NATIONAL EVALUATION OF THE ENERGY EFFICIENCY AND CONSERVATION BLOCK GRANT PROGRAM

Volume II: Appendices A through L

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APPENDIX A. SUMMARY OF RESEARCH PLANNING ACTIVITIES

This appendix provides a brief history of how the research plan for the EECBG National Evaluation was developed and refined.

Additional information on selected key activities that are not addressed in other appendices is also provided below.

A.1. ENERGY EFFICIENCY AND BLOCK GRANT EVALUATION PLAN

EECBG was conceived as a one-time grant offering to state and local governments and tribal organizations to make energy efficiency improvements. Its funding source was stimulus money made possible through the 2009 American Reinvestment and Recovery (ARRA). As such, there was no prior program for which an evaluation had been conducted. A new evaluation plan therefore had to be developed specific to the one-time EECBG grant program.

In September 2010, the U.S. Department of Energy (DOE) approached ORNL to conduct an evaluation of the formula grants in the EECBG program.[1] DOE developed a white paper, providing a broad outline of the EECBG evaluation. Martin Schweitzer (ORNL) and Nick Hall (TecMarket Works) then prepared a draft scope of work (SOW) for the study based on the framework provided in the DOE white paper.

The draft SOW was sent a Peer Review Panel of evaluation experts. In January of 2011, ORNL met with the Peer Review Panel members to solicit their comments on the draft SOW. The peer review panel then delivered a comments document to ORNL and ORNL, in turn, provided a formal response to each comment from the Panel. In April 2011, ORNL finalized the SOW, incorporating suggestions from the Panel.

Key events from the study's inception through finalization of the study design and sample are summarized in Table 1.

Table 1: Timeline of significant EECBG evaluation design and planning events

Event	Date
DOE approaches ORNL to do EECBG evaluation	September 2010
DOE develops white paper providing broad outline of EECBG evaluation	November 2010
Draft Scope of Work Prepared by ORNL and TecMarket Works	December 2010
Peer Review Panel Meets to Review Draft Scope of Work (SOW)	January 2011
Comments on draft SOW received from Peer Review Panel	February 2011
Detailed Scope of Work Finalized	April 2011
Evaluation Contractor Team Selected through Competitive Solicitation Process	August 2011*
Evaluation Team Prepares Draft Detailed Work Plan	December 2011
Detailed Work Plan Finalized by Evaluation Contractor Team	February 2012
Information Collection Request Submitted to OMB	September 2012
OMB Approves Information Collection Request	April 2013
Sample of Activities Finalized Following Evaluability Assessment	September 2013

**Date contract received. Project launched September 8, 2011.*

[1] Formula grants are grants where recipients are selected based on a specific formula, rather than a competitive application for a grant.

A.2. OMB REVIEW AND APPROVAL OF INFORMATION COLLECTION REQUEST

In compliance with the terms of the Paperwork Reduction Act, the contactor team prepared an Information Collection Request (ICR) package containing all survey instruments to be used to collect identical data from 10 or more respondents, along with a detailed set of supporting materials describing the proposed study. That package was submitted to OMB September 2012 and final approval was received April 2013. Key events in the ICR submission and review process are summarized in Table 2.

Table 2: Timeline of key events in OMB approval process

Event	Date
ICR Submitted to DOE	June 2012
DOE comments received by ORNL	August 2012
ICR Submitted to OMB	September 2012
ORNL and DOE conduct conference call with OMB to discuss ICR status	January 2013
OMB Provides Evaluation Team with Feedback on Survey Instruments	January - February 2013
Evaluation Team Sends OMB Responses to its Comments and Suggestions	February 2013
Evaluation Team Sends Revised ICR Package to OMB	March 2013
OMB Approves Information Collection Request	April 2013

APPENDIX B. FINAL DATA COLLECTION DISPOSITION

The telephone survey was administered during the period of November 2013 through March 2014. The web survey was available to telephone respondents from November 2013 through May 2014. Three hundred twenty-one EECBG Activity managers completed the telephone survey. Of the 321 telephone respondents, 262 completed the web portion of the survey. The telephone and web survey data were processed, and a final respondent database was created. The contractor team then reviewed the survey database together with the activity data provided by DOE, via PAGE and the Program Officers, to determine the feasibility of calculating energy savings for each of the 262 Activities. Of the 262 Activities, 169 were deemed to be evaluable. The 169 Activities account for 41% of the EECBG Activity dollars allocated to the 262 activities for which the web survey was completed. Table 3 and Table 4show the disposition of web survey respondents.

Table 3: Number of Activities for Telephone and Web Survey Respondents

Category	Total	Percent
Completed telephone interviews	321	
Completed web surveys	262	100%
Evaluable activities	169	65%
Insufficient information to evaluate	93	35%

Table 4 shows the disposition of the final respondent sample by BPA.

Table 4: Summary of Sample Frame, Selected and Final Evaluated Sample by BPA

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

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

APPENDIX C. DETAILED SAMPLING AND WEIGHTING METHODOLOGY

C.1. OVERVIEW

The overall objective of this evaluation of the Energy Efficiency and Conservation Block Grant (EECBG) Program is to provide national estimates of key outcomes covering the entire program period, from 2009 through 2011. The key outcomes of this evaluation include estimates for:

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

More than $2.7 billion was distributed by the EECBG Program through formula grants to about 2,350 cities, counties, states, territories, and Indian tribes across a range of 14 categories or **Broad Program Areas (BPAs)**. The grants funded over 7,400 individual programs, projects, or activities (referred to herein as **activities**). Grants could be used for a range of initiatives, including energy efficiency building retrofits, financial incentives, building code support, renewable energy installations, distributed energy technologies, transportation activities, recycling and waste management efforts, and other activities approved by the U.S. Department of Energy (DOE).

Table 5 lists the distribution of grant activities across the full range of categories or BPAs for which EECBG funding was provided. The table shows the amount of funding, the number of activities, and the average funding per activity for each Broad Program Area studied. It also shows the percent of total program funding and activities occurring in each BPA. The total amount of funding associated with each BPA varied considerably from $18 million for codes and inspections to more than $1 billion dollars for energy efficiency retrofits. And the average funding per activity varied considerably from $128 thousand for activities in technical consultant services to $1.4 million dollars for activities in the financial incentive program BPA. This illustrates the wide breadth, depth and high variability among activities that received funding from the EECBG program.

Table 5: Distribution of Funding (in thousands) and Activities across 14 EECBG BPAs

Broad Program Area (BPA)	Funding[1]	Percent	Activities	Percent	Funding[1] per Activity
Energy Efficiency Retrofits	$1,077,760	39%	2,525	34%	$427
Financial Incentive Program	$497,494	18%	361	5%	$1,378
Buildings and Facilities	$270,503	10%	784	10%	$345
Lighting	$197,059	7%	637	9%	$309
On-site Renewable Technology	$165,974	6%	456	6%	$364
Energy Efficiency and Conservation Strategy	$129,413	5%	759	10%	$171
Transportation	$118,013	4%	533	7%	$221
Other	$77,236	3%	79	1%	$978
Technical Consultant Services	$66,363	2%	518	7%	$128
Residential and Commercial Buildings and Audits	$63,712	2%	443	6%	$144
Material Conservation Program	$33,130	1%	164	2%	$202
Energy Distribution	$30,245	1%	68	1%	$445
Reduction/Capture of Methane/Greenhouse Gases	$30,122	1%	42	1%	$717
Codes and Inspections	$18,180	1%	110	1%	$165
Total	**$2,775,204**	**100%**	**7,479**	**100%**	

[1]Funding in thousands.

Funding may not sum to the total displayed in this table due to rounding.

The selection of activities for this evaluation of the EECBG program proceeded in a manner that ensured statistically defensible results within the confines of a finite evaluation budget as follows:

- In order to obtain reliable results for the largest portion of the EECBG program possible given the available evaluation budget, the target population of this evaluation was limited to activities within those BPAs that, in combination, account for approximately (but no less than) 80% of total EECBG funding. A discussion of the target population is presented in **Section C.2**.

- After the target population was defined, an appropriate sample frame was constructed. In general, a sample frame is a data file or list that has one record for every member of the target population. For this evaluation, the sample frame contained one record for each EECBG activity in the target population. The frame contained numerous auxiliary variables that would be used in subsequent steps of the sample selection process. A discussion of the sample frame is presented in **Section C.3**.

- The sample frame provided the list from which a random selection of activities was drawn from for this evaluation. Some activities were selected for the evaluation with certainty, meaning they were *purposely* selected for this evaluation. However most activities were *randomly* selected with a known selection probability. Selecting activities randomly is important because it enabled the analysis team to create unbiased estimates for the target population as well as estimate the precision of the resulting estimates. The sample selection process is summarized in **Section C.4**.

- A telephone interview was attempted with an appropriate point-of-contact for each activity selected for the evaluation. At the conclusion of the telephone interview, the point-of-contact was asked to submit various pieces of information (files, results, etc.) and to complete a more detailed on-line survey to provide detailed information on the project(s) completed with the EECBG funding. These data would then enable the estimation of gross and net[2] impacts of the program by sector, fuel type and source. Sampled activities with a point-of-contact who completed the telephone interview and were able to provide the additional information needed for the evaluation comprised the final set of activity-level respondents. Results from the data collection process are summarized in **Appendix B** and **Section C.5**.

- Responding activities were assigned a sample weight, or expansion factor, that was used during the final analysis and estimation process to form appropriate estimates for the entire target population from the respondent data. A summary of the methodology used to create the sample weights is discussed in **Section C.6**.

The sample weights associated with the responding activities, along with the final results from the activity-level evaluation, were used to estimate descriptive statistics for the entire target population. Many of these descriptive statistics (and estimates of their precision) are reported directly in this report. This includes estimates of energy impacts, bill savings and cost-effectiveness. These descriptive statistics were also used as input to various other evaluations presented in this report, including the carbon impact and labor analyses.

A summary of the sample selection and data collection process is summarized in Figure 1.

[2] Net impacts refers to EECBG attributable impacts.

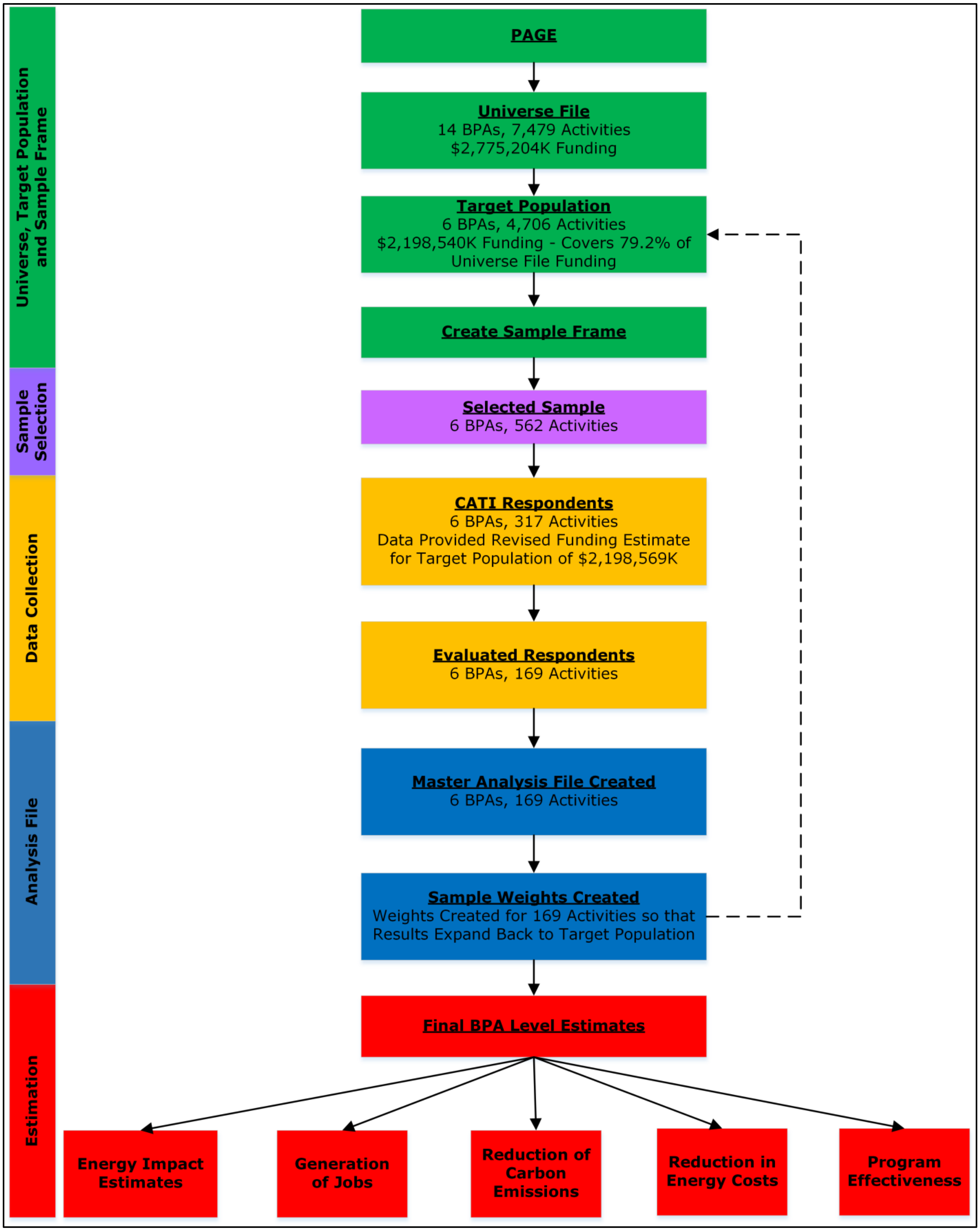

Figure 1: Summary of the EECBG Sample Selection and Data Collection Processes

C.2. TARGET POPULATION

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

As noted in **Section C.1**, in order to obtain results from this evaluation in a cost-effective manner, it was initially decided to restrict the target population of this evaluation so that it covered approximately (but no less than) 80% of the total amount of EECBG funding awarded. This was achieved by restricting the initial set of EECBG activities as follows:

- This evaluation was done on the activities associated with the six most heavily funded BPAs. These six BPAs are the first six presented in Table 5.
- Only those activities in the largest BPAs that received more than $10,000 in funding would be considered for this evaluation.
- Activities that had not started and had not spent any funding dollars at the time the sample was being drawn were excluded from the evaluation.

Activities that received funding from the EECBG program can be partitioned into the 14 Broad Program Areas (BPAs) as noted in Table 5. These same activities can also be partitioned into two **activity (or grant) types**: **direct and indirect**. Direct grants are those that were awarded directly to a recipient. Indirect grants were awarded to state/territorial agencies and were to be sub-granted to other recipients. The distinction is important because different data collection approaches were needed for the two types of grants and it was expected that energy efficiency estimates might be considerably different between the two types, depending on the BPA under consideration. Because of its importance, activity type was considered an important stratification variable in the sample selection process and the sample was therefore designed and selected to ensure an appropriate representation of both direct and indirect grants in the BPAs that comprise the target population for this study. The stratification used in the sample selection process is discussed in **Section C.4**.

One of the six largest BPAs (in terms of funding) was energy efficiency and conservation strategy. For a variety of reasons, this evaluation concluded with no completed responses associated with selected indirect grants in this BPA. Consequently, the indirect grant portion of this BPA was removed from the target population.

