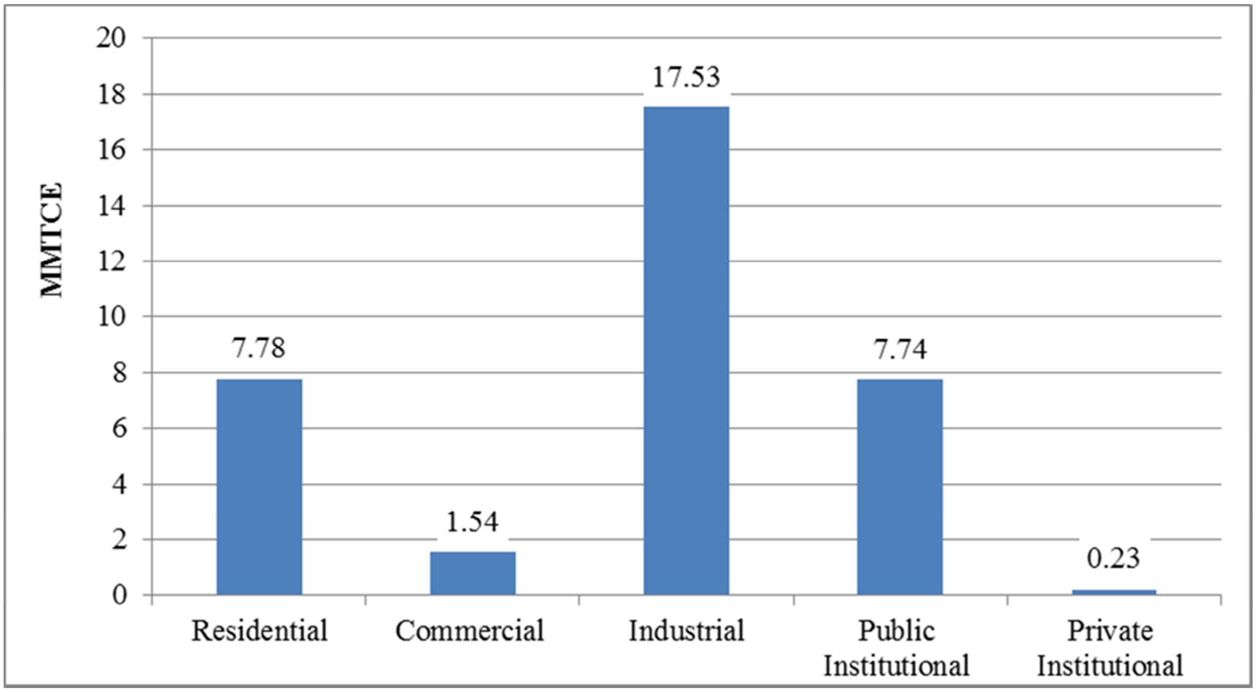

Figure 5-48: Avoided lifetime carbon emissions from loans, grants, and incentives activities by sector (MMTCE)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

5.4.3.2 Avoided social costs of carbon (loans, grants, and incentives)

As shown below in **Figure 5-49**, avoided social costs total about $2.5 billion. Energy displaced from renewable generation and energy savings each account for about half of the cumulative avoided social costs, at $1.3 billion each.

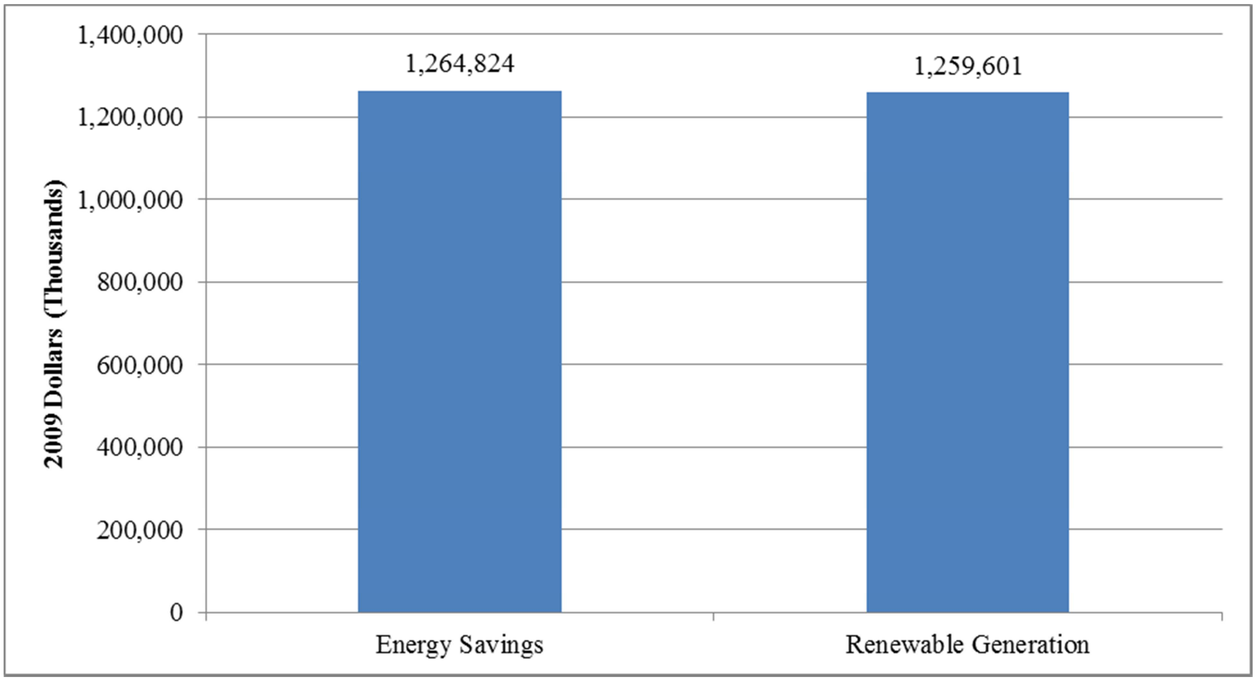

Figure 5-49: Avoided social costs of carbon emissions from loans, grants, and incentives activities by program mechanism (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided social costs of carbon over time are presented in **Figure 5-50** for the Loans, Grants, and Incentives BPAC. Similar to the pattern of avoided carbon emissions, the associated avoided social costs rise quickly to 2012, continue rising through 2026, and then decline steadily through 2050.

