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

EXECUTIVE SUMMARY

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Table of Contents

List of Figures

List of Tables

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

[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).

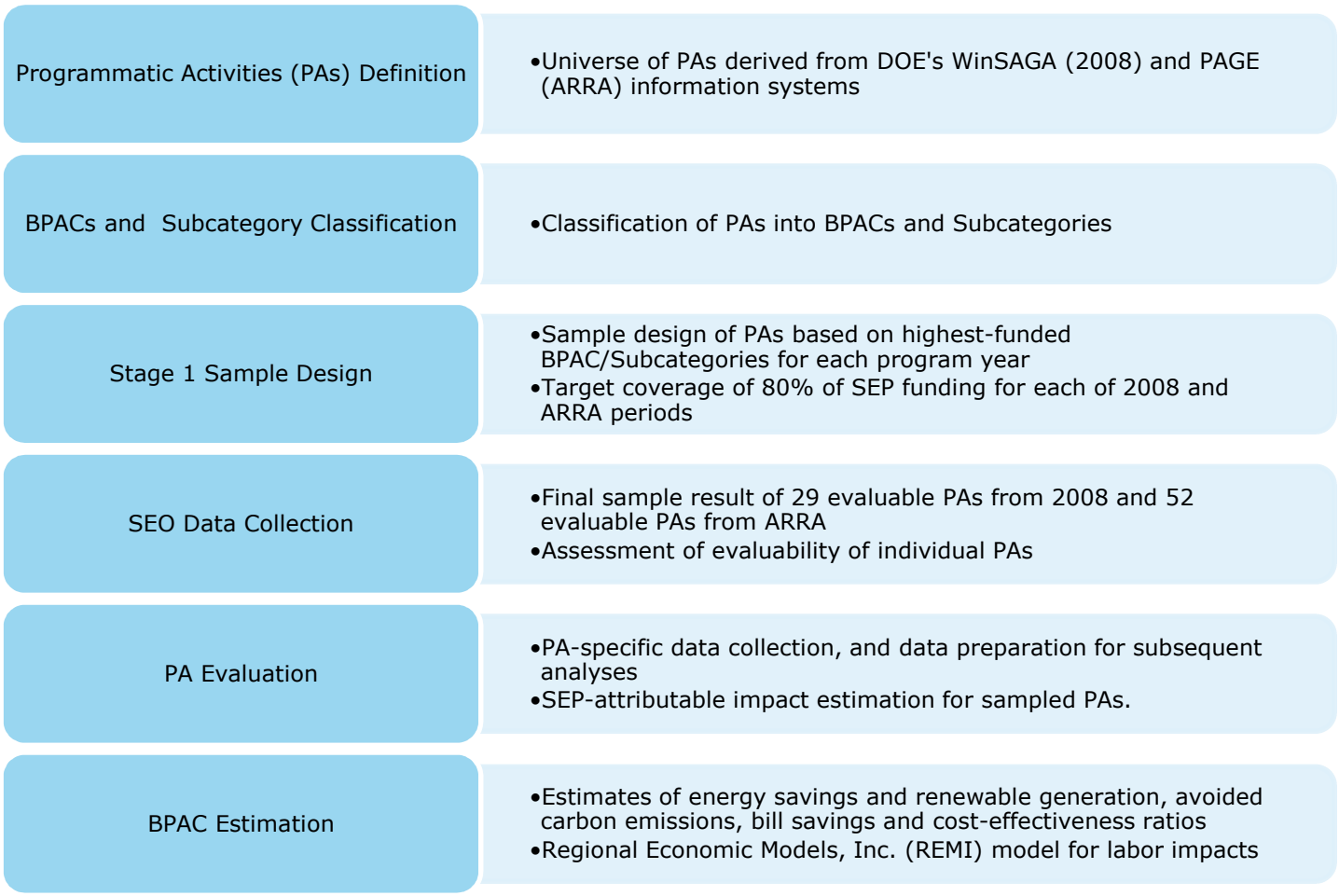

Figure ES-1: Overview of study approach

[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

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