Table 6 presents a summary of the final target population for this evaluation. The target population covers 79% of the funding of the original EECBG population which is just under the initial target of 80%. And the target population covers 63% of the total activities. Note that the funding coverage[3] within the six BPAs is not 100% because those activities that received less than $10,000 in funding and those that did not start at the time the sample was being drawn were omitted from the target population.

[3] Funding coverage refers to total funding associated with activities in the target population divided by the total funding associated with activities in the original EECBG universe file, within some group (such as BPA.)

Table 6: Summary of EECBG Evaluation Target Population

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

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

C.3. SAMPLE FRAME

Given the target population defined in the previous section, the next step in the sample selection process was to develop an appropriate sample frame of activities. In this evaluation, the **sample frame** was simply a data file where each record in the file represents an activity in the target population. The sample frame file contained various address and contact information as well as appropriate stratification variables. **Stratification** is used in the sample selection process and is desirable because it allowed us to control the sample size for various subgroups while simultaneously providing both precision and data collection efficiency by combining similar activities into appropriate groups, or **strata**.

The process of constructing a sample frame began by constructing a universe file that accounted for all funding distributed as part of the EECBG program. The construction of the **universe file** began with the PAGE[4] management and information system. An extraction of EECBG activity-level data was taken from the PAGE system on March 30, 2012. The PAGE data provided a wealth of information needed for the construction of the sample frame, including the proposed and spent funding for each activity, the activity's BPA classification and the activities' primary process metric activity, state and grant number. After the universe file was constructed, those activities not in the target population were removed and the resulting file was the sample frame for this study. Consequently the sample frame and target population were equivalent.

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

[4]Performance and Accountability for Grants in Energy reporting database that is the primary source of descriptions of activities performed by EECBG grant recipients.

category the activity fell under. So in some instances, the primary process metric was different than the BPA assignment for an activity.

The primary process metrics were classified into one of the following categories noted in Table 7. Several categories closely match the 14 BPAs categories noted in Table 5, for example "building codes and standards" is a process metric and "codes and inspections" is a BPA category.

Table 7: Primary Process Metrics

Primary Process Metric
Building Codes and Standards
Building Energy Audits
Building Retrofits
Clean Energy Policy
Energy Efficiency Rating and Labeling
Financial Incentives and Rebates
Government, School, Institutional Procurement
Industrial Process Efficiency
Loans and Grants
Renewable Energy Market Development
Technical Assistance
Transportation
Workshops, Training, and Education
Other

The primary process metric was retained on the sample frame and used in the sample selection process. This is discussed in the next section.

During the universe file construction process, DOE provided information that enabled each activity to be classified as a "direct" or "indirect" grant. See **Section C.3** for additional discussion on the direct and indirect grants. The grant type (direct or indirect) was also retained on the sample frame for each activity.

Table 8 summarizes the sample frame by direct/indirect grant type and BPA. Notice the majority of grants are of the direct type. Direct grants account for 71% of the total funding on the frame and 97% of the activities. Also note that for direct grants, the largest BPA was energy efficiency retrofits, accounting for 38% of the total frame funding and 46% of the activities. In contrast, for indirect grants the largest BPA was financial incentive programs, accounting for 17% of the total frame funding and 1% of the activities.

Table 8: Summary of Sample Frame by Grant Type and BPA

Broad Program Area (BPA)	Funding (in thousands)		Activities	
	Total	Percent	Total	Percent
Direct Grants				
Energy Efficiency Retrofits	$844,841	38%	2,144	46%
Financial Incentive Program	$125,995	6%	268	6%
Buildings and Facilities	$197,684	9%	639	14%
Lighting	$174,801	8%	565	12%
On-site Renewable Technology	$151,255	7%	390	8%
Energy Efficiency and Conservation Strategy (Direct Grants)	$64,694	3%	560	12%
Total	$1,559,270	71%	4,566	97%
Indirect Grants				
Energy Efficiency Retrofits	$198,037	9%	43	1%
Financial Incentive Program	$365,144	17%	52	1%
Buildings and Facilities	$55,255	3%	28	1%
Lighting	$10,265	0%	7	0%
On-site Renewable Technology	$10,570	0%	10	0%
Energy Efficiency and Conservation Strategy (Direct Grants)	$0	0%	0	0%
Total	$639,271	29%	140	3%
All Grants				
Energy Efficiency Retrofits	$1,042,878	47%	2,187	46%
Financial Incentive Program	$491,138	22%	320	7%
Buildings and Facilities	$252,939	12%	667	14%
Lighting	$185,066	8%	572	12%
On-site Renewable Technology	$161,825	7%	400	8%
Energy Efficiency and Conservation Strategy (Direct Grants)	$64,694	3%	560	12%
Total	$2,198,540	100%	4,706	100%

Funding may not sum to the totals displayed in this table due to rounding.

C.4. SELECTING THE SAMPLE OF ACTIVITIES

For this study, 562 activities were selected for the evaluation: 452 direct grants and 110 indirect grants. Initially, the sample was designed to achieve 350 evaluated activities distributed across the six BPAs of interest roughly proportional to funding. This target was modified and the original sample selected for this evaluation was supplemented during data collection to account for higher than anticipated nonresponse in some BPAs and to a lesser extent, because of schedule and funding constraints. The 562 activities selected in the sample reflect the changes made during data collection and represent the final selected sample size.

Table 9 presents a summary of the selected sample by grant type (direct or indirect) and BPA. To the extent possible, the distribution of the selected sample was chosen to represent the distribution of funding across grant type and BPA. For example, 42% of the selected sample was energy efficiency retrofits (direct grants), which account for 38% of the total funding in the six BPAs.

Table 9: Summary of Selected Sample

Broad Program Area (BPA)	Frame Activities	Funding (in thousands)		Selected Sample			
		Total	Percent	Total	Percent	Certainty	NonCertainty
Direct Grants							
Energy Efficiency Retrofits	2,144	$844,841	38%	237	42%	24	213
Financial Incentive Program	268	$125,995	6%	35	6%	5	30
Buildings and Facilities	639	$197,684	9%	56	10%	9	47
Lighting	565	$174,801	8%	54	10%	3	51
On-site Renewable Technology	390	$151,255	7%	48	9%	2	46
Energy Efficiency and Conservation Strategy (Direct Grants)	560	$64,694	3%	22	4%	0	22
Total	4,566	$1,559,270	71%	452	80%	43	409
Indirect Grants							
Energy Efficiency Retrofits	43	$198,037	9%	40	7%	36	4
Financial Incentive Program	52	$365,144	17%	48	9%	43	5
Buildings and Facilities	28	$55,255	3%	14	2%	9	5
Lighting	7	$10,265	0%	4	1%	1	3
On-site Renewable Technology	10	$10,570	0%	4	1%	2	2
Energy Efficiency and Conservation Strategy (Direct Grants)	0	$0	0%	0	0%	0	0
Total	140	$639,271	29%	110	20%	91	19
All Grants							
Energy Efficiency Retrofits	2,187	$1,042,878	47%	277	49%	60	217
Financial Incentive Program	320	$491,138	22%	83	15%	48	35
Buildings and Facilities	667	$252,939	12%	70	12%	18	52
Lighting	572	$185,066	8%	58	10%	4	54
On-site Renewable Technology	400	$161,825	7%	52	9%	4	48
Energy Efficiency and Conservation Strategy (Direct Grants)	560	$64,694	3%	22	4%	0	22
Total	4,706	$2,198,540	100%	562	100%	134	428

Funding may not sum to the totals displayed in this table due to rounding.

The sample of activities for this evaluation was selected from the frame with probability proportionate to funding using a stratified, systematic sampling approach attributed to Chromy (1979)[5]. Chromy's procedure for selecting units from a frame is commonly used in studies because:

1. It is a "with-replacement" sample selection approach that is designed to minimize the number of times any unit will be selected into the sample,

2. It is a "proportionate-to-size" selection approach that's beneficial because it tends to increase the precision of final estimates for outcomes that are correlated with the size measure used,

3. It is a systematic selection approach allowing one to sort the frame prior to sample selection using variables that are highly correlated with outcome measures of interest or are reporting domains of interest, and

4. The precision of estimates can be estimated from the final sample.

Chromy's procedure was used to select activities for this evaluation within groups, or strata, defined by BPA and grant type. Sample selection was done independently between these strata so BPA and grant type are considered the **explicit stratification variables** in the design. For sample selection purposes, within each explicit stratum the frame was ordered by primary process metric and funding prior to the systematic selection. So, primary process metric can be viewed as an **implicit stratification variable** in the sample selection process. Primary process metric was discussed in **Section C.3**.

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

Table 9 also shows a summary of the certainty and noncertainty selected samples. 134 of the 562 selected activities were chosen with certainty. And most of these (91) were indirect grants.

C.5. DATA COLLECTION RESULTS

The sampled activities were contacted by telephone via a CATI interview. Data were gathered on what their EECBG funding was spent on and this was used to verify eligibility for this evaluation. An activity would be considered ineligible if, for example, they spent their funding on programs that are

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

more appropriately classified in a BPA that was not within the scope of this evaluation. The 562 activities reflect the final, *eligible* selected sample for this evaluation.

Most of the activities that completed the CATI interview were asked to answer additional questions and submit data files and various pieces of additional information via a web-based instrument. This post-CATI, web-based data collection effort was generically referred to as the **evaluation stage** of data collection in this evaluation because information obtained was used to measure the energy impact of the activities. Activities that completed the CATI interview and completed the evaluation stage represent the final set of evaluated respondents in this study.

Table 10 summarizes the selected sample, CATI respondents and evaluated respondents. The CATI portion of the data collection effort completed with a response rate of 56.4%, i.e. 56.4% of the 562 activities completed the CATI interview. The evaluation completed with a response rate of 53.3%, i.e. 53.3% of those responded to the CATI interview (317 activities) also completed the evaluation phase. And the final response rate, defined as the product of these two, was 30.1%. The final response rate for direct grants was 32.3%, which was higher than what was obtained for indirect grants (20.9%.) And the final response rate across the BPAs ranges from 41.4% for lighting to 16.9% for energy efficiency retrofits.

Reasons for nonresponse at both the CATI and evaluation phase of data collection varied. This is discussed in **Appendix B**.

Table 10: Data Collection Results

Broad Program Area (BPA)	Frame Activities	Selected Sample	CATI Respondents	CATI Response Rate	Evaluation Respondents	Evaluation Rate	Final Response Rate
Direct Grants							
Energy Efficiency Retrofits	2,144	237	139	58.6%	74	53.2%	31.2%
Financial Incentive Program	268	35	15	42.9%	7	46.7%	20.0%
Buildings and Facilities	639	56	33	58.9%	20	60.6%	35.7%
Lighting	565	54	30	55.6%	22	73.3%	40.7%
On-site Renewable Technology	390	48	25	52.1%	18	72.0%	37.5%
Energy Efficiency and Conservation Strategy (Direct Grants)	560	22	8	36.4%	5	62.5%	22.7%
Total	4,566	452	250	55.3%	146	58.4%	32.3%
Indirect Grants							
Energy Efficiency Retrofits	43	40	21	52.5%	8	38.1%	20.0%
Financial Incentive Program	52	48	34	70.8%	7	20.6%	14.6%
Buildings and Facilities	28	14	7	50.0%	5	71.4%	35.7%
Lighting	7	4	3	75.0%	2	66.7%	50.0%
On-site Renewable Technology	10	4	2	50.0%	1	50.0%	25.0%
Energy Efficiency and Conservation Strategy (Direct Grants)	0	0	0	n/a	0	n/a	n/a
Total	140	110	67	60.9%	23	34.3%	20.9%
All Grants							
Energy Efficiency Retrofits	2,187	277	160	57.8%	82	51.3%	29.6%
Financial Incentive Program	320	83	49	59.0%	14	28.6%	16.9%
Buildings and Facilities	667	70	40	57.1%	25	62.5%	35.7%
Lighting	572	58	33	56.9%	24	72.7%	41.4%
On-site Renewable Technology	400	52	27	51.9%	19	70.4%	36.5%
Energy Efficiency and Conservation Strategy (Direct Grants)	560	22	8	36.4%	5	62.5%	22.7%
Total	4,706	562	317	56.4%	169	53.3%	30.1%

C.6. SAMPLE WEIGHTING

A nonresponse adjusted and calibrated sample weight was created for each of the 169 final, evaluated activities. This sample weight was used to expand the activity-level data back to the BPA target population during the final estimation phase of this evaluation. The estimation methodology used in this evaluation is discussed in more detail in **Appendix H**.

The activity-level weights that allowed the activity-level results to expand back to the BPA target population consisted of several components. These included the inverse of the probability of selecting the activity, adjustments to account for nonresponse at the CATI and evaluation phases of data collection, and several components that were applied to calibrate the weighted funding estimates to the best estimate of total target population funding for each BPA that was available at that stage in the weighting process. The best estimates of total target population funding were either the initial frame funding or were derived using data collected during the CATI phase of data collection process. The five weighting factors that comprised the final expansion weight for each activity are as follows:

1. The inverse of the unconditional probability of selecting the activity into the sample. Activities selected with certainty received an initial weight of 1.00. Other activities received a weight equal to the inverse of their probability of being selected. The sample selection process was discussed in **Section C.4**.

2. A calibration adjustment was applied to the initial sampling weights that forced the weighted sum of funding estimated from the selected activities to equal the target population total for each BPA and grant type (direct and indirect grants). At this point in the weight adjustment process, the best estimate of total funding for each BPA and grant type was the data represented in the sample frame from the PAGE system.

3. The sample of activities was sent to CATI data collection. Nonresponse was encountered at this phase of the process, and a suitable adjustment to the sample weights was applied to correct for this.

4. During the CATI data collection, data were collected on the BPA classification and EECBG funding received for each activity that responded to the CATI survey. These data were used to reclassify and correct the funding on a small number of CATI responding activities. At this stage in the sample weight development process an adjustment to the sample weights was not being made. This was considered a separate “adjustment” in the weighting process only to delineate the notion that some activities have moved to different BPAs and revised estimates of total funding by BPA and type are available.

5. The last adjustment to the sample weight was a nonresponse adjustment. 317 activities responded to the CATI interview and are the set of activities with a nonzero weight after applying adjustment #3 and #4. 169 activities responded to the evaluation phase of data collection. This adjustment accounts for the 317-169 = 148 nonrespondents.

At the conclusion of this weighting process, a nonzero sample weight was available for each of the 169 final responding activities in this evaluation.

Table 11 shows the estimated funding and number of activities at various points in the weighting process. A few things to note:

- Funding estimates using the selected sample (column B in Table 11) equal the frame total (column A in Table 11) by BPA and grant type due to the calibration adjustment #2 that was applied to each weight.

- Funding estimates using the new BPA and new funding data collected during CATI (column D in Table 11) are fairly close to the frame and selected sample estimates (column B in Table 11) indicating the frame data were fairly accurate. The largest differences occurred with the financial incentive program (direct grants) and building and facilities (direct grant) where absolute differences in the original frame estimate of funding and the CATI revised estimate of funding was just over $40 million.

- Weighted funding estimates for the final evaluated sample (column E in Table 11) equal the weighted CATI data (column D in Table 11) using the new BPA and new funding data, by design. This column reflects the final estimates generated from this evaluation.