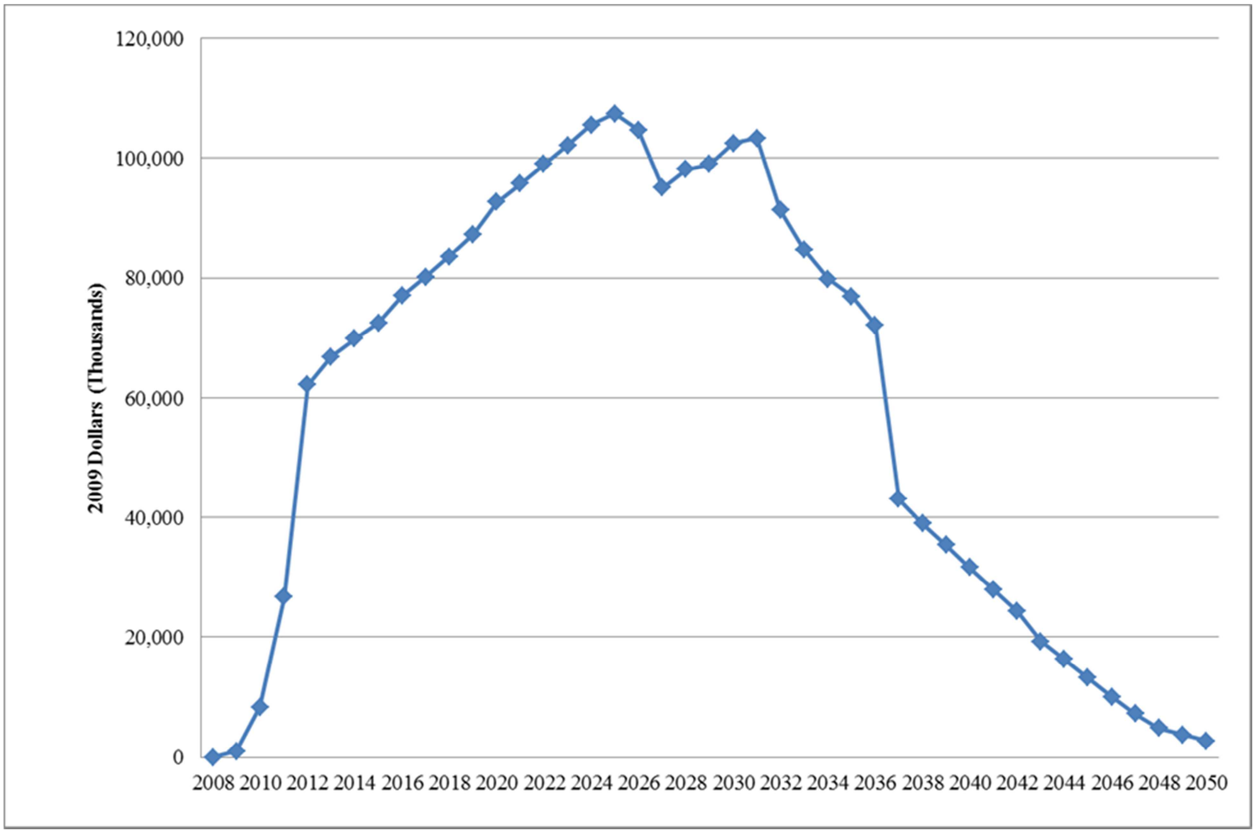

Figure 5-50: Avoided social costs of carbon from loans, grants, and incentives activities over time (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-51 shows how those avoided social costs of carbon distribute across sectors. Similar to the distribution of avoided carbon emissions, the industrial sector accounts for the largest amount of avoided social costs ($1.2 billion), followed by the public institutional sector ($579 million), the residential sector ($569 million), the commercial sector ($122 million), and the private institutional sector ($16.0 million).

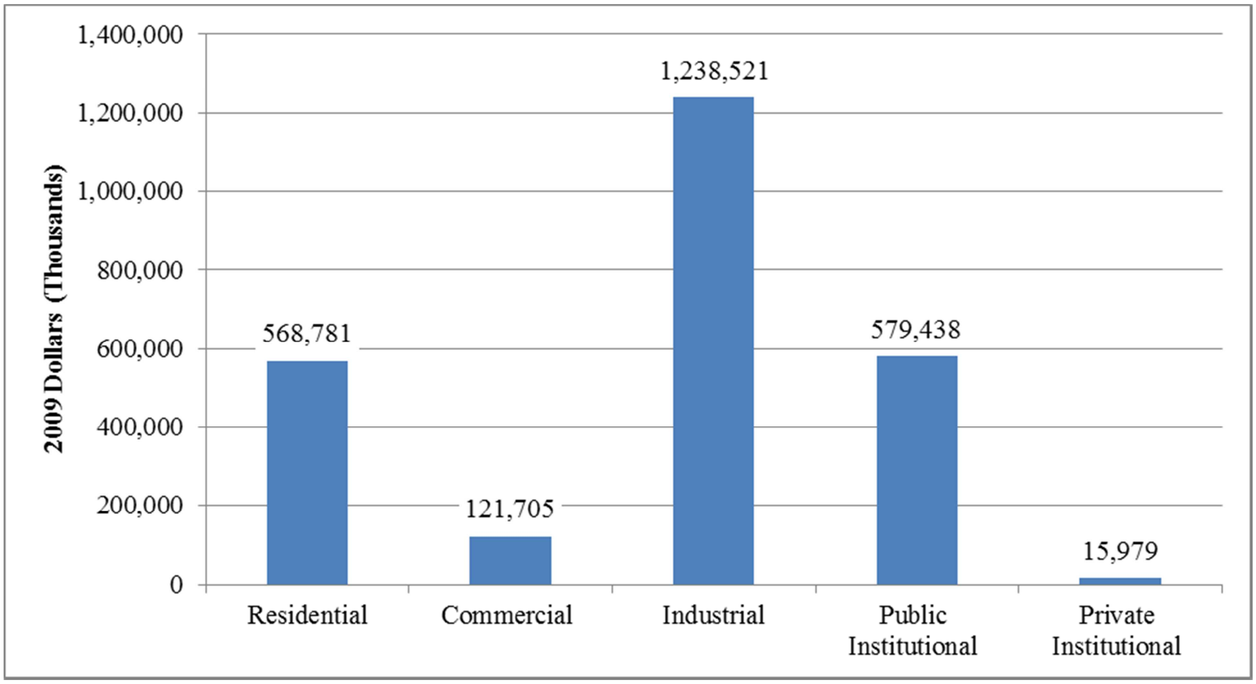

Figure 5-51: Avoided lifetime social costs of carbon from loans, grants, and incentives activities by sector (thousands of 2009$)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

5.4.4 Renewable energy market development (ARRA-period)

5.4.4.1 Avoided carbon emissions (renewable energy market development)

Avoided carbon emissions from the Renewable Energy Market Development BPAC are derived from energy displaced from renewable generation and energy savings. As shown **Figure 5-52**, avoided carbon emissions total 104 MMTCE. Avoided carbon emissions from Renewable Energy Market Development BPAC activities are derived almost exclusively from energy displaced from renewable generation at 104 MMTCE, with 0.05 MMTCE from energy savings.

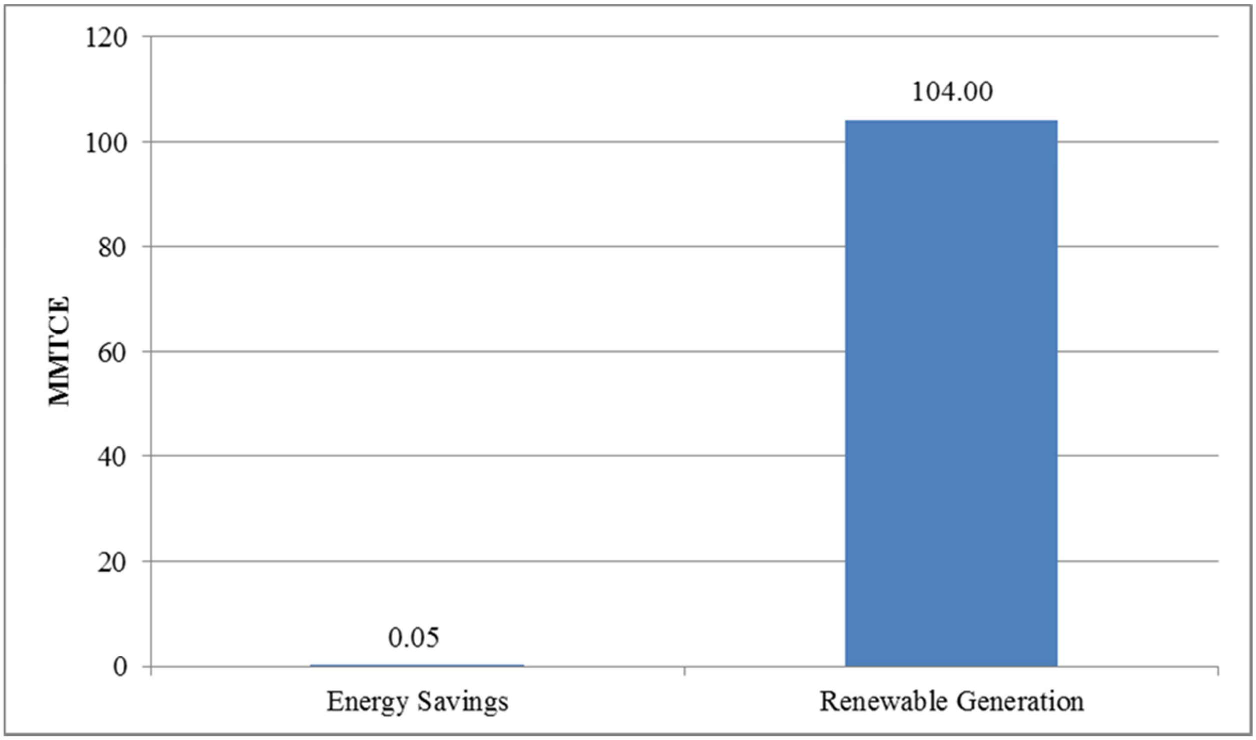

Figure 5-52: Avoided carbon emissions from renewable energy market development activities by program mechanism (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-53 shows SEP-attributable avoided carbon emissions over time from Renewable Energy Market Development programmatic activities in MMTCE. Avoided carbon emissions rise gradually from 2009, reach a peak from 2020 through 2028, and fall gradually over time to 2046, after the impacts of all programmatic activities have ceased.

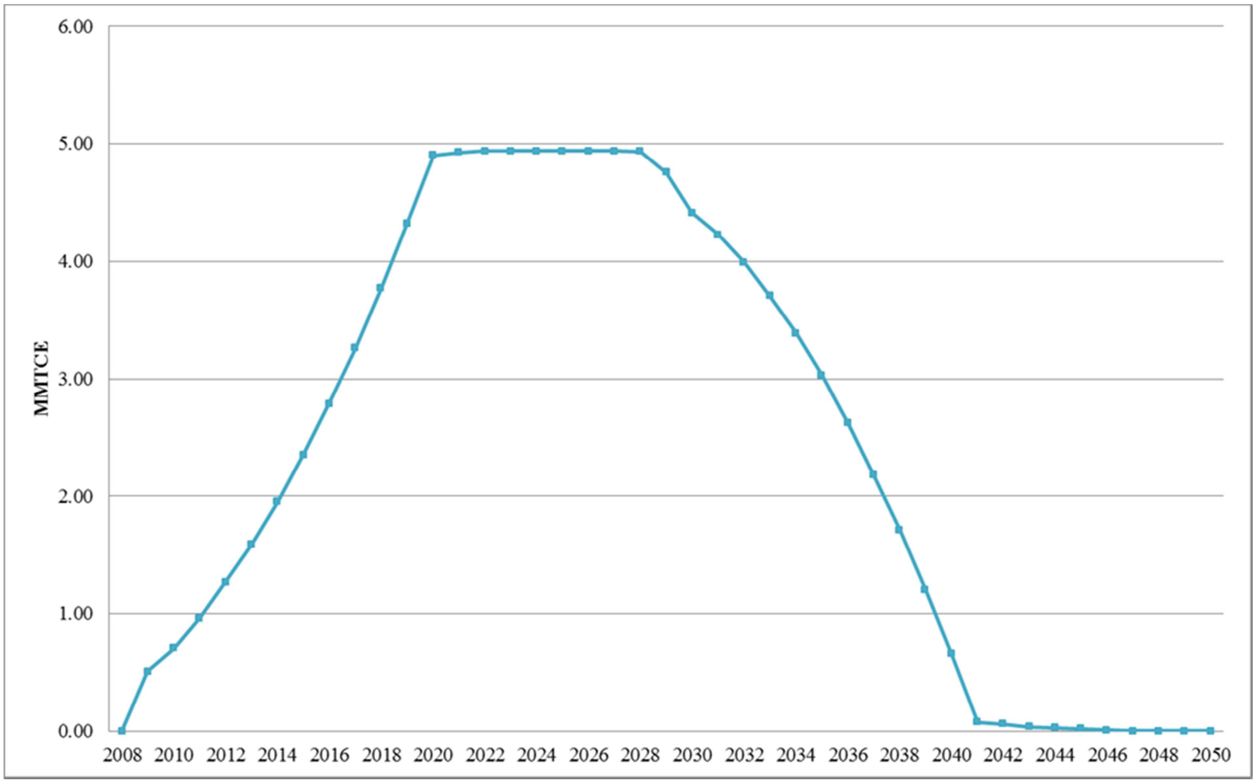

Figure 5-53: Avoided carbon emissions from renewable energy market development activities over time (MMTCE)

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.

Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided carbon emissions over the lifetime of energy impacts, by sector, are presented in **Figure 5-54**. The industrial sector accounts for the largest amount of avoided MMTCE (103 MMTCE). The public institutional sector had 0.61 avoided MMTCE, followed by the commercial, residential, and private institutional sectors, each with around 0.05 avoided MMTCE.