Table 11: Evolution of Sample during Weighting Process

Broad Program Area (BPA)	A. Frame		B. Selected Sample		C. CATI Respondents (Using Frame BPA and Funding Data)		D. CATI Respondents (Using New BPA and Funding Data)		E. Evaluated (Final Respondents and Final Weight)	
	Funding	Activities	Funding Estimated Using Weight Factors 1-2	Activities	Funding Estimated Using Weight Factors 1-3	Activities	Funding Estimated Using Weight Factors 1-4	Activities	Funding Estimated Using Weight Factors 1-5	Activities
Direct Grants										
Energy Efficiency Retrofits	$844,841	2,144	$844,841	237	$844,841	139	$885,267	146	$885,267	77
Financial Incentive Program	$125,995	268	$125,995	35	$125,995	15	$126,263	16	$126,263	8
Buildings and Facilities	$197,684	639	$197,684	56	$197,684	33	$155,909	22	$155,909	13
Lighting	$174,801	565	$174,801	54	$174,801	30	$183,021	33	$183,021	25
On-site Renewable Technology	$151,255	390	$151,255	48	$151,255	25	$147,231	25	$147,231	18
Energy Efficiency and Conservation Strategy (Direct Grants)	$64,694	560	$64,694	22	$64,694	8	$65,728	8	$65,728	5
Total	$1,559,270	4,566	$1,559,270	452	$1,559,270	250	$1,563,419	250	$1,563,419	146
Indirect Grants										
Energy Efficiency Retrofits	$198,037	43	$198,037	40	$198,037	21	$184,804	21	$184,804	9
Financial Incentive Program	$365,144	52	$365,144	48	$365,144	34	$374,567	34	$374,567	6
Buildings and Facilities	$55,255	28	$55,255	14	$55,255	7	$54,944	7	$54,944	5
Lighting	$10,265	7	$10,265	4	$10,265	3	$10,265	3	$10,265	2
On-site Renewable Technology	$10,570	10	$10,570	4	$10,570	2	$10,570	2	$10,570	1
Energy Efficiency and Conservation Strategy (Direct Grants)	$0	0	$0	0	$0	0	$0	0	$0	0
Total	$639,271	140	$639,271	110	$639,271	67	$635,150	67	$635,150	23

Broad Program Area (BPA)	A. Frame		B. Selected Sample		C. CATI Respondents (Using Frame BPA and Funding Data)		D. CATI Respondents (Using New BPA and Funding Data)		E. Evaluated (Final Respondents and Final Weight)	
	Funding	Activities	Funding Estimated Using Weight Factors 1-2	Activities	Funding Estimated Using Weight Factors 1-3	Activities	Funding Estimated Using Weight Factors 1-4	Activities	Funding Estimated Using Weight Factors 1-5	Activities
All Grants										
Energy Efficiency Retrofits	$1,042,878	2,187	$1,042,878	277	$1,042,878	160	$1,070,071	167	$1,070,071	86
Financial Incentive Program	$491,138	320	$491,138	83	$491,138	49	$500,830	50	$500,830	14
Buildings and Facilities	$252,939	667	$252,939	70	$252,939	40	$210,853	29	$210,853	18
Lighting	$185,066	572	$185,066	58	$185,066	33	$193,286	36	$193,286	27
On-site Renewable Technology	$161,825	400	$161,825	52	$161,825	27	$157,801	27	$157,801	19
Energy Efficiency and Conservation Strategy (Direct Grants)	$64,694	560	$64,694	22	$64,694	8	$65,728	8	$65,728	5
Total	$2,198,540	4,706	$2,198,540	562	$2,198,540	317	$2,198,569	317	$2,198,569	169

All funding data in thousands.
Funding may not sum to the totals displayed in this table due to rounding.

Table 12 shows the movement of the CATI respondents from their original BPA classification (column C in Table 11) to the new BPA classification that was collected to during the CATI interview. Table 12 also shows the weighted amount of original frame funding affiliated with those activities that change BPAs. Note that original frame funding is used in Table 12 so funding totals will not logically agree with the funding displayed in column E in Table 11.

Results from this evaluation suggest the biggest movement of funding, considering the percent of the original frame funding, occurred in the building and facilities BPA. Estimates from the CATI data indicated 19.2% of the funding in this BPA should have been classified in the energy efficiency retrofit BPA. Results also suggested 14.6% of the energy efficiency retrofit funding moved to the financial incentive programs for indirect grants. In all other cases, 95% or more the original funding remained in the original BPA classification after the CATI results were applied.

Table 12: Summary of Re-Assigned BPA Classifications Using CATI Data

Frame Broad Program Area (BPA)	Revised BPA Using CATI Data	Activities	Original Frame Funding (in thousands)	Percent
Direct Grants				
Energy Efficiency and Conservation Strategy (Direct Grants)	Energy Efficiency and Conservation Strategy (Direct Grants)	7	$63,911	98.8%
	Energy Efficiency Retrofits	1	$784	1.2%
Financial Incentive Program	Financial Incentive Program	15	$125,995	100.0%
Energy Efficiency Retrofits	Energy Efficiency Retrofits	136	$828,210	98.0%
	Buildings and Facilities	1	$11,533	1.4%
	Lighting	2	$5,097	0.6%
Buildings and Facilities	Buildings and Facilities	21	$144,274	73.0%
	Energy Efficiency Retrofits	9	$48,633	24.6%
	Energy Efficiency and Conservation Strategy (Direct Grants)	1	$1,888	1.0%
	Financial Incentive Program	1	$1,541	0.8%
	Lighting	1	$1,349	0.7%
Lighting	Lighting	30	$174,801	100.0%
On-site Renewable Technology	On-site Renewable Technology	25	$151,255	100.0%
Indirect Grants				
Financial Incentive Program	Financial Incentive Program	32	$347,487	95.2%
	Energy Efficiency Retrofits	2	$17,657	4.8%
Energy Efficiency Retrofits	Energy Efficiency Retrofits	19	$169,102	85.4%
	Financial Incentive Program	2	$28,935	14.6%
Buildings and Facilities	Buildings and Facilities	7	$55,255	100.0%
Lighting	Lighting	3	$10,265	100.0%
On-site Renewable Technology	On-site Renewable Technology	2	$10,570	100.0%
Total				
Energy Efficiency and Conservation Strategy (Direct Grants)	Energy Efficiency and Conservation Strategy (Direct Grants)	7	$63,911	98.8%
	Energy Efficiency Retrofits	1	$784	1.2%
Financial Incentive Program	Financial Incentive Program	47	$473,482	96.4%
	Energy Efficiency Retrofits	2	$17,657	3.6%
Energy Efficiency Retrofits	Energy Efficiency Retrofits	155	$997,313	95.6%
	Financial Incentive Program	2	$28,935	2.8%
	Buildings and Facilities	1	$11,533	1.1%
	Lighting	2	$5,097	0.5%
Buildings and Facilities	Buildings and Facilities	28	$199,528	78.9%
	Energy Efficiency Retrofits	9	$48,633	19.2%
	Energy Efficiency and Conservation Strategy (Direct Grants)	1	$1,888	0.7%
	Financial Incentive Program	1	$1,541	0.6%
	Lighting	1	$1,349	0.5%
Lighting	Lighting	33	$185,066	100.0%
On-site Renewable Technology	On-site Renewable Technology	27	$161,825	100.0%
Total		$317	$2,198,540	

Funding may not sum to the totals displayed in this table due to rounding.

APPENDIX D. FINAL EVALUABILITY ASSESSMENT METHODOLOGY

D.1. OVERVIEW

After the primary and secondary samples for the EECBG study were selected (see Appendix C for the discussion of sampling methodology), information collected by the Department of Energy (DOE) for each activity was reviewed to determine the likelihood of obtaining sufficient information to evaluate the activity. Activities that were deemed evaluable were then moved to the next data collection phase where telephone interviews and web surveys[6] with the activities' EECBG Grant Administrators were conducted.

The evaluability analysis focused on documentation from the following sources:

- Output from the PAGE[7] information system Activity-Level reports
- Output from the PAGE information system Quarterly Milestone reports
- Documents and spreadsheets provided by the DOE program administrators (PAs)

The contractor team defined protocols whereby the engineering teams determined which activities included or were likely to include enough information for conducting the evaluation. Because documentation for direct and indirect grant activities differed in the type of information collected by DOE, different evaluability protocols were used for each type. The evaluability criteria included:

- Direct grant activities: the documentation must contain sufficient information to identify the types of measures installed. This information was then used to identify the relevant sections of the telephone and web surveys that would be used to collect measure specific information.
- Indirect (state) grant activities: the documentation must contain tracking data that identified information about the type of projects undertaken in the activity.

D.2. DOCUMENTATION REVIEW PROTOCOLS AND DISPOSITION CODES– DIRECT GRANTS

The engineering teams used the following protocols for reviewing the documentation for the direct grant activities in the sample.

- Output from the PAGE information system Activity-Level :
  - On the *Activities* tab, the data were filtered by Grant Number and Activity Worksheet Unique ID and the following fields were reviewed:
    - Project Title – Description of the type of project
    - Activity – Identify the types of measures installed and then grouped by type such as nonresidential interior lighting, street lighting, residential gas heating, etc.
    - Metric Activity – Review to determine if any additional information was provided that was useful to determine the energy savings for this activity, such as equipment size, quantity, type, configuration, building type, etc.

[6] Both the telephone and web surveys were administered as Computer Aided Telephone/Web Surveys (CATI).

[7] PAGE is the primary information system that DOE used to store program information and generate reports.

        - Project Summary - measure-specific detail data were identified. Data included information such as measure type, size, quantity, efficiency, fuel, energy savings, or any other information that describes what the project included).
- Output from the PAGE information system Quarterly Milestone reports:
    - On the *Milestones* tab, the data were filtered by the Grant Number and Activity Worksheet Unique ID and the following fields were reviewed:
        - Activity
        - Milestone Description – Identify fields which identify measure-specific detail as described above
- Documents and spreadsheets provided by the DOE PAs
    - Review of all PA documents which were relevant to the selected activity.
    - Identify all information which identifies measure-specific detail for the selected activity.

Based upon the findings from the documentation review, the engineering teams assigned each selected activity a disposition code (**Table 13**). Activities receiving a code of A or B were deemed evaluable and remained in the sample.

Table 13 : Direct Grant Disposition Codes

Determination	Recommended Action	Disposition Code
All projects have sufficient information to determine which CATI sections to apply.	Evaluate using the appropriate survey sections. Ask about other project types and be ready to change sections if the information is wrong.	A
More than half of projects (based on estimated savings or dollars spent) have sufficient information to determine which CATI sections to apply.	Evaluate using the appropriate survey sections. Ask about other project types and be ready to change sections if the information is wrong.	B
Less than half of projects (based on estimated savings or dollars spent) have sufficient information to determine which CATI sections to apply	Remove from sample.	C
None of the projects have sufficient information to determine which CATI sections to apply	Remove from sample.	D

D.3. DOCUMENTATION REVIEW PROTOCOLS AND DISPOSITION CODES– INDIRECT GRANTS

Since the indirect grants were comprised of large state-wide programs, the PAGE data contained limited detailed measure data. The initial documentation review focused on the information provided by the DOE PAs. The engineering teams used the following protocols to review the documentation for the indirect grant activities:

- Documents and spreadsheets provided by the DOE program administrators (PAs)
    - Project Type: Project Title – Description of the type of project
    - Identify Sub-grant Recipients and Project Types – Identify the types of measures installed. Measure types were reviewed and grouped by type such as nonresidential interior lighting, street lighting, residential gas heating, etc.

- Measure-Specific Information: Enter any additional information that may be useful to determine the energy savings for this activity, such as equipment size, quantity, type, configuration, building type, etc.

Based upon the findings from the documentation review, the engineering teams assigned each selected activity a disposition code (Table 14). Activities receiving a code of E, F or G were deemed evaluable and remained in the sample. Activities receiving a disposition code of H were then further reviewed to determine what information was available and if it was sufficient to calculate energy savings.

Table 14: Indirect Grant Disposition Codes

Determination	Recommended Action	Disposition Code
This activity has a list of project types and sub-grant recipients.	Evaluate using the appropriate survey sections. Ask about other project types and be ready to change sections if the information is wrong.	E
This activity has a list project types but not sub-grant recipients.	Evaluate using the appropriate survey sections. Ask about other project types and be ready to change sections if the information is wrong.	F
This activity has a list sub-grant recipients but not project types.	Evaluate using the appropriate survey sections. Ask about other project types and be ready to change sections if the information is wrong.	G
This activity does not have either a list of project types or sub-grant recipients.	Will decide how to handle these once all projects in the activity are reviewed.	H

Some of the indirect grants were comprised of large state-wide programs. For these indirect grants the PAGE data and the documentation from the DOE PAs contained limited detailed measure data and the evaluation team could not determine if the indirect grant activities were evaluable. These indirect grants were kept in the sample and the screening questions in the CATI telephone survey were used to identify the type of projects and measures installed under the indirect grant and determine the disposition codes.

APPENDIX E. BPA ACTIVITY AND FUNDING DATA

Table 15 shows the number of responding EECBG activities to this evaluation by BPA and grant type. The number of evaluated activities ranged across the BPAs from 5 (energy efficiency and conservation strategy) to 86 (energy efficiency retrofits). And most of the evaluated activities were direct grants (86%).

Table 16 shows the distribution of funding in the target population by BPA and grant type. The BPA that received the least amount of funding among the six was energy efficiency and conservation strategy ($69,759) and the BPA that received the largest amount of funding among the six was energy efficiency retrofits ($1,100,227k). Additionally, the direct activities received 76% of the funding over all six BPAs.

So in summary, the respondent distribution matched the distribution of population funding fairly closely. In large part, this is by design because the sample of activities selected for this evaluation was allocated to the BPAs and grant types proportional to funding. This is discussed in greater detail in Appendix C.

Table 15: Distribution of evaluated activities by BPA and grant type

BPA	Grant Type	Total	Percent within BPA
Total of Six Evaluated BPAs	Direct	146	86%
	Indirect	23	14%
	Total	169	100%
Energy Efficiency and Conservation Strategy (Direct Grants)	Direct	5	100%
	Total	5	100%
Financial Incentive Program	Direct	8	57%
	Indirect	6	43%
	Total	14	100%
Energy Efficiency Retrofits	Direct	77	90%
	Indirect	9	10%
	Total	86	100%
Buildings and Facilities	Direct	13	72%
	Indirect	5	28%
	Total	18	100%
Lighting	Direct	25	93%
	Indirect	2	7%
	Total	27	100%
On-site Renewable Technology	Direct	18	95%
	Indirect	1	5%
	Total	19	100%

Table 16: Distribution of EECBG funding by BPA and grant type

BPA	Grant Type	Funding (in $1,000's)	Percent within BPA
Total of Six Evaluated BPAs	Direct	$2,045,112	76%
	Indirect	$649,022	24%
	Total	$2,694,134	100%
Energy Efficiency and Conservation Strategy (Direct Grants)	Direct	$69,759	100%
	Total	$69,759	100%
Financial Incentive Program	Direct	$171,498	31%
	Indirect	$380,442	69%
	Total	$551,940	100%
Energy Efficiency Retrofits	Direct	$906,679	82%
	Indirect	$193,548	18%
	Total	$1,100,227	100%
Buildings and Facilities	Direct	$563,050	91%
	Indirect	$54,166	9%
	Total	$617,215	100%
Lighting	Direct	$186,359	95%
	Indirect	$10,288	5%
	Total	$196,648	100%
On-site Renewable Technology	Direct	$147,767	93%
	Indirect	$10,578	7%
	Total	$158,345	100%

APPENDIX F. DETAILED ACTIVITY-LEVEL ENERGY IMPACT ESTIMATION METHODOLOGY

F.1. OVERVIEW

This appendix details the methods used to estimate overall energy savings and renewable generation impacts for each of the activities within the EECBG evaluation. The overall energy impacts referred to in this section correspond with "gross savings," a term is commonly used in evaluation of utility energy efficiency programs that refers to the total savings achieved by program activities, not just that portion attributable to EECBG.