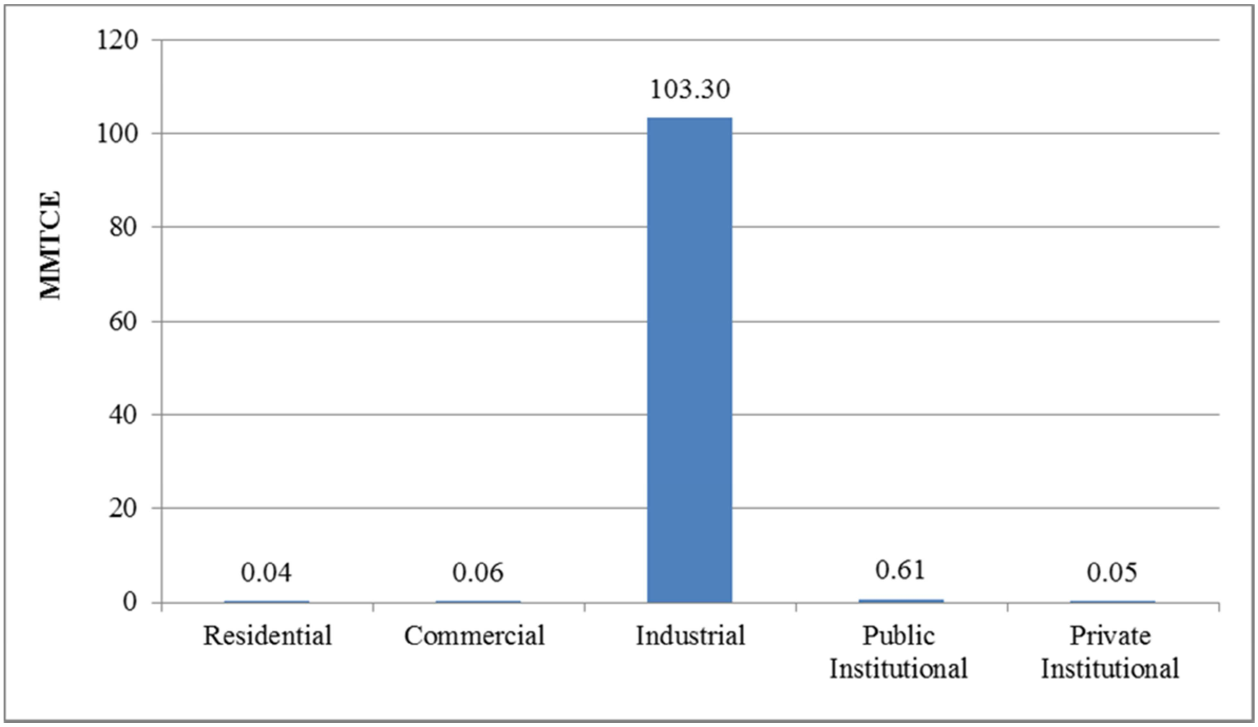

Figure 5-54: Avoided lifetime carbon emissions from renewable energy market development activities by sector (MMTCE)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.4.4.2 Avoided social costs of carbon (renewable energy market development)

As shown below in **Figure 5-55**, avoided social costs total $7.6 billion. Energy displaced from renewable generation accounts for the vast majority of the cumulative avoided social costs, with energy savings accounting for about $3.1 million in avoided social costs.

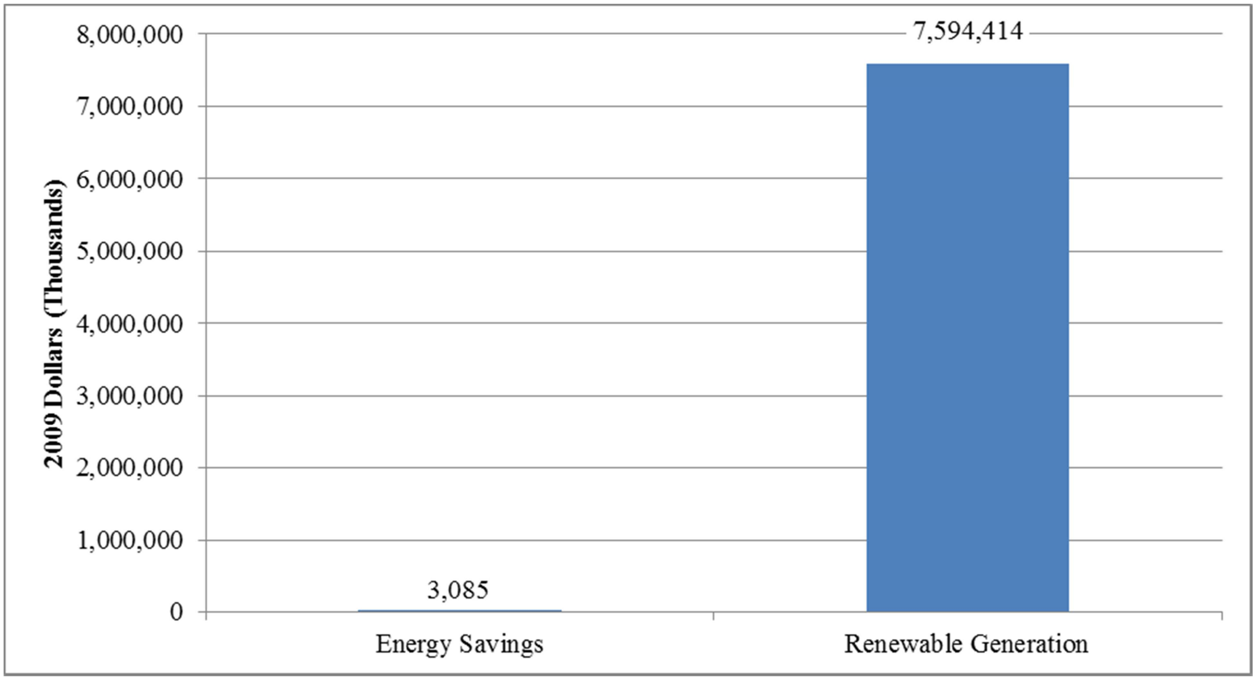

Figure 5-55: Avoided social costs of carbon emissions from renewable energy market development activities by program mechanism (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Avoided social costs of carbon over time are presented in **Figure 5-56** for the Renewable Energy Market development BPAC. Similar to the pattern of avoided carbon emissions, the associated avoided social costs rise gradually, peak in 2028, and decline gradually over time as various technologies' reach the end of their expected useful lives in 2046.

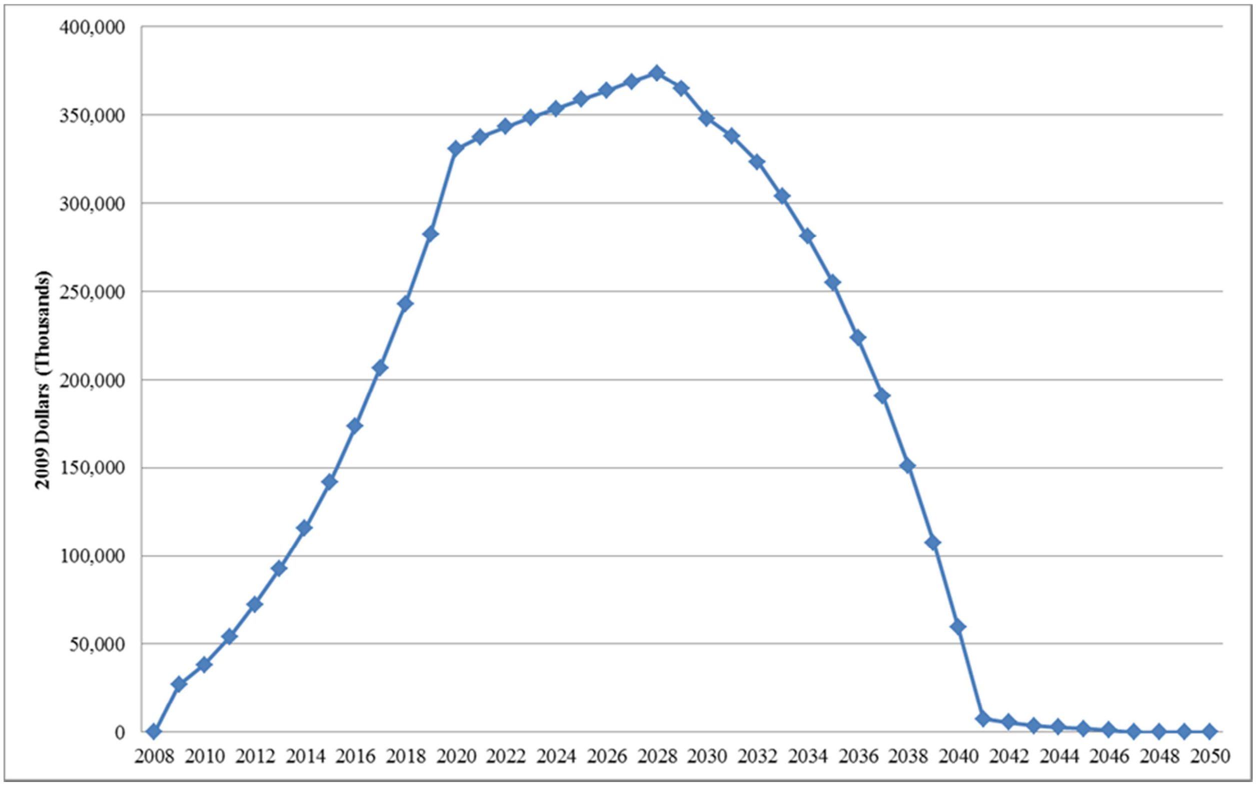

Figure 5-56: Avoided social costs of carbon from renewable energy market development activities over time (Thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Figure 5-57 shows how those avoided social costs of carbon distribute across sectors. Similar to the distribution of avoided carbon emissions, the industrial sector accounts for the largest amount of avoided social costs ($7.5 billion), followed by the public institutional sector ($42.9 million). The commercial, residential and private institutional sectors all had avoided social costs between $2.4 and $3.9 million.

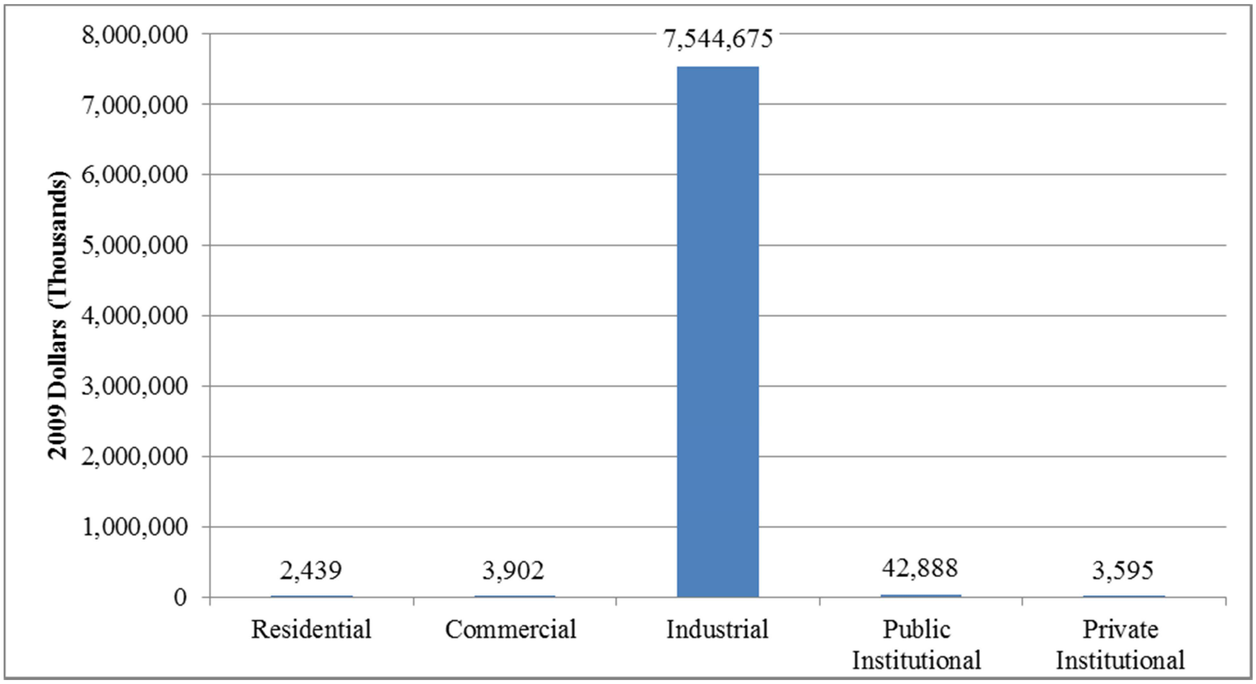

Figure 5-57: Avoided lifetime social costs of carbon from renewable energy market development activities by sector (thousands of 2009$)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

5.5 Bill savings and cost-effectiveness (ARRA-period)

This section presents findings on bill savings and cost-effectiveness indicators for each of the four studied BPACs funded during the ARRA-period through SEP. Bill savings are presented in 2009 dollars, and include bill savings from energy efficiency, on-site renewable generation, and customer bill savings related to utility scale generation For cost-effectiveness, two indicators are presented in this report: the SEP RAC test result and ratio of SEP-attributable bill savings to SEP expenditures in present value terms.

5.5.1 Building retrofits (ARRA-period)

5.5.1.1 Customer energy bill savings (building retrofits)

Figure 5-58 shows how the SEP-attributable customer energy bill savings associated with Building Retrofit activities distribute across different sectors over time, with the majority of bill savings accumulating to the public institutional sector, followed by the industrial sector with the private institutional and residential sectors also contributing a small amount. Bill savings peak in 2011 and decrease as the end of useful lives of equipment are reached. Total bill savings over the period of analysis was $836 million, compared to estimated program funding of $595 million for this BPAC.

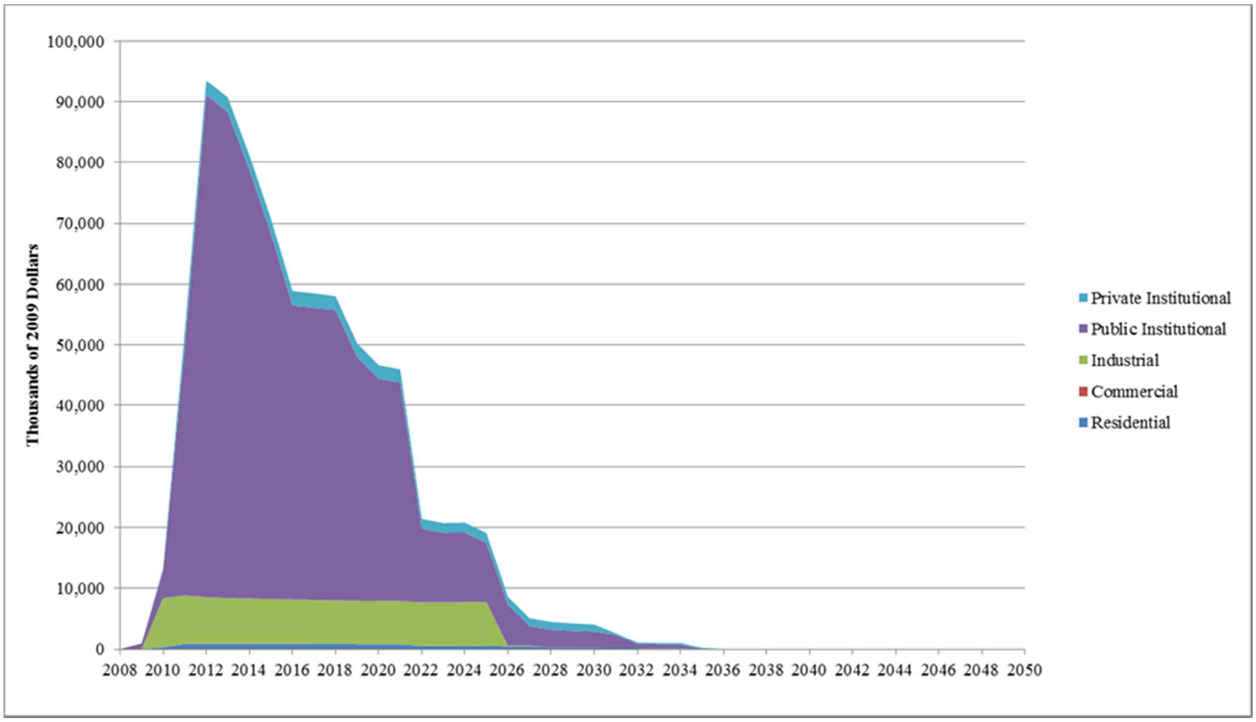

Figure 5-58: Bill savings for ARRA-period building retrofits by sector by year (thousands of $2009)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 5-35 shows how customer bill savings distribute by sector and fuel. The majority of bill savings across all sectors are derived from electricity savings, followed by natural gas and then fuel oil savings. The public institutional sector accounts for over half of all bill savings in this BPAC.