Table 2-1 in Volume I shows the major data collection and impact estimation methods used for the various broad program areas (BPAs) studied. Each of the impact calculation methods is explained in detail in Sections F.3 through F.6 of this appendix. Section F.4 details the standard calculation tool (SCT) used to calculate energy savings impacts from energy efficient equipment in all BPAs except On-site Renewable Technology. Section F.3 describes the secondary source research used for Energy Efficiency and Conservation Strategy. Section F.5 describes the standard renewable protocol used for calculating energy savings and generation from renewable energy technologies. Finally, Section F.6 outlines the method used to calculate revolving loan impacts, which occurred for activities across several of the applicable BPAs.

F.2. ACTIVITIES WITH INSUFFICIENT DOCUMENTATION

In some cases, the contractor team was unable to determine the energy savings resulting from a sampled EECBG activity because sufficient documentation of the measure and scope could not be obtained. Although the SCT (described below) was built to address some data gaps, there were four main conditions for dropping a sampled activity from the study:

- Insufficient contact information: In these cases, the primary contact was no longer with the grant recipient's organization and the remaining staff was unable to complete the survey.
- Survey non-completes: The contractor team did not conduct the participant survey because the contact did not respond to the telephone survey request.
- Partial survey completes: The participant survey was conducted in two steps; first by telephone to verify the contact information and the size of the grant, and then online to elicit more information about the actual measures installed. Some respondents participated in the telephone survey but not the online portion. In such cases, the contractor team reviewed the documentation and, where possible, determined the energy savings for those activities. If it was not possible to do that based on the information available, then the activity was dropped from the study.
- Insufficient online survey information: In many cases, the information provided during the online survey was insufficient to determine energy savings. In these cases, engineers from the contactor team attempted to conduct follow-up phone interviews with the respondent and other members of the grant recipient's organization to get more data. If the respondent could not be reached, or, once reached, could not provide the data needed, the activity was dropped from the study.

F.3. SECONDARY SOURCE RESEARCH

Secondary source research was used for measures in the Energy Efficiency and Conservation Strategy BPA. This BPA was distinct from the others offered in the EECBG program in that potential grantees/sub-grantees were required to develop an Energy Efficiency and Conservation Strategy plan for their state, territory, municipality, or tribe. The objective of the plan was to ensure that recipients developed a forward-looking framework to identify and capture energy saving opportunities and associated benefits, such as job growth and environmental benefits. Some strategies developed in this BPA do not necessarily translate to direct energy savings. In many cases, funds were used for activities such as building operator training or elementary school education modules. To estimate savings for these measures, the contract team researched similar programs that had been implemented and evaluated previously. Verified savings from the researched studies on a per-unit basis (such as per student or per training) were identified and applied to the EECBG activity to estimate overall savings.

F.4. THE STANDARD CALCULATION TOOL'S ENERGY SAVINGS IMPACT METHODS

The SCT was developed to support the SEP and EECBG evaluations. Section F.4.1 describes the general functionality of the SCT. Section F.4.2 describes the selection of calculation algorithms from publicly available sources. Section F.4.3 presents the methodology for defining the appropriate baseline for each technology. Finally, Section F.4.4 describes the application of state and national codes and the associated general assumptions made in the development of the tool.

F.4.1. Description of the SCT

The SCT was developed to ensure consistency of calculation methods across multiple activities through transparent procedures, replicable results, and an auditable trail for quality control. The tool is a collection of engineering-based methods that allows the user to estimate energy savings for 21 residential and 17 nonresidential energy efficient measures.

The contractor team assembled the best available information on the measures into a software application that prompts the user for the inputs necessary to perform the relevant calculations. Energy savings can be estimated for measures located anywhere in the country using input data that can vary greatly in terms of content and quality. For example, in the absence of detailed equipment quantity, sizing, or efficiency information, the tool can estimate savings for many measures based only on the square footage of the space affected. The SCT makes the best use of available measure-specific data while making the most reasonable use of assumptions given the nature of the local program, measures, and operating environment.

Each of the 38 measures included in the SCT had individual specifications; however, they all follow consistent general principles, which include:

- **Algorithms and assumptions based on industry standards.** Existing technical resource manuals (TRMs) served as the source of the calculation algorithms and some default assumptions for the SCT.
- **Life-cycle savings estimate.** The contractor team calculated life-cycle energy savings or the energy savings over the life of the installed measure.
- **Dual baseline.** A dual baseline allowed the team to estimate savings for accelerated measures, or measures that were installed earlier than they would have been without the program. A dual baseline calculation uses the efficiency of the existing (replaced) equipment as the baseline during the acceleration period and standard efficiency as the baseline during the remainder of the installed equipment life.
- **Retrofit and new construction measures.** The developed algorithms were capable of addressing both retrofit and new construction measures.

- **Local and regional characteristics.** Where practical, the effects of local and regional differences were included in the calculation. The major differences included:
  - **Weather**. Population-weighted, normalized weather data allowed production of state-level estimates for heating degree-days, cooling degree-days, and average outdoor temperature.
  - **Energy Intensity.** The SCT uses energy intensity information to estimate energy savings if the equipment capacity was missing. This information was determined for each census region using the EIA Commercial Building Energy Consumption Survey data.
- **Model energy codes.** State energy codes served as the baseline in some situations, adjusted to consider noncompliance and, for accelerated and add-on measures, equipment degradation. The actual values came from the model energy code on which the state code is based.

Table 17 shows the measures programmed in the SCT by sector. Most of the measures reference a standard, one-for-one equipment replacement. The SCT is not equipped to handle most fuel switching calculations.

When energy efficiency measures installed through EECBG could not be calculated with one of the SCT measures, custom calculation methods were developed and independently documented. Custom calculation documentation included the input values, algorithms, assumptions, and clear justification for the recommended approach.

Table 17: Measures in the SCT

Residential		Nonresidential	
Boiler	Furnace	Boiler	Lighting
Lighting	Refrigerators	Chillers	Heat Pumps
Dishwashers	Clothes Washers	Doors	Windows
Doors	Windows	Air Sealing	Insulation
Air Sealing	Insulation	Cool Roof	Furnace
Cool Roof	Central AC	Programmable Thermostat	Packaged and Split AC
Heat Pumps	Programmable Thermostat	HVAC Controls	Water Heater
Room/Window AC	Water Heater	Variable Frequency Drives	Motors
Low-Flow Showerhead	Low Flow Aerator	Package Terminal Air Conditioner (PTAC) and Package Terminal Heat Pump (PTHP)	
Turn-Down Water Heater Temperature	Pipe Insulation		

F.4.2. SCT Calculation Algorithm Selection

We reviewed 22 national, regional, and state-level technical reference manuals (TRMs) to identify the best ones as judged on transparency and national applicability of source information, nationally relevant or modifiable algorithms, and range of measures per sector. Based on these selection criteria, nine TRMs were designated as preferred sources, including: ENERGY STAR, Regional Technical Forum (RTF) in the Pacific Northwest, Mid-Atlantic, Pennsylvania, Ohio, Wisconsin (nonresidential), New York, TVA, and Texas (residential).

One nonresidential and eight residential calculations were built using nationally applicable ENERGY STAR calculators. The New York TRM contributed to four measures, Pennsylvania to three measures, Wisconsin to three measures, Ohio to three measures, Mid-Atlantic to two measures, and TVA to one measure. We did not rely on RTF or Texas for any measure calculations. The residential air sealing calculation utilized an existing Lawrence Berkeley National Laboratory (LBNL) tool, while the cool roof calculations utilized an existing ORNL tool.

In addition to the preferred TRMs, the SCT also uses the Indiana TRM for two measures, Arkansas for one measure, Illinois for one measure, and Vermont for most space heating and cooling measures. Alternative TRMs were used when the preferred TRMs did not contain a calculation for the measures addressed, such as low-flow showerheads or faucet aerators. Vermont was used as an alternative calculation for building load (using square footage) when the equipment capacity was not available. Finally, the contractor team used an original calculation to estimate savings for window replacements, HVAC controls, and nonresidential air sealing, as none of the reviewed TRMs had a standard calculation for this measure.

F.4.3. Determining the Appropriate Baseline

The baselines used in the SCT correspond to the baselines referenced in the survey instrument in order to produce appropriate impact results. The baselines depend on measure category and timing effect.

The measure categories are:

- **Add-on measures:** Equipment or practices that can be combined with existing equipment or structures. Examples include variable speed drives (VSDs) and controls. These measures do not have a range of efficiency levels, but represent efficiency improvements by themselves. The savings from add-on measures are the difference in usage for the site with and without the measure in place. If the add-on measure is added without changing other equipment, the baseline condition is the prior equipment without the add-on measure. If the add-on measure is added in conjunction with replacement equipment, the baseline condition for the add-on measure is the new equipment without the add-on measure.
- **Incremental efficiency measures:** These are higher-efficiency versions of equipment that could be installed at a lower-efficiency level. The savings from incremental efficiency measures are the difference in usage for the site with the (high-efficiency) equipment installed under the program compared with the lower-efficiency equipment that would otherwise be in place.

The timing effects are:

- **Natural replacement:** This references replacement of equipment at the same time as it would have been replaced absent the program. For natural replacement, the baseline is the usage with standard efficiency new equipment in place.
- **New construction:** This references the installation of new equipment or structure for a new building or a new addition to an existing building. The baseline condition is the facility with standard equipment or construction.
- **Accelerated replacement:** This references replacement of existing equipment with new equipment, sooner than the equipment replacement would have occurred absent the program. For accelerated replacement, the baseline condition is the old equipment for the acceleration period, and standard efficiency new equipment from the end of the acceleration period to the end of the measure life, shown in Figure 2. If the old equipment would have stayed in place indefinitely, the acceleration period is the full measure life, and the baseline is the old equipment for the full measure life.

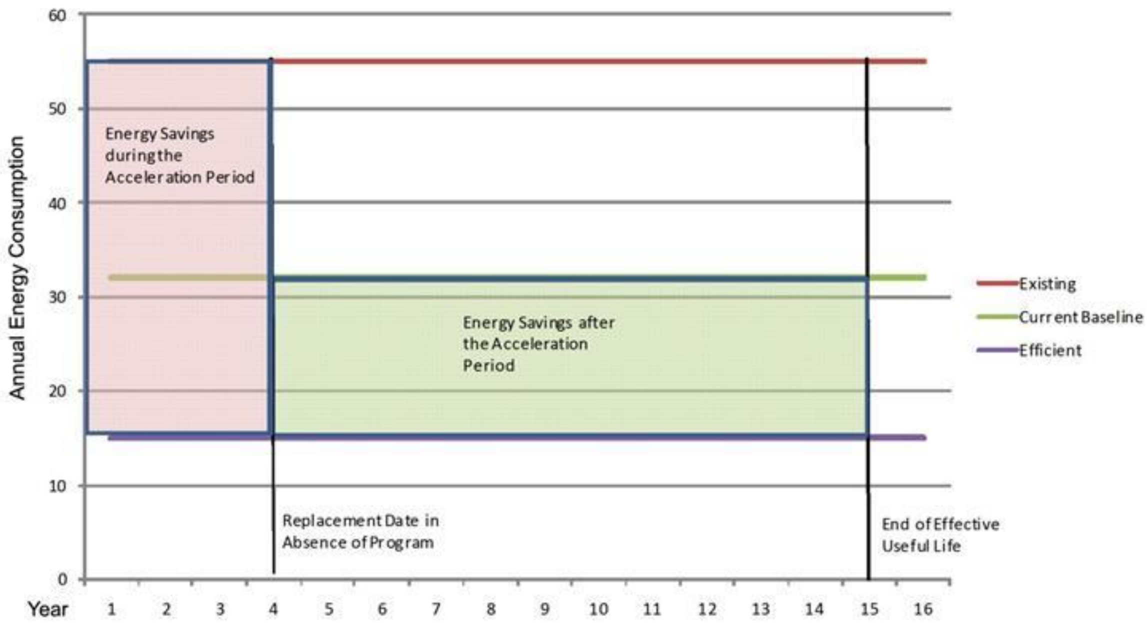

Figure 2: Representation of energy savings from retrofit

Table 18 shows the baseline definitions by measure category and timing effect.

Table 18: Baseline definitions by measure category and timing effect

Timing Effect		Incremental Efficiency Measures*	Add-on Measures*
Natural Replacement		Federal standards Standard alternative	Federal standards, D% Standard alternative State energy code, DR%, D%
New Construction		State energy code, DR%	State energy code, DR%
Accelerated Replacement	Acceleration Period	Federal standards, D% Standard alternative State energy code, DR%, D%	Federal standards, D% Standard alternative State energy code, DR%, D%
	Remainder of effective useful lifetime (EUL)	Federal standards Standard alternative	Federal standards, D% Standard alternative State energy code, DR%, D%

*D% refers to degradation adjustment; DR% refers to adjustment factor related to compliance

To apply the above definitions, we needed a basis for specifying standard and existing equipment. In most cases, we did not have an opportunity to observe actual equipment prior to measure installation, and we did not have local information on standard practice for new equipment. We used the following to specify standard and prior equipment baselines.

The timing effect was based on responses to the surveys. The participant questionnaires asked if the measure would have been installed earlier, later, or at the same time absent the program, and if later how much later. We used the following classification based on the timing response:

- Would otherwise have been installed at the same time or earlier: Natural replacement.
- Would otherwise have been installed four or more years later: Early replacement.
- Would otherwise have been installed x months later, up to 47 months: Accelerated replacement with x/12 years of acceleration.
- Don't know: Early replacement.

Section F.4.4 discusses federal standards and state energy codes, including the degradation adjustment and adjustment factor related to compliance.

"Standard alternative" refers to standard baseline assumptions used by energy efficiency professionals for measures that do not have an efficiency standard, or may not have been covered by the state energy code. Examples include most lighting and water reduction measures. These assumptions represent the typical non-energy efficient equipment replaced by the qualifying equipment, or the typical non-energy-efficient equipment improved by the add-on measure. Examples include 400 W metal-halide bulbs as the baseline for 6-lamp T8 high-bay fixtures or incandescent bulbs as the baseline for residential CFLs. We used common industry practice and guidance from the source TRMs to determine the standard practice.

F.4.4. SCT Application of Standards and Codes

"State energy code" refers to the primary energy code in effect at the time and in the state in which a particular structure was built. State energy codes have currently been adopted in all states and territories but 10. "Federal standards" refers to equipment efficiency standards mandated by the federal government. Such standards have been created for many types of equipment, including furnaces, air conditioners, household appliances, and electronics, and can change over time. Standards are created through legislation or DOE rulemakings, and require all affected appliances manufactured after a certain date to conform to the standard.

Federal standards and model energy codes served as the input for baseline information in the following ways. In all cases, it was assumed that these definitions of standard efficiency would correspond to what our survey respondents were likely to have in mind when they answered attribution sequences.

- **Standard efficiency for current new construction measures.** For new construction measures, the baseline efficiency was equal to the energy code requirement in the state in which the building was built. An adjustment factor was applied to help address noncompliance based on publicly available studies and professional judgment. We feel that this definition of standard efficiency corresponded to what our survey respondents were likely to have in mind when they answered attribution sequences.
- **Standard efficiency for natural and accelerated replacement.** For natural and accelerated (remainder of EUL) replacement measures, the baseline efficiency was equal to the federal standard for the minimum required equipment efficiency the year before the project was installed. More discussion on the lag year is found in the following paragraphs.
- **Federal standards:** Actual/prior efficiency for accelerated replacement and add-on measures. For accelerated replacement (acceleration period) and add-on measures where federal standards were applicable, the baseline efficiency was equal to the minimum required equipment efficiency the year

before the actual/prior piece of equipment was purchased.8 An adjustment of 10% reduction in efficiency over the life of the equipment was applied to HVAC equipment to account for efficiency degradation, based on professional judgment. If the respondent could not provide an accurate estimate of the actual/prior equipment age, we assumed the maximum EUL for that piece of equipment.

- **Energy code:** Actual/prior efficiency for accelerated replacement and add-on measures. For accelerated replacement and add-on measures, where federal standards were not applicable, the baseline efficiency was equal to the energy code requirement in effect in the state at the time the retrofit structure was built, adjusted to consider noncompliance and efficiency degradation based on age. If the actual age of the building was not known, we assumed the maximum EUL for that piece of equipment and used the code value in effect at that time with the adjustment and degradation assumption.

The federal standard was applied one year after it was adopted. This simplification allowed us to address two issues across all measures:

- **Effective standard date.** Federal standards do not always begin on January 1 of the year in which they go into effect. We assigned a single federal standard to the entire year based on the standard that was in effect for the majority of that year. We did not use standard-specific change dates.
- **Adoption lag from storage.** Federal standards address the efficiency of the equipment manufactured, not the equipment sold. There is a lag in actual market adoption of the new equipment standard as the stored, less efficient equipment is sold in the market. The actual lag time likely differs by region and type of equipment, but there was no systematic way to determine what it should have been for each technology. To account for the storage lag, we applied a one-year lag period, based on professional judgment, before applying the change in standard.

For state energy codes, the contractor team used the values from the model energy code on which the state code was based. We made the following assumptions for simplification purposes:

- The appropriate model energy code was applied at the state level, using information from the DOE Building Energy Codes Program. State-level assignments were important because the energy programs were designed to provide incremental efficiency above state codes, not a national average.
- We used the model energy code as written, without applicable state-specific amendments.
- We assigned a single model energy code to the entire year, based on the code that was in effect for the majority of that year. We did not use state-specific change dates.
- We assumed a lag in code adoption to account for the time it takes to complete the construction of a building. The lag was one year for residential buildings and two years for nonresidential buildings. Our assumptions were based on professional judgment because there was no systematic way to determine what the lag should be for each technology.
- Adjusted baselines were developed as follows:

[8] For add-on measures (measures that consist of equipment or practices that can be combined with existing equipment or structures and represent efficiency improvements by themselves, such as VSDs or controls), the baseline was the prior equipment without the add-on measure.

- We developed an adjustment factor that helps to address the percentage of buildings that are noncompliant based on publicly available studies.[9] The adjustment factors are 16% for commercial buildings and 33% for residential buildings.
- We weight (multiply) the efficiency level from the previous applicable code by the adjustment factor. We weight (multiply) the efficiency level from the current applicable code by the complement of the adjustment factor.
- We calculated a weighted average efficiency level (sum of the two products from the previous bullet) based on the two efficiency levels (current and previous code) and the adjustment factor.

- Where other information was not available, the baseline used for commercial buildings was ASHRAE 90.1-1989; for residential buildings it was Model Energy Code 1993 because our research showed that these were the first widely adopted model energy codes.

F.5. RENEWABLE GENERATION IMPACT METHODS

Standard calculation methods were used for estimating all electrical or thermal energy generation and/or savings associated with renewable energy systems installed through EECBG.

Thermal energy savings were calculated for solar water-heating systems used for space heating and hot water production. Electrical energy generation was calculated for photovoltaic and wind systems that displace fossil fuel used in the generation of electricity. Findings regarding displaced fuels and grid electricity were also used in the carbon model described in Appendix J.

Calculation methods are provided below for photovoltaic systems (F.5.1), solar water heating (F.5.2), and wind systems (F.5.3). Each section includes a description of the chosen calculation algorithm or tool and describes input parameters and assumptions.

F.5.1. Photovoltaic (Solar Electric) Energy Impacts

Estimates of solar energy (kWh) generated by photovoltaic (PV) systems were performed using PVWatts, an online software package provided by the National Renewable Energy Laboratory (NREL).[10] This tool was chosen based on the public availability of both the tool and of supporting solar resource data provided by DOE.

Calculation documentation for PV systems includes, but is not limited to, the information listed in Table 19. These data points are required entries in the model and appear in the PVWatts output.

[9] The limited number of noncompliance studies, variations in methodology, and wide range of results prevents us from determining a more robust noncompliance adjustment factor.

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

Table 19: Solar photovoltaic calculation default assumptions

Calculation parameter	Default assumption, if missing
Displaced energy source	Regional grid electricity mix
New Equipment Installation Year ($Y_{install}$)	Program year
System Lifetime	Manufacturer warranty; 20 years
Array Type	• Commercial building: rack mounted. • Residential building: rooftop mounted.
Panel Tilt (degrees from horizontal)	• If rooftop mounted, use rooftop incline. • If not rooftop mounted, tilt based on latitude.
Rooftop Incline	30 degrees
Panel Orientation (degrees from north)	South facing
AC to DC Derate Factor (0.0 to 1.0)	0.77 (PVWatts default value)
System Lifetime	25 years (Average Manufacturer Warranty Lifetime)
Degradation Factor (0.0 to 1.0)	0.5% per year (NREL)[11]

In addition to the required inputs, additional information was asked of program funding recipients to determine the amount of shading occurring at various times of the day and year due to surrounding objects or snow.

In instances where there are multiple arrays of panels at a site with different tilt angles, orientations, or shading, the PVWatts calculations were performed separately for each array.

F.5.2. Solar Water Heating Energy Impacts

Energy savings from solar water heating were calculated using RETScreen v4,[12] a tool developed by Natural Resources Canada for predictive modeling. This tool was chosen for its larger scope of program specific input parameters than other considered tools. It includes regional weather data, information on the specific system used, application, and replaced system information.

The RETScreen model requires various operational parameters of the solar water heater installation and of the load. Examples of these parameters include climate data, system design specifications, and the quantity of water heated. The model then calculates the estimated energy savings due to the installation of solar water heating systems for service hot water with storage, service hot water without storage, and swimming pools, as applied to residential, commercial, and industrial applications.

The RETScreen model provides algorithms and recommendations for default input parameters for use when program data are not available. Table 20 lists modeling assumptions made in addition to RETScreen default input parameters.

[11] Dirk Jordan and Sarah Kurtz. Photovoltaic Degradation Rates – an Analytical Review. National Renewable Energy Laboratory (NREL). http://www.nrel.gov/docs/fy12osti/51664.pdf
[12] RETScreen International. Natural Resources Canada. www.retScreen.net (Accessed October 7, 2013)

Table 20: Solar water heater calculation default assumptions

Calculation Parameter	Default Assumption, if missing
Energy Savings Fuel Source	Regional grid electricity mix
New Equipment Installation Year ($Y_{install}$)	Program year
System Lifetime	Manufacturer warranty; 20 years[13]
Panel Orientation (degrees from north)	South facing
Type of collector (unglazed, glazed, evacuated)	• Pool heating or aquaculture: unglazed • All others: glazed
Total capacity [Number of tanks & capacity of each (gal)]	• Residential: daily water usage = tank capacity • Nonresidential: Use square footage of facility & facility type to estimate hot water usage
[Residential Only] Number of people in home	Average persons/household for State per 2010 census data[14]

RETScreen also estimates the "parasitic"[15] energy used by the solar water heating circulation pump. The model estimates an annual electricity usage (MWh) for the pump based on an input value for pump power per unit area of solar panel (W/ft^2). RETScreen will calculate the MWh used by the pump by dividing the pump power by the solar collector area. The user subtracts the parasitic energy usage from total production when electric energy is displaced.

RETScreen calculates the parasitic load based on user inputs regarding storage capacity, heat exchangers, miscellaneous losses and pump power per solar collector area. RETScreen provides recommendations in the help section for pump sizing and power ranges per collector aperture area.[16] For residential systems, the value will be small, but not insignificant, if an electric pump is used. For industrial operations, the value can be sizeable. These loads were neglected for:[17]

- thermosiphon systems, as a circulation pump is not required.
- systems with photovoltaic-powered pumps, as the required electric energy is produced by photovoltaic panels.
- outdoor swimming pool systems when the filtration system pump can be used for the solar loop; if the solar loop requires a high head (e.g., collectors placed too high above pool level, a booster pump may be required) then include the pump as parasitic load.
- industrial systems where water is diverted through the collectors before being delivered to the load.

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[13] *Save Money and More with Energy Star Qualified Solar Water Heaters.* http://www.energystar.gov/index.cfm?c=solar_wheat.pr_savings_benefits ; The Cadmus Group, Inc. Overview of Solar Water Heating Inputs and Results. October, 2012. http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2013IRP/PAC%202013IRP_SWH%20Memo_10-05-12.pdf

[14] http://quickfacts.census.gov/qfd/index.html

[15] Parasitic energy is the energy used by the system to operate that reduces the overall energy savings. In this situation, it's the energy used by the circulation pump, which is necessary to operate the system but reduces the overall energy savings from installing the solar water heater.

[16] Aperture area is the area in which solar radiation enters the collector. This is different from absorber area, or the area of the energy absorber, and gross area, which is the area based on the outer dimensions of the collector.

[17] *RETScreen Software Online User Manual, Solar Water Heating Model.* RETScreen® International. www.retscreen.net.

F.5.3. Wind Energy Impacts

The NREL Wind Energy Payback Period Workbook version 1.0 (NREL model)[18] was chosen for calculation of wind energy impacts for the EECBG evaluation. The model is similar to other publicly available models, such as the Idaho National Laboratories (INL) wind model, in that it bases its kWh production estimates from a Weibull probability distribution function. The differentiating factor that makes the NREL model preferable is that it provides default assumptions for some of the inputs, and corrects for air density and derate factors19 when calculating contribution to average wind turbine power (kW).

The model uses project site information such as wind speed, elevation, and density to estimate the wind profile. Physical characteristics of the turbine, including rated capacity, hub height, and power curve (power production at different wind speeds), can also be input to the model. Finally, miscellaneous factors such as turbine maintenance and weather can be input to better define the capacity factor, which is the amount of time available for electricity production at the site.

The NREL model uses the Weibull function formula to create a probability distribution of wind speeds at the specific site and percent of the time during the year the wind speed will be at projected levels.

A range of average annual wind speeds are taken from an NREL geographic information system (GIS) wind speed map for the particular location being studied. The site evaluator selects an average annual wind speed from the range using his or her best assessment of the site’s characteristics. For a selected turbine hub height, a value for the annual average wind speed is estimated using the Power Law equation:

Equation 1: Average Wind Speed

$$Hub\ Height\ Average\ Wind\ Speed\ (AWS) = A \times \left(\frac{G}{B}\right)^{\alpha}$$

A	=	Average wind speed
G	=	Rotor hub height
B	=	Anemometer height
α	=	Wind shear exponent (see Table 21)

With these inputs, the model yields an expected kW rating on a yearly basis at each of the different wind speeds at the turbine site. The model then sums the expected yearly kW at all the different wind speeds to get a total kW estimate at the site. This number is then multiplied by 8,760 hours/year to obtain the annual energy production (kWh/year).

Table 21 lists the inputs used for the model and defaults that can be assumed in the absence of respondent data.

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

[19] A derate factor is a number which values the proportion of electricity that is retained by the system after taking into account electricity loss throughout a system, which could be caused by inverters, lack of maintenance, or external conditions (e.g., weather).

Table 21: Solar photovoltaic calculation default assumptions

Calculation parameter	Default assumption, if missing
Displaced energy source	Regional grid electricity mix
New Equipment Installation Year ($Y_{install}$)	Program year
System Lifetime	Manufacturer warranty; 20 years
Wind Shear Estimate[20]	• 0.10 inches – very smooth terrain or open water use • 1/7 inches – smooth terrain • 0.20 inches – flat terrain with some surface roughness (the Great Plains)
Weibull k	• k = 2 – inland sites • k = 3 – coastal sites • k = 4 – island sites and trade wind regimes
Turbine hub height (m)	80 feet (AWEA)[21]
Anemometer Height (meters)	10 meters
Availability (%)	95 - 98 %
Performance Margin	• 0.0 (0%) –grid-connected applications • 0.05 (5%) – remote homes and village power sites with back-up power • 0.15 (15%) - 0.25 (25%) – telecommunication applications with back-up power • 0.2 (20%) - 0.4 (40%) – high-priority loads at sites without back-up power (should have solar component).
Performance Derating	10%

F.6. REVOLVING LOAN IMPACT METHODS

This section outlines the default assumptions used in calculating the effects of revolving loan repayment streams. In a revolving loan fund arrangement, loans are awarded to projects through a central fund. Program participant repayments to the fund are then redistributed to new projects, extending the impact per dollar of initially awarded funding. Revolving loan repayment streams affect the energy impact, cost-effectiveness, labor, and carbon impacts that occur.

The evaluation contractor team calculated revolving loan impacts through the application of several common assumptions. These assumptions are intended to capture the full benefits and costs of revolving loan funds, while still making the analysis as reasonable and accessible as possible. The method for calculation of revolving loan impacts involves the following steps:

- Disburse the full loan pool amounts over the 2009 program year unless detailed documentation is available indicating an alternative arrangement.
- Start repayment of principal and interest (P+i) in the year following disbursement and run it through the full term of the loan. This step assumes that there are no early repayments and no defaults.

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[20] M. L. Ray, A.l. Rogers, and J.G. McGowan, *Analysis of Wind Shear Models and Trends in Different Terrains*, AWEA Wind Power 2005 Conference, Pittsburgh, PA, June 2006.

[21] *Frequently Asked Questions*. American Wind Energy Association. http://www.awea.org/Issues/Content.aspx?ItemNumber=4638&navItemNumber=727 (Accessed October 9, 2013)

- Assign all cash flows at the end of each year.
- Attribute repayment of P+i on an annual basis rather than monthly.[22]
- Assume the borrower collects P+i for one year and then reloans the full amount repaid minus funds used for administrative expenses (typically equal to the interest rate charged on the loan). In other words, the loans "revolve" once per year.
- Assume the new portfolio of loans has the same interest rate, loan duration, repayment risk profile and energy savings potential as the initial round of loans.[23]
- The assessment is no longer than 20 years such that no loans are made after 20 years from the final year of the program. For example, if an activity starts loaning funds in 2010 and the last loan made from the original funding is in 2012, the revolving loan schedule for 2012 continues no longer than 2032.
- Exclude income and sales tax rates from the calculations.
- Assume the impacts of the revolved loans follow the same pattern of the initial loans, only at a reduced proportion because defaults and the repayment rate never fully replenishes the original loan fund. This proportion is determined by the ratio of new loaned dollars to original loaned dollars. It should also be noted that the number of years over which the streams occur is the same. So, for example, if the initial loan had 10 years of energy savings, then a revolved loan will also have 10 years of savings, just at a smaller proportion.