Table 5-35: SEP-attributable bill savings for ARRA-period building retrofit activities by fuel type by sector (thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	$9,731	-	$118,870*	$564,066	$16,304	$708,970
Natural Gas	$1,168*	-	-	$89,708*	$14,665	$105,542
Oil	n/a	-	-	$9,442*	$6,773*	$16,215*
Propane	$2,747*	-	-	-	$2,198	$4,946*
Kerosene	n/a	-	-	-	-	-
Wood	n/a	-	-	$11*	-	$11*
Diesel	n/a	-	-	-	-	-
Ethanol	n/a	-	-	-	-	-
Gasoline	n/a	-	-	-	-	-
Other	n/a	-	-	-	-	-
Total	**$13,647**	**-**	**$118,870***	**$663,227**	**$39,940**	**$835,684**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
"*" indicates estimate exhibits low precision.
"n/a" indicates not applicable.
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.

5.5.1.2 Cost-effectiveness indicators (building retrofits)

This section presents cost-effectiveness indicators for Building Retrofit activities funded under ARRA. As shown in **Table 5-36**, the SEP RAC test result for this BPAC is 16.7 from both the building and system perspectives, which exceeds the ARRA-period benchmark of 10 by 67%.

Table 5-36: SEP RAC test result for ARRA-period building retrofit BPAC (source MMBtu/$1,000)

Perspective	Benchmark	Finding
Building	10	16.7
System	10	16.7

Under all three discount scenarios this BPAC produced present value ratios greater than 1.0 when comparing participant bill savings to program expenditures, indicating that bill savings exceeded expenditures. The present value ratios ranged from 1.1 to 1.3, depending on the discount rate used in the analysis (**Table 5-37**).

Table 5-37: Lifetime present value ratios for ARRA-period building retrofits BPAC

Discount Rate	0.7%	2.7%	4.7%
Ratio of Bill Savings to PA Funding	1.3	1.2	1.1

The lower SEP RAC test result and lifetime present value ratio for Building Retrofits in the ARRA period, compared to PY 2008 outcomes, can largely be explained by differences in the nature of the programmatic activities undertaken in the two periods, as previously noted. The state leveraging requirement for PY 2008, which did not apply under ARRA, also contributed to the finding of greater SEP-attributable savings per SEP dollar in PY 2008 because that state investment would not have occurred in the absence of SEP. As explained in **Sections 3.4.4** and **3.5.4**, cost-effectiveness is calculated by dividing SEP-attributable savings by SEP funding only.

5.5.2 Building codes and standards (ARRA-period)

5.5.2.1 Customer energy bill savings (building codes and standards)

Figure 5-59 shows how the customer energy bill savings associated with Building Codes and Standards activities distribute across different sectors over time, with the majority of bill savings accumulating to the residential sectors, followed by the commercial and private institutional sectors. Savings gradually increase to a plateau in 2020, remain at those high levels until 2030, and then decline steadily to 2042, generally maintaining their proportional shares over time. Total bill savings was about $4 billion over the period of analysis, compared to estimated program funding of $10.8 million for this BPAC.

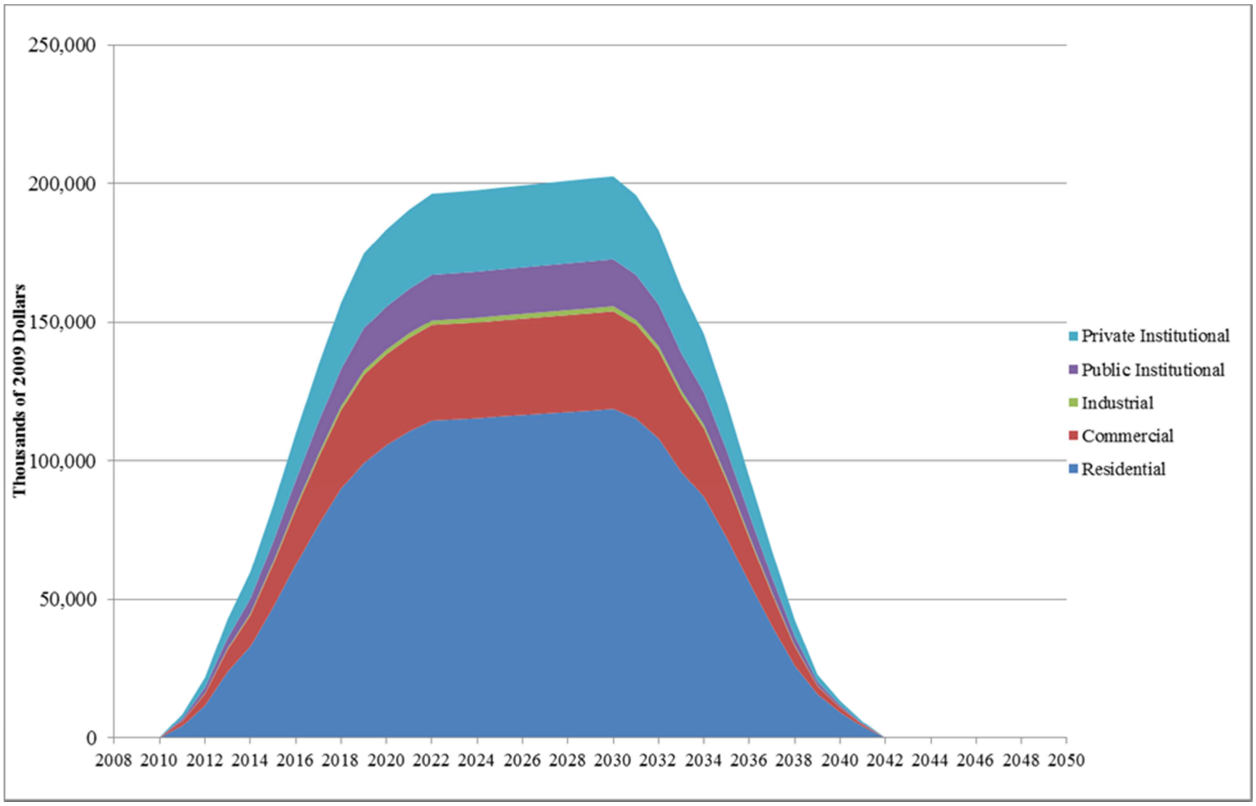

Figure 5-59: Bill savings for ARRA-period building codes and standards activities by sector by year (Thousands of $2009)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

Table 5-38 shows how customer bill savings distribute by sector and fuel. Improvements and enforcement in residential codes accounted for over half ($2.3 billion) of the total bill savings. The majority of bill savings across all sectors are derived from electricity savings, followed by natural gas and then oil savings. The residential sector also received some bill savings related to avoided propane consumption.