The treatment of revolving loans affects each criterion for cost-effectiveness (RAC and present value) in a different way, as outlined in Table 22. Where the loan interest rate is different from the discount rate, the present value loan analysis produces residual dollars (i.e., net present value is not zero). When positive, these amounts represent a benefit to the borrower because, in present value terms, the borrower is paying back fewer dollars than they borrowed. A positive balance also implies a cost to the lender because they are receiving fewer dollars than they loaned out in present value terms.

Table 22: Effects of revolving loans on cost-effectiveness calculations

Criteria	Initial Loan Disbursement	Loan Repayment
RAC	Increases program expenditures (cost)	No Impact
Present Value Ratio	Increases present value of program expenditure (cost)	Reduces present value of program expenditure (cost) by offsetting some – but not all – of the loan disbursement amount Reduces present value of participant bill savings (benefit) since free cash flow from bills savings is reduced by the amount of loan payments Increases program expenditures (cost) when present value dollars paid back are less than present value dollars borrowed

Because revolving loans have annual impacts reported as a percentage change from a baseline forecast, they have associated employment and economic impacts. Changes in economic activity from short-term and long-term spending influence the degree of change in employment. The timing of initial loan disbursements and the repayment terms of these loans determine the level of cash flow (and therefore spending) of borrowers. This spending drives changes in economic activity as detailed in Table 23.

[22] Technically, discounting is applied to periods rather than years. Given that the discount and inflation rates from OMB are provided on an annual basis, a period is defined here as one year.

[23] The risk profile of the borrower can be considered constant due to the same application requirements and interest rate assignment (an indicator of risk). However, this does not imply that all borrowers will adjust to changing market conditions in the same way.

Table 23: Effects of revolving loans on employment impacts

Employment	Initial Loan Disbursement	Loan Repayment
Direct	Increase current period employment	No Impact on current period employment
Indirect	No impact on future period employment	Dampens impact on future spending/reinvestment (and employment) until loan is paid off

F.7. REFERENCES

American Wind Energy Association. Frequently Asked Questions. http://www.awea.org/Issues/Content.aspx?ItemNumber=4638&navItemNumber=727 (Accessed October 9, 2013)

The Cadmus Group, Inc. Overview of Solar Water Heating Inputs and Results. October, 2012. http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2013IRP/PAC%202013IRP_SWH%20Memo_10-05-12.pdf

Energy Star. Save Money and More with Energy Star Qualified Solar Water Heaters. http://www.energystar.gov/index.cfm?c=solar_wheat.pr_savings_benefits

Goldman, Charles A. et al. Interactions between Energy Efficiency Programs funded under the Recovery Act and Ratepayer-funded Energy Efficiency Programs (Draft). Berkeley CA: Lawrence Berkeley National Laboratory. January, 2011.

Jordan, Dirk and Sarah Kurtz. Photovoltaic Degradation Rates – an Analytical Review. National Renewable Energy Laboratory (NREL). http://www.nrel.gov/docs/fy12osti/51664.pdf

M. L. Ray, A.l. Rogers, and J.G. McGowan, Analysis of Wind Shear Models and Trends in Different Terrains, AWEA Wind Power 2005 Conference, Pittsburgh, PA, June 2006.

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

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

RETScreen International. RETScreen Software Online User Manual, Solar Water Heating Model. Natural Resources Canada. www.retScreen.net (Accessed October 7, 2013)

TecMarket Works. The State Energy Program: Building Energy Efficiency and Renewable Energy Capacity in the States. Oak Ridge, TN: Oak Ridge National Laboratory. September 30, 2010.

U.S. Census Bureau. State & County QuickFacts. http://quickfacts.census.gov/qfd/index.html

APPENDIX G. EECBG-ATTRIBUTABLE IMPACT METHODOLOGY

This section presents the standard evaluation approach used to assess the extent to which the estimated energy impacts for each sample activity were attributable to the EECBG program. The attribution methodology was designed to answer the two fundamental research questions that were asked for each evaluated activity: what are the EECBG program effects on market actors and if EECBG activities overlapped with other programs, to what extent are the observed activities and outcomes attributable to one program or another?

EECBG-attributable savings were estimated from project-level data using a standard methodology across all 174 activities. This section presents the standard EECBG evaluation approach to assessing the extent that each sampled activity estimated energy impacts could be attributed to the EECBG.

The EECBG activities focused on providing individual market actors with the information, tools, and incentives they would need to more quickly adopt energy efficiency and renewable energy measures of specific projects. Assessment of attribution for these programs relied on program manager reports that provided insight into how decision makers made choices.

1. Program Effects on Market Actors

Question: What would the market actors targeted by the activity have done to adopt the activity-supported technology or service in the absence of the program?

This question provides the framework for attributing the appropriate portion of overall outcomes to 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.

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

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

The specific methodology is provided in detail later in this appendix.

2. EECBG Influence on Activities and Outcomes of Other Programs and Vice Versa

In instances when other programs target the same activities and outcomes as EECBG in the same domain,[24] *to what extent were observed activities and outcomes attributable to one program or another?*

In many states, ratepayer funded programs targeted some of the same outcomes as EECBG. In some of those cases, EECBG provided resources for efficiency and renewable measures in addition to the resources offered by other programs. This could result in other programs possibly claiming some of EECBG program savings, but this study did not find evidence of that. Even in the few cases where EECBG participants indicated that other programs had an effect on their decision-making, there was no clear indication that the other programs influenced these participants enough to claim EECBG savings.

Attribution Analysis Methodology

This section provides a detailed explanation of the program attribution methodology used in this evaluation. An attribution analysis is used to determine the ratio between verified gross savings and net (attributable) savings for the program. In this evaluation, the verified gross savings analysis is a parameter that fed into the net savings analysis. Previous sections of this report have explained the verified gross savings analysis that the contractor team conducted for each program to determine the gross savings.

The remainder of this section introduces the parameters used in the attribution analysis. The next section outlines the method used to combine those parameters into a single attribution value. The last sections describe, in detail, how the parameters are determined from the participant survey.

The attribution analysis is based on the following parameters that are determined from the engineering verification review and participant survey:

- **Acceleration Period, m_a:** This reflects the effect the program had on *when* the equipment was installed. The acceleration period corresponds to the number of months between when the equipment was actually installed and when it would have been installed in the absence of the program. For respondents who say they would have installed the measure at the same time or earlier without the program, $m_a = 0$. For those who say they would have installed later, m_a is the number of months later they say they would have installed, up to a maximum of 48. This factor is based on responses to attribution questions in the participant survey.

- **Existing Equipment Efficiency:** This is the efficiency of the equipment that was replaced. Where necessary, the contractor team estimated this efficiency level based on the age of the replaced equipment provided by survey respondents. The existing equipment efficiency was used as the baseline efficiency for gross savings calculations during the acceleration period; therefore, it was only used for accelerated measures or measures with $m_a > 0$.

- **Standard Equipment Efficiency:** This is the standard efficiency level for the type of measure installed at the time the respondent purchased the new equipment. The standard equipment efficiency is used as the baseline efficiency level during the non-acceleration period and for measures with no acceleration effect. For some measures, such as lighting, the standard equipment efficiency and the existing equipment efficiency are the same. The standard equipment efficiency was used for all measures, not just accelerated measures.

[24] By domain, we mean the groups of market actors, regulators, government bodies, and other institutions, and the interactions of these multiple actors regarding a program.

- **Efficiency Attribution (A_E)**: This is the effect the program had on the efficiency of the equipment installed. The efficiency attribution measures the proportion of savings attributable to the program for increasing the efficiency of the equipment above what would have been installed otherwise. This factor is based on responses to attribution questions in the participant survey.
- **Quantity Attribution (A_Q):** This is the effect the program had on the quantity of the equipment installed. The quantity attribution measures the proportion of savings attributable to the program for increasing the quantity of equipment above what would have been installed otherwise. This factor is based on responses to attribution questions in the participant survey.
- **Measure Life (m_L)**: This represents the average amount of time a piece of equipment will remain installed and operational before being replaced by a new piece of equipment. The measure life assignments for each measure are in the program-specific sections of this report.

The complement of attribution is free-ridership. Attribution measures the portion of the savings that result because of the actions of the program. Free-ridership measures the portion of the savings that would have happened in the absence of the program. The free-ridership equivalents of the attribution factors are used along with other factors to determine the overall program net savings. They are:

- **Efficiency Free-ridership (f_E)**: This is the fraction of verified gross savings per unit that would have occurred without the program.
- **Quantity Free-ridership (f_Q):** This is the fraction of installed units that would have been installed without the program.

The free ridership values are easily calculated from the attribution factors:

$f_E = 1 - A_E$

$f_Q = 1 - A_Q$

G.1. ATTRIBUTION ANALYSIS

This section outlines the methods necessary to determine net program savings using the attribution analysis parameters defined in the previous section.

G.1.1. Simple Program Attribution (SPA) Calculation

The fraction of annual verified gross savings that would have occurred *without* the program is the product of the fraction of units that would have been installed without the program, f_Q, and the fractional unit savings that these units would have had without the program, $f_{E.}$

$f_{QE} = f_Q\, f_E$

For example, if two-thirds as many units would have been installed without the program ($f_Q = 2/3$), and the savings per unit would have been only half as much ($f_E = 1/2$), the portion of the savings that would have occurred without the program would be:

$$f_{QE} = (2/3) \times (1/2) = 1/3.$$

The Simple Program Attribution (SPA) is the complement of this free rider portion.

$$SPA = 1\text{-}f_{QE} = 1\text{-}\ f_Q\ f_E$$

The relationship is illustrated in Figure 3.

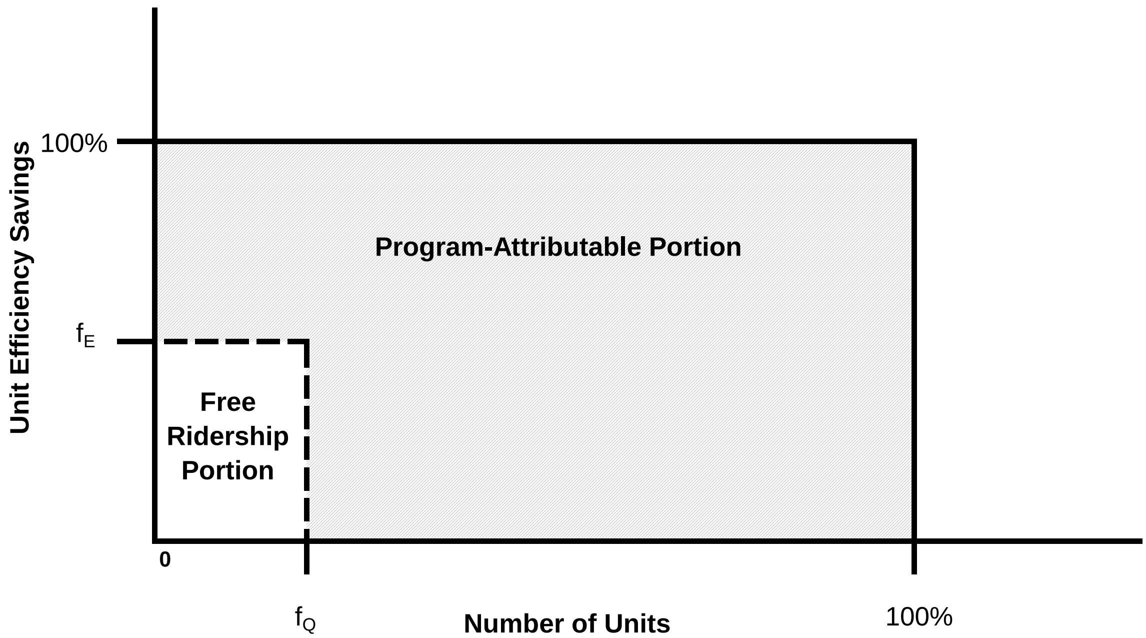

Figure 3: Graphical derivation of the SPA equation

G.2. TIMING EFFECTS

The goal of the attribution analysis is to produce an estimate of net savings for each year in the lifetime of the measure. For measures without acceleration, the program-reported annual gross savings can be combined with the measure life, m_L to produce the simple lifetime gross savings, plotted in Figure 4. The simple lifetime savings are simply the first year savings multiplied by the measure life. First year savings are determined by the difference between the high efficiency that was installed and the baseline efficiency.

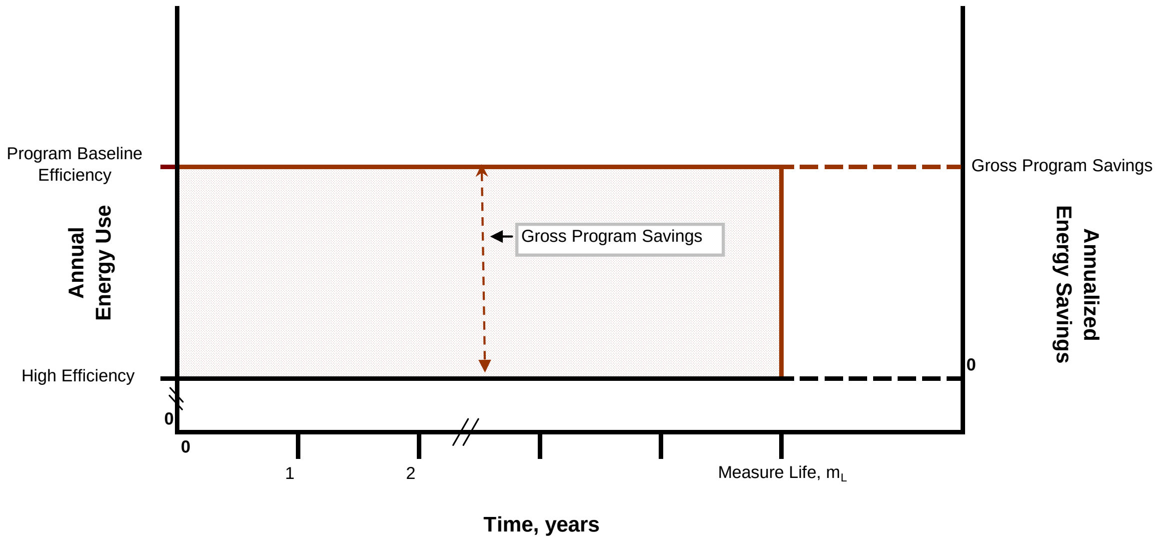

Figure 4: Simple lifetime savings of a program measure

For a replacement measure with acceleration, the program caused the participant to install an energy efficiency measure before they originally intended to do so. During the acceleration period, the energy savings caused by the program are the difference between the energy use of the high efficiency equipment that was installed and the energy use of the equipment that was replaced. This could also be termed as the difference between the high efficiency equipment efficiency and the existing equipment efficiency. We call this value the acceleration period savings.

The evaluating engineer is able to determine the Existing Equipment Efficiency from the age of the replaced equipment provided in the participant surveys. The engineer then uses a number of sources including the documentation provided by the program and secondary sources to estimate the acceleration period savings for a particular measure.

Figure 5 shows the acceleration period savings superimposed over the gross program savings. The lifetime acceleration period savings are the acceleration period savings multiplied by the acceleration period, m_a.

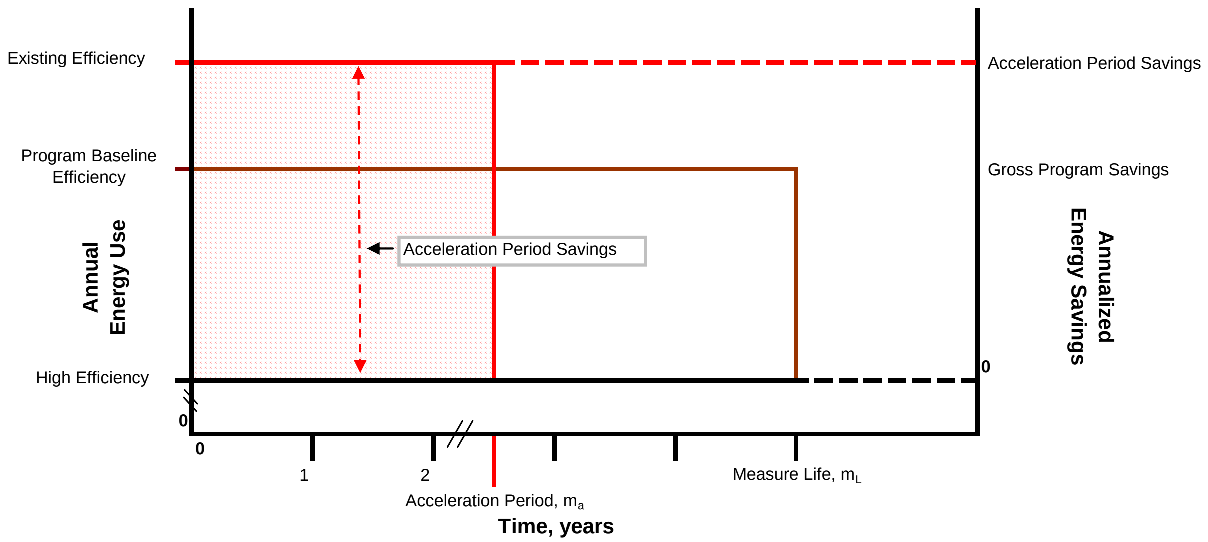

Figure 5: Acceleration period savings

There is no "net" or "gross" associated with the acceleration period savings. The concept of acceleration already incorporates elements of net savings so no further adjustments to acceleration period savings are necessary.

The post-acceleration period savings are shown in Figure 6. The post-acceleration period verified gross savings (identified as verified gross installed (VGI) savings in the figure) are the evaluation-verified gross savings for the measure, which assume a Standard Equipment Efficiency to determine savings. The post-acceleration period net savings are equal to the verified gross savings times the SPA calculated in Section G.1.1

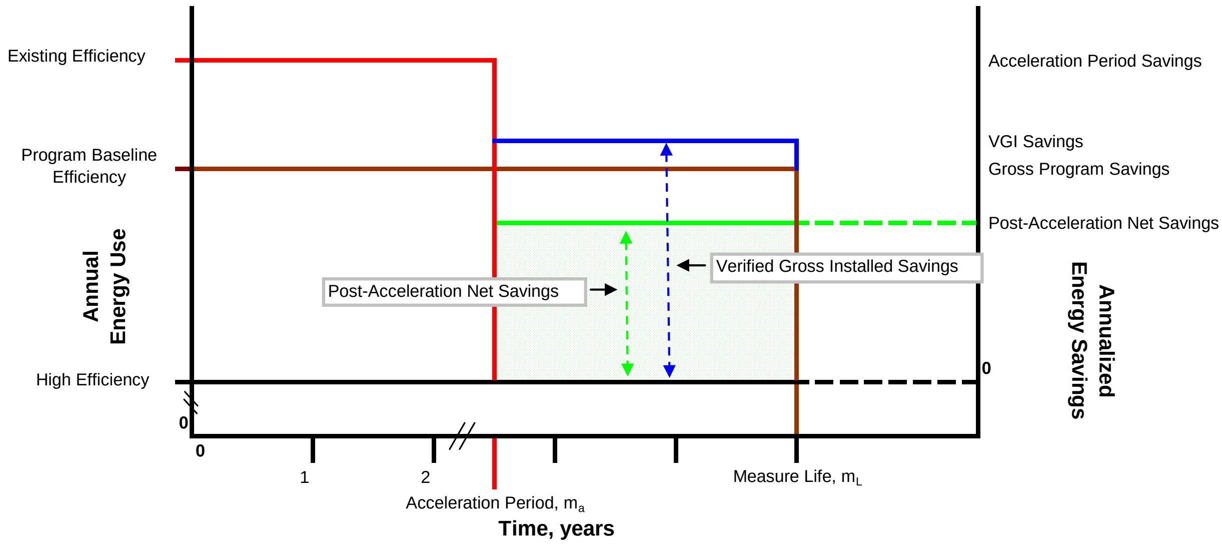

Figure 6: Post-acceleration period net savings

The lifetime net savings for an accelerated measure are the sum of the acceleration period savings and the post-acceleration net savings. This can also be written as:

$$\text{Lifetime net savings}_{\text{accelerated}} = \text{Acceleration Period Savings} + \text{Verified Gross}_{\text{post-accel}} * \text{SPA}$$

The lifetime net savings are shown graphically in Figure 7.

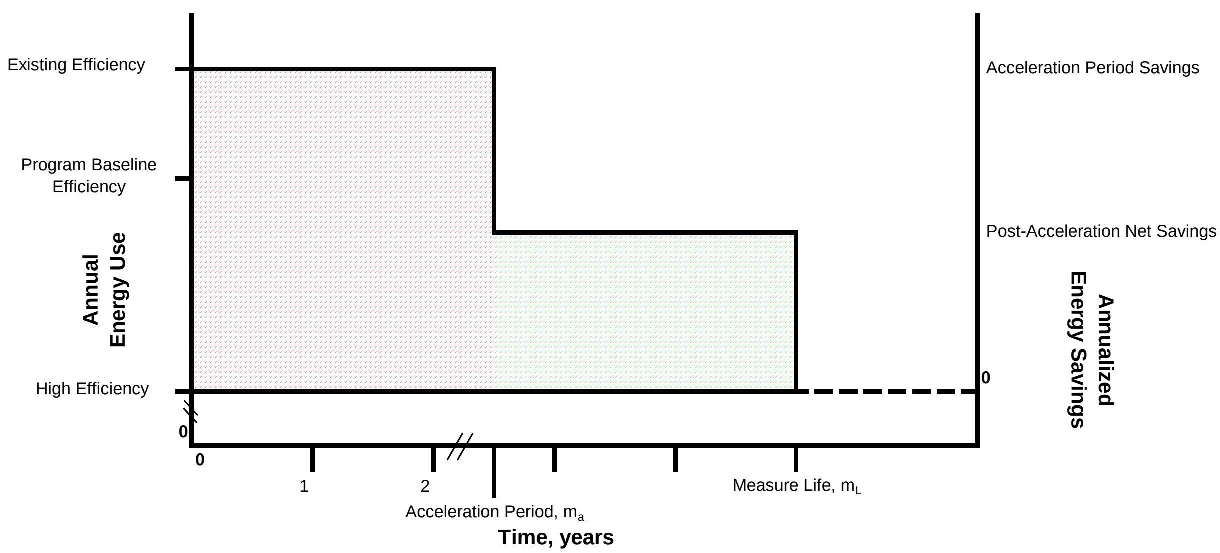

Figure 7: Simple lifetime net savings

APPENDIX H. DETAILED BPA EXPANSION METHODOLOGY

H.1. OVERVIEW

All estimates presented in this report were computed using the fully calibrated and nonresponse adjusted sample weights discussed in Appendix C. Estimates are reported for the following six BPAs:

- Energy Efficiency Retrofits
- Financial Incentives
- Buildings and Facilities
- On-site Renewables
- Lighting
- Energy Efficiency and Conservation Strategy

In many sections of this report, estimates of the total for the six BPAs combined are also presented.

In summary, results from the respondents were expanded back to the population of EECBG activities using the calibrated sample weights discussed in Appendix C. These weights are numeric quantities assigned to each responding activity that are greater than or equal to 1.00 and conceptually represent the total number of activities in the population that a particular respondent represents. Weighted respondent data is then aggregated to the BPA of interest to form the final estimates from this evaluation. The estimation process is discussed below.

H.2. ESTIMATION AND VARIANCE ESTIMATION

All estimates in this report were created using direct weighted estimation techniques. However, because the weights were calibrated to the correct population funding totals,[25] using direct weighted estimation techniques is equivalent to using a Separate Ratio Estimator with funding as the size measure. There was no item nonresponse in this study, so corrections for item nonresponse were unnecessary.

To illustrate the estimator, suppose

h	=	BPA by activity type. Activity type refers to the direct/indirect grant classification of the activity.
i	=	Activity within group *h*
x_{hi}	=	Is some outcome measure from the evaluation for activity *i*. For example, this might be the energy savings estimate associated with electricity (kWh) attributed to EECBG.
s_{hi}	=	EECBG funding for activity *i* in group *h*.
S_h	=	Estimate of total funding for group *h* in the EECBG population (not just the sample).

[25] See Appendix C.

w_{hi} = The calibrated and nonresponse-adjusted sample weight for activity *i*.

Then estimates of a total $\tilde{\tilde{X}}$ were formed using a separate ratio estimator as follows:

$$\tilde{\tilde{X}} = \sum_h S_h \frac{\sum_i w_{hi} x_{hi}}{\sum_i w_{hi} s_{hi}} \qquad (1)$$

As noted in Appendix C, the adjusted sample weights were created so that the final weighted funding sum across responding activities equals the best estimate of total funding for the BPA/type group. This means:

$$\sum_i w_{hi} s_{hi} = S_h \quad \text{for each group } h.$$

Therefore, the separate ratio estimator defined by Equation (1) is equivalent to the direct weighted survey estimator:

$$\tilde{\tilde{X}} = \sum_h \sum_i w_{hi} x_{hi}$$

Variance estimates were computed for many statistics displayed in this report. The variance estimates were computed using the Taylor series linearization method. This method was first suggested by Tepping (1968) and has been discussed in numerous articles and books since then [see, for example, Binder (1983) and Wolter (1985)]. In general, the Taylor series linearization process for estimating variances accounts for the complex design features that are often found in survey samples, such as stratification, clustering and/or unequal weighting. Therefore, this variance estimation process was appropriate for estimates reported in this analysis.

H.3. ESTIMATES WITH LOW PRECISION

In this report, some estimates are flagged with an asterisk (*), indicating that the estimate exhibits low precision. An estimate is considered to have low precision if one or both of the following was true:

1. Fewer than five responding activities contributed to the estimate.
2. The relative standard error of the estimate was 75% or greater. The relative standard error is the design-based standard error divided by the estimate itself. The design-based standard error is the standard error of an estimate that accounts for the complex design features of the study, such as stratification and unequal weighting.

Several tables in this report present the margin of error associated with an estimate. The margin of error is the radius of the 90% confidence interval and is defined as:

Margin of Error = $t_{df} \cdot \hat{\sigma}_{design}$

Where: t_{df} is a constant from the student t-distribution that equals roughly 1.67 and

$\hat{\sigma}_{design}$ is the design-based standard error of the estimate.

Hence, the 90% confidence interval of an estimate is the estimate +/- its margin of error.

H.4. LABOR IMPACTS, AVOIDED CARBON EMISSIONS, PERFORMANCE FACTORS, BILL SAVINGS, AND COST-EFFECTIVENESS ESTIMATES

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

- Estimates of precision are not presented for the labor impacts, avoided carbon emissions, performance factors and several cost-effectiveness estimates presented in this report. 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. The margin of error (a measure of sampling error) associated with various energy impact and bill savings estimates are presented in Appendix M. Note that the energy impact and bill savings estimates (as well as some others) were used as inputs into the models and algorithms used to generate estimates for the labor impacts, avoided carbon emissions, performance factors and cost-effectiveness sections of this report.
- Several models and algorithms used to generate estimates required location-specific inputs in order to account for geographic variation in model parameters and algorithm assumptions. Some of the models and algorithms required state-specific estimates while others only required estimates by the U.S. Bureau of Economic Analysis regions. This evaluation did not have the sample size to support obtaining direct survey, state- and region-specific estimates within evaluated BPAs and direct/indirect grant type group. Therefore to account for geographic variation, state-level estimates were created as follows:
    - If a state had one or more evaluated activity in a specific BPA and grant type, then the state-level estimate was created using data associated with the state.
    - Otherwise direct survey estimation (discussed above) was used to estimate national totals for each BPA and grant type, such as the total EECBG-attributable energy savings associated with electricity or gas. These estimates of totals were proportioned to the states with no sampled activities proportional to the funding that the state received within a BPA and grant type.
    - These BPA by grant type by state estimates of totals were summed to the required geographic level necessary for the model or algorithm under consideration. This process of deriving state-level estimates within each BPA and grant type adds additional sampling error and potentially some bias to the estimates generated from the models and algorithms.

Table 24 displays the EECBG funding by BPA and grant type.

Table 24: Distribution of funding by BPA and grant type

BPA	Grant Type	Funding (in $1,000's)	Percent within BPA
Total of Six Evaluated BPAs	Direct	$2,045,112	76%
	Indirect	$649,022	24%
	Total	$2,694,134	100%
Energy Efficiency and Conservation Strategy (Direct Grants)	Direct	$69,759	100%
	Total	$69,759	100%
Financial Incentive Program	Direct	$171,498	31%
	Indirect	$380,442	69%
	Total	$551,940	100%
Energy Efficiency Retrofits	Direct	$906,679	82%
	Indirect	$193,548	18%
	Total	$1,100,227	100%
Buildings and Facilities	Direct	$563,050	91%
	Indirect	$54,166	9%
	Total	$617,215	100%
Lighting	Direct	$186,359	95%
	Indirect	$10,288	5%
	Total	$196,648	100%
On-site Renewable Technology	Direct	$147,767	93%
	Indirect	$10,578	7%
	Total	$158,345	100%

Figures 8 through 27 show the variation in funding by state for each BPA and direct/indirect grant type group considered in this evaluation. Some items to note about the funding distribution:

- 24% of the total funding over the six BPAs evaluated is associated with indirect grants and 76% is associated with direct grants. Most of the indirect grant dollars are coming from financial incentive programs. And most of the direct grant dollars are coming from energy efficiency retrofits.
- The states receiving the largest amount of funding in the direct grant group are California, Texas, Florida, New York, Illinois, Pennsylvania, Arizona, Michigan, Ohio and New Jersey. And the states receiving the largest amount of funding in the indirect grant group are Texas, California, Florida, New York, Ohio, Pennsylvania, Georgia, Illinois, Virginia and Louisiana.
- Louisiana received a large portion of funding in the indirect grant group primarily because of activities in the financial incentive programs BPA.
- A relatively large portion of the funding in the indirect grant category for lighting and on-site renewable technology were associated with U.S. territories (greater than 34%). But again, the indirect grants for these BPAs accounts for a small portion of the total BPA.

The bias in estimates generated from the models and algorithms that used geographic estimates is unknown and depends on three things:

1. The bias depends on the differences in EECBG funding between states and regions. This difference can be large depending on the BPA and grant type group under consideration.
2. The bias depends on how sensitive the model and algorithm is to variations in geographic estimates that are used as inputs. This will vary by model and algorithm.
3. More importantly, the bias depends on how different the population parameters are between states and regions. This variation is simply unknown given the survey data that is being analyzed in this evaluation.