Table 5-38: SEP-attributable bill savings for ARRA-period building codes and standards activities by fuel type by sector (Thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	$1,919,441	$578,446	$27,525	$275,962	$490,192	$3,291,566
Natural Gas	$411,196	$90,838	$5,618	$43,336	$76,979	$627,967
Oil	n/a	$35,712	$2,827	$17,037	$30,263	$85,840
Propane	$13,331	-	-	-	-	$13,331
Kerosene	n/a	-	-	-	-	-
Wood	n/a	-	-	-	-	-
Diesel	n/a	-	-	-	-	-
Ethanol	n/a	-	-	-	-	-
Gasoline	n/a	-	-	-	-	-
Other	n/a	-	-	-	-	-
Total	**$2,343,968**	**$704,996**	**$35,970**	**$336,336**	**$597,434**	**$4,018,704**

Note:
"-" indicates estimate rounds to zero and is considered imprecise.
"*" indicates estimate exhibits low precision.
"n/a" indicates not applicable.
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

5.5.2.2 Cost-effectiveness indicators (building codes and standards)

This section presents cost effectiveness indicators for Building Codes and Standards activities funded under ARRA. As shown in **Table 5-39**, for Codes and Standards, the SEP RAC test result is 1,562 from both the building and system perspectives, which is more than 150 times the ARRA-period benchmark of 10.

Table 5-39: SEP RAC test result for ARRA-period building codes and standards BPAC (source MMBtu/$1,000)

Perspective	Benchmark	Finding
Building	10	1,562.4
System	10	1,562.4

Under all three discount scenarios this BPAC produced present value ratios much greater than 1.0 when comparing participant bill savings to program expenditures, indicating that bill savings exceeded expenditures. The present value ratios ranged from 191.6 to 333.8, across the range of discount rates used in the analysis (**Table 5-40**).

Table 5-40: Lifetime present value ratios for ARRA-period building codes and standards BPAC

Discount Rate	0.7%	2.7%	4.7%
Ratio of Bill Savings to PA Funding	333.8	250.3	191.6

5.5.3 Loans, grants, and incentives (ARRA-period)

5.5.3.1 Customer energy bill savings (loans, grants, and incentives)

Figure 5-60 shows how customer energy bill savings associated with Loan, Grant and Incentive activities distribute across different sectors over time, with the majority of bill savings coming from the public institutional and the residential sectors, and lesser amounts from the commercial and industrial sectors. Bill savings for this BPAC peak about half way through the study period, with cumulative bill savings totaling about $2.8 billion through 2050, compared to estimated program funding of $847.7 million for this BPAC.[90]

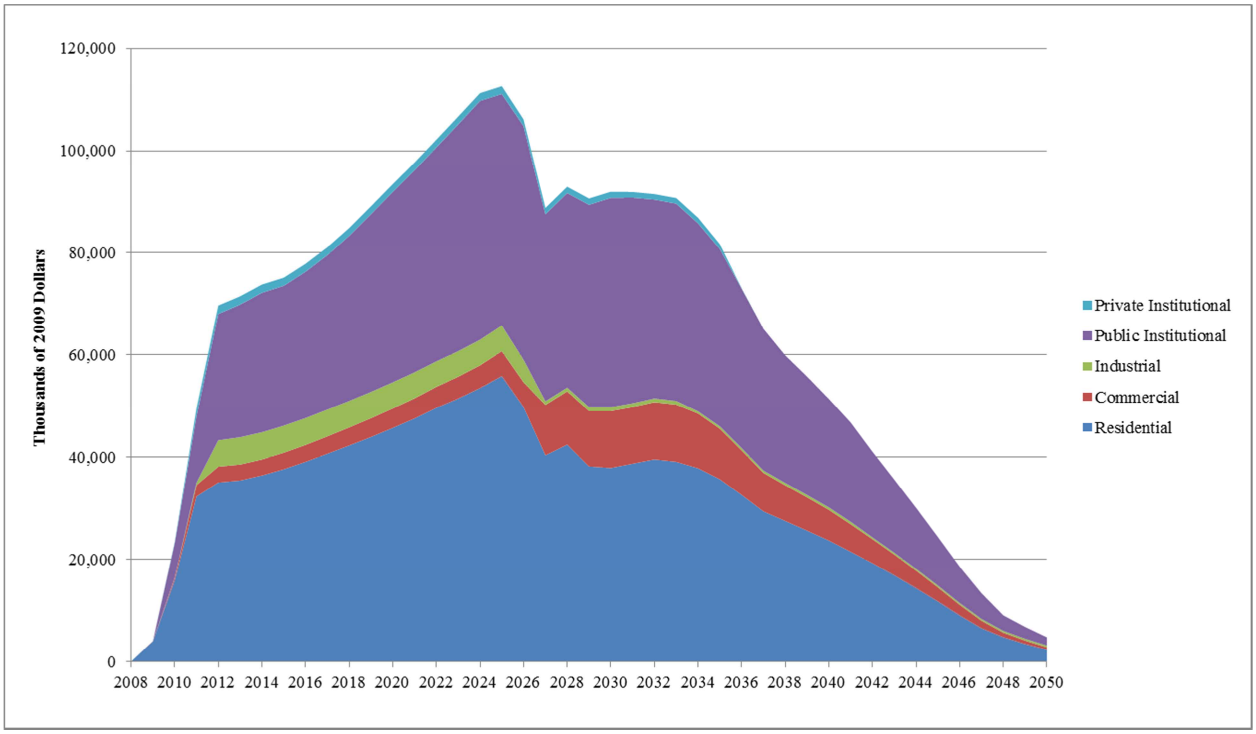

Figure 5-60: Bill savings for ARRA-period renewable loan, grant and incentive activities by sector by year (thousands of $2009)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

90 Customer bill savings related to on-site generation are included in total bill savings. All on-site renewable generation evaluated in this study is customer-owned and therefore the savings accrue to the customer.

Table 5-41 shows how customer bill savings distribute by sector and fuel. The majority of bill savings across all sectors are derived from electricity savings, followed by natural gas and other fuels.

Table 5-41: SEP-attributable bill savings for ARRA-period loan, grant and incentive activities by fuel type by sector (thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	$993,020	$182,692	$80,368*	$825,584	$31,806*	$2,113,470
Natural Gas	$149,117*	$25,094*	$6,920*	$243,155*	$756	$425,041
Oil	$142,525*	$7,689	$1,231*	$45,110*	$2,627*	$199,182
Propane	$29,979*	$532	$15*	$1,814	$32*	$32,373*
Kerosene	n/a	-	-	-	-	-
Wood	n/a	-	-	-	-	-
Diesel	n/a	$801*	$392*	$1,118*	-	$2,311
Ethanol	n/a	-	-	-	-	-
Gasoline	n/a	$529*	-	-	-	$529*
Other	n/a	-	-	-	-	-
Total	$1,314,641	$217,338	$88,925*	$1,116,783	$35,220*	$2,772,906

Note:
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"*" indicates estimate exhibits low precision.
"n/a" indicates not applicable.
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

5.5.3.2 Cost-effectiveness indicators (loans, grants, and incentives)

This section presents cost effectiveness indicators for the ARRA-period Loans, Grants, and Incentives BPAC activities. This BPAC includes loans that are included as program expenditures. However, those loans are eventually repaid by borrowers and can be viewed alternatively as not being a program expenditure. Therefore, SEP RAC test results are presented both with and without the initial loan disbursements.[91]

As shown in **Table 5-42**, the SEP RAC test result for this BPAC with loan dollars included is 20.6 from the building perspective and 21.5 from the system perspective and is over 100% above the benchmark of 10. Without the loan dollars, the SEP RAC test result increases to 35.1 from the building perspective and 36.6 from the system perspective and is over 250% above the RAC benchmark.

Table 5-42: SEP RAC test result for ARRA-period loans, grants, and incentives BPAC (source MMBtu/$1,000)

Perspective	Benchmark	Finding
Building with loans	10	20.6
Building without loans	10	35.1
System with loans	10	21.5
System without loans	10	36.6

Under all three discount scenarios this BPAC produced present value ratios greater than 1.0 when comparing participant bill savings to program expenditures, indicating that bill savings exceeded expenditures. With loan dollars included, the present value ratios ranged from 1.7 to 2.9 depending on the discount rate used in the analysis. Without loan dollars, the range of present value ratios extended from 3.0 to 4.9 (**Table 5-43**).[92]

[91] For the ARRA-period, approximately 85% of initial disbursements are included in the "With Loan Principal" scenario.

[92] Customer costs associated with switching electricity service for on-site generation technologies are not considered in the PV ratio.

Table 5-43: Lifetime present value ratios for ARRA-period loans, grants, and incentives BPAC

Discount Rate	0.7%	2.7%	4.7%
Ratio of Bill Savings to PA Funding, with Loans	2.9	2.2	1.7
Ratio of Bill Savings to PA Funding, without Loans	4.9	3.7	3.0

5.5.4 Renewable energy market development (ARRA-period)

5.5.4.1 Customer energy bill savings (renewable energy market development)

Figure 5-61 shows how the customer energy bill associated with Renewable Energy Market Development activities distribute across different sectors over time. This BPAC funded both on-site and utility scale renewable generation. While there was a high amount of renewable generation for this BPAC, much of it was in utility scale generation, which does not result in any measurable bill savings. The public institutional sector accounts for most of the bill savings that does occur in this BPAC, followed by the residential sector. Total bill savings over the study period was over $130 million, compared to estimated program funding of $424.2 million for this BPAC.[93]

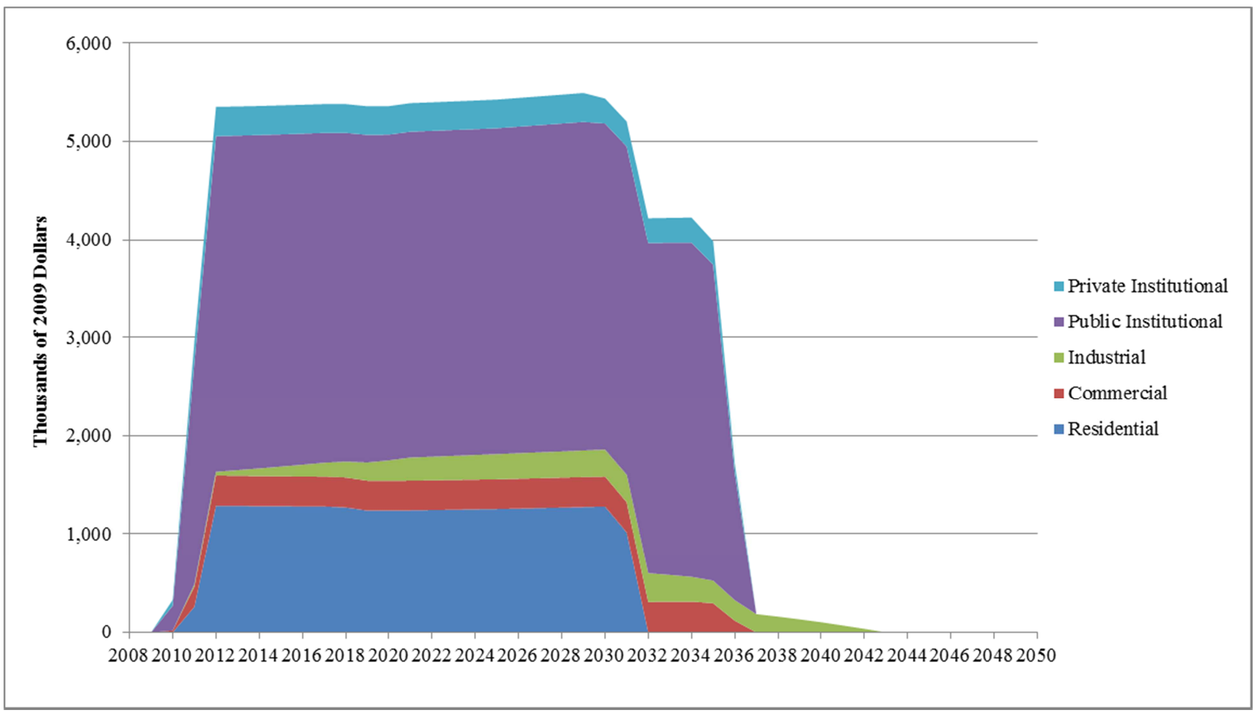

Figure 5-61: Bill savings for ARRA-period renewable energy market development activities by sector by year (thousands of $2009)

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.
Additional information on the precision of estimates from this study is provided in Section 2.4.

[93] Customer bill savings related to on-site generation are included in total bill savings. All on-site renewable generation evaluated in this study is customer-owned and therefore the savings accrue to the customer.

Table 5-44 shows how customer bill savings distribute by sector and fuel. The majority of bill savings across all sectors are derived from electricity savings, followed by natural gas.

Table 5-44: SEP-attributable bill savings for ARRA-period renewable energy market development activities by fuel type by sector (thousands of $2009)

	Residential	Commercial	Industrial	Public Institutional	Private Institutional	Total
Electricity	$23,507*	$7,651*	-	$83,928*	$6,831*	$121,917*
Natural Gas	$1,766*	-	$5,945*	$234*	$304*	$8,249*
Oil	n/a	-	-	-	-	-
Propane	n/a	-	-	-	-	-
Kerosene	n/a	-	-	-	-	-
Wood	n/a	-	-	-	-	-
Diesel	n/a	-	-	-	-	-
Ethanol	n/a	-	-	-	-	-
Gasoline	n/a	-	-	-	-	-
Other	n/a	-	-	-	-	-
Total	$25,273*	$7,651*	$5,945*	$84,162*	$7,135*	$130,165*

Note:
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"*" indicates estimate exhibits low precision.
"n/a" indicates not applicable.
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.

5.5.4.2 Cost-effectiveness indicators (renewable energy market development)

This section presents cost effectiveness indicators for Renewable Energy Market Development activities funded under ARRA. As shown in **Table 5-45**, the SEP RAC test result from the building perspective is 227.1 and exceeds the ARRA-period benchmark of 10 by about 2,171%. From the system perspective, the SEP RAC test result is 228.1.

Table 5-45: SEP RAC test result for ARRA-period renewable energy market development BPAC (source MMBtu/$1,000)

Perspective	Benchmark	Finding
Building	10	227.1
System	10	228.1

Under all three discount scenarios this BPAC produced present value ratios lower than 1.0 when comparing participant bill savings to program expenditures, indicating that expenditures exceeded bill savings. The present value ratio ranged from 0.2 to 0.3 depending on the discount rate used in the analysis (**Table 5-46**). While there was a high amount of renewable generation for this BPAC, much of it was in renewable manufacturing at the utility-scale, which does not result in any measurable bill savings.[94]

Table 5-46: Lifetime present value ratios for ARRA-period renewable energy market development BPAC

Discount Rate	0.7%	2.7%	4.7%
Ratio of Bill Savings to PA Funding	0.3	0.2	0.2

94 Customer costs associated with switching electricity service for on-site generation technologies are not considered in the PV ratio.

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