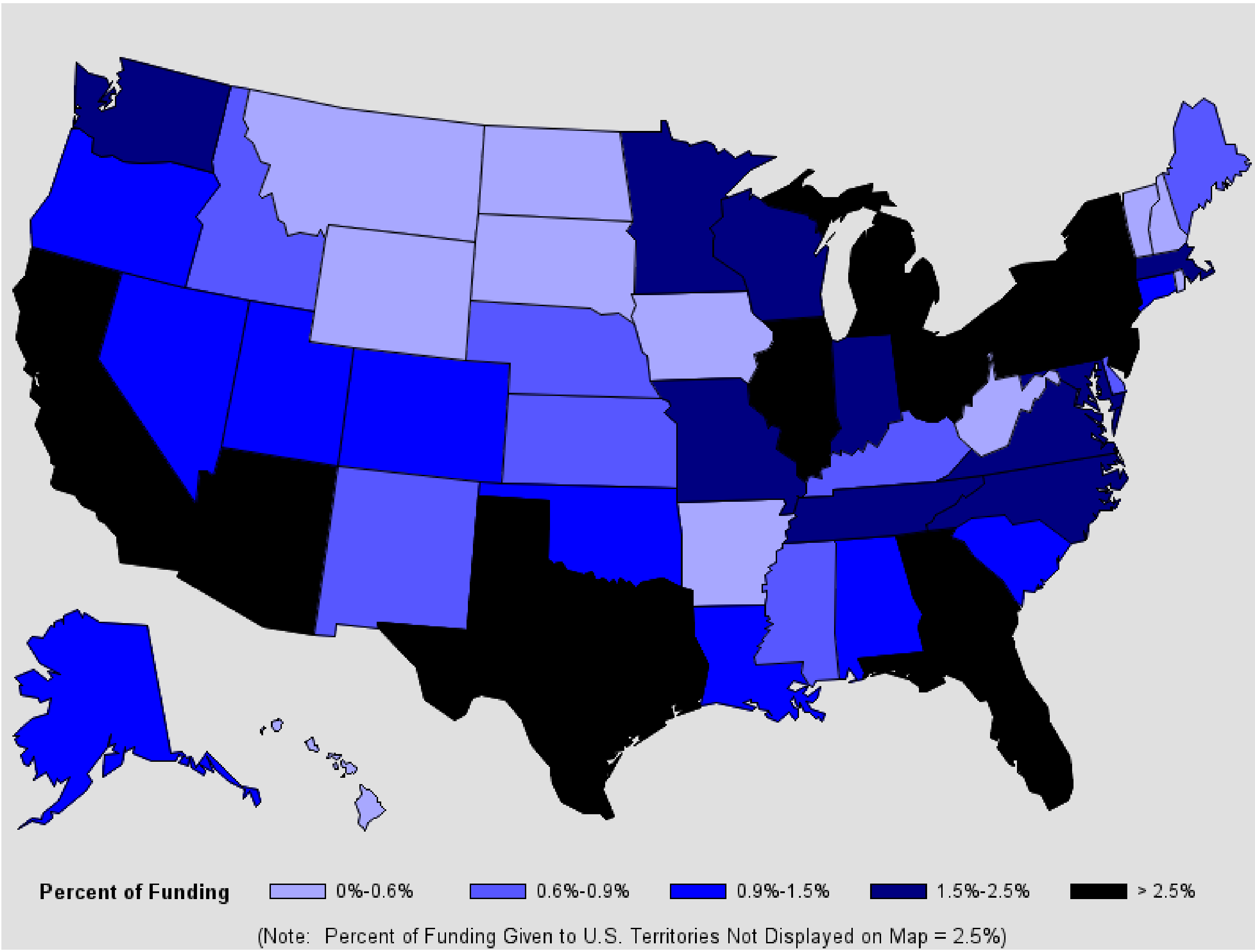

Figure 8: BPA=total of six evaluated BPAs, type=total, percent of funding by state

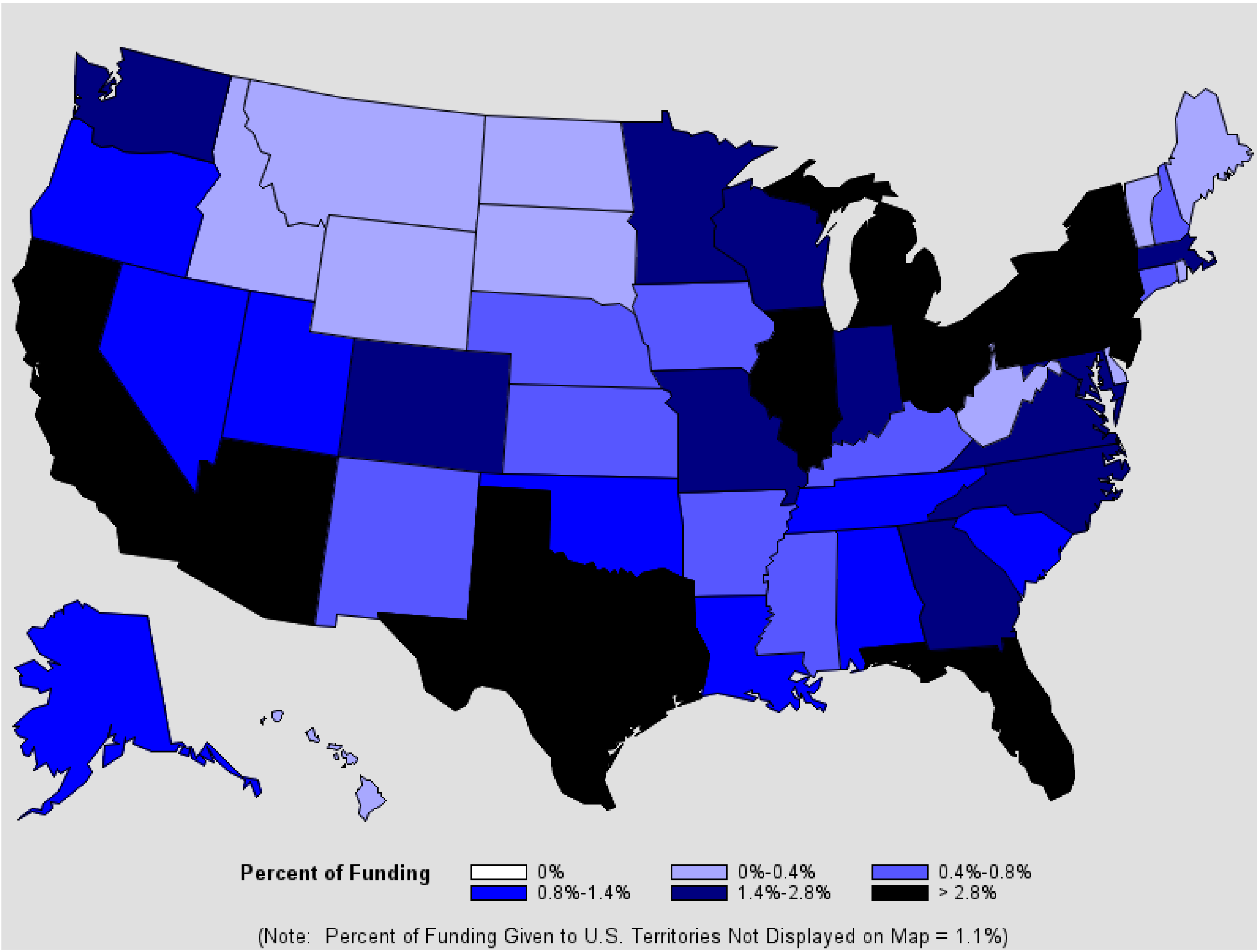

Figure 9: BPA=total of six evaluated BPAs, type=direct, percent of funding by state

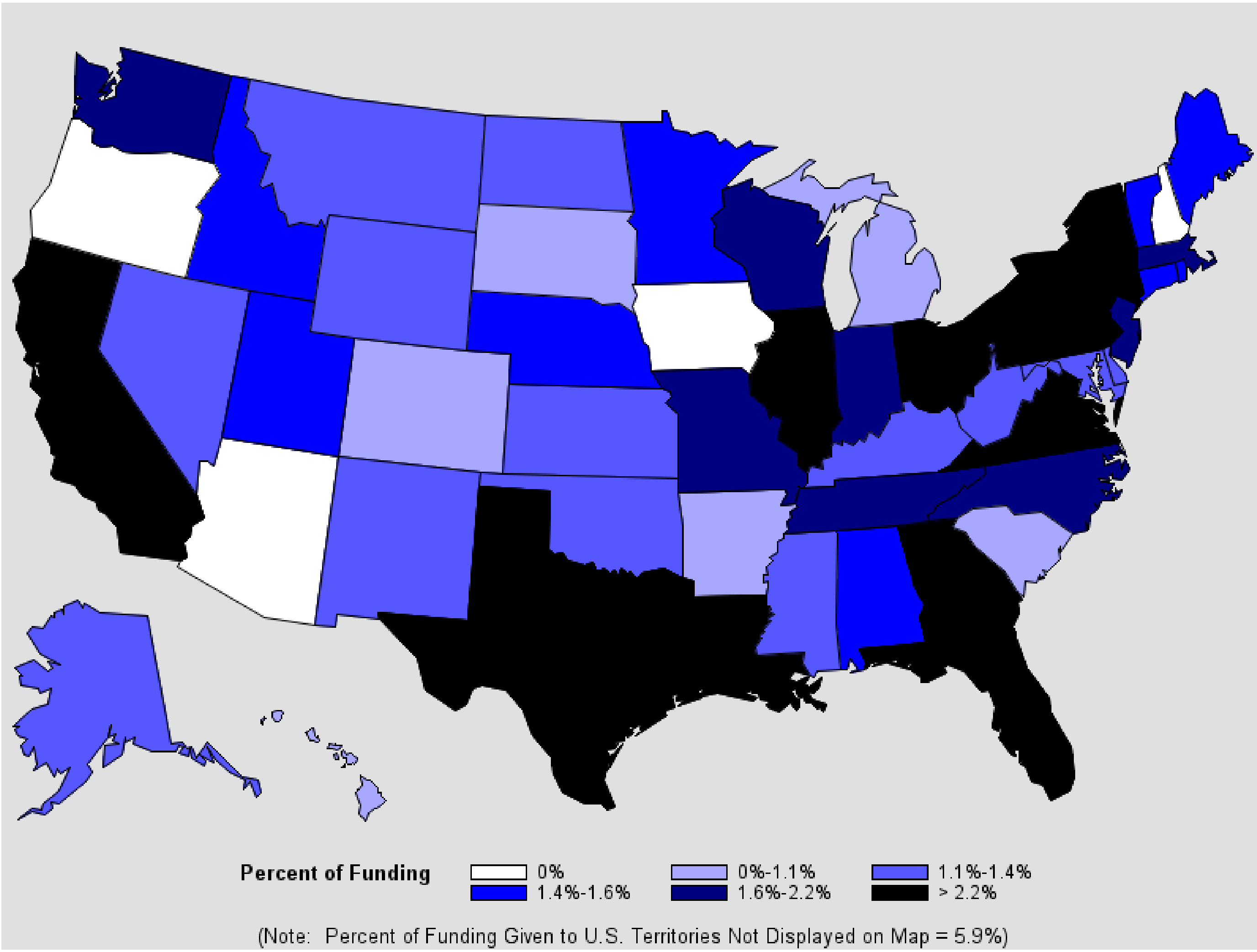

Figure 10: BPA=total of six evaluated BPAs, type=indirect, percent of funding by state

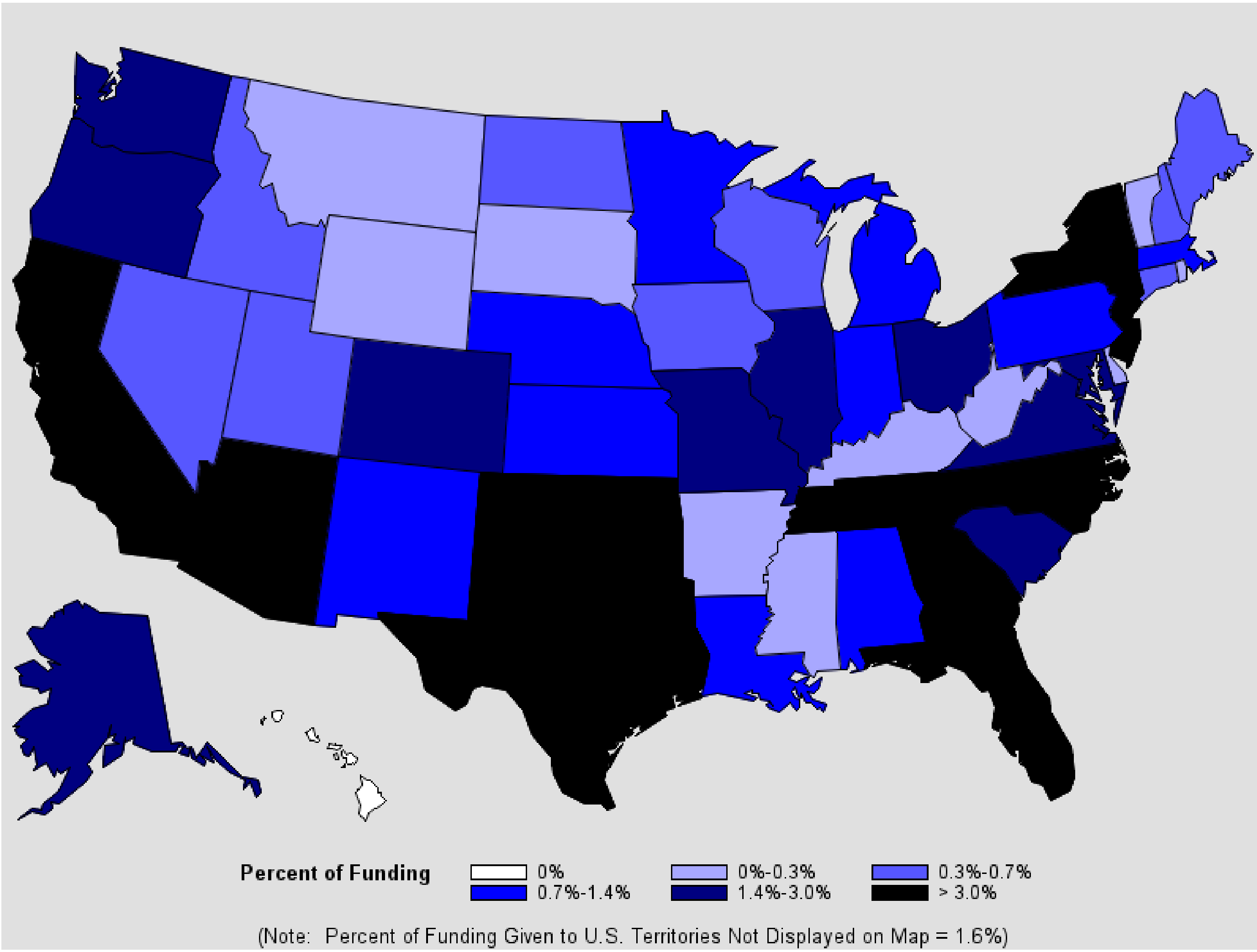

Figure 11: BPA=energy efficiency and conservation strategy (direct grants), type=total, percent of funding by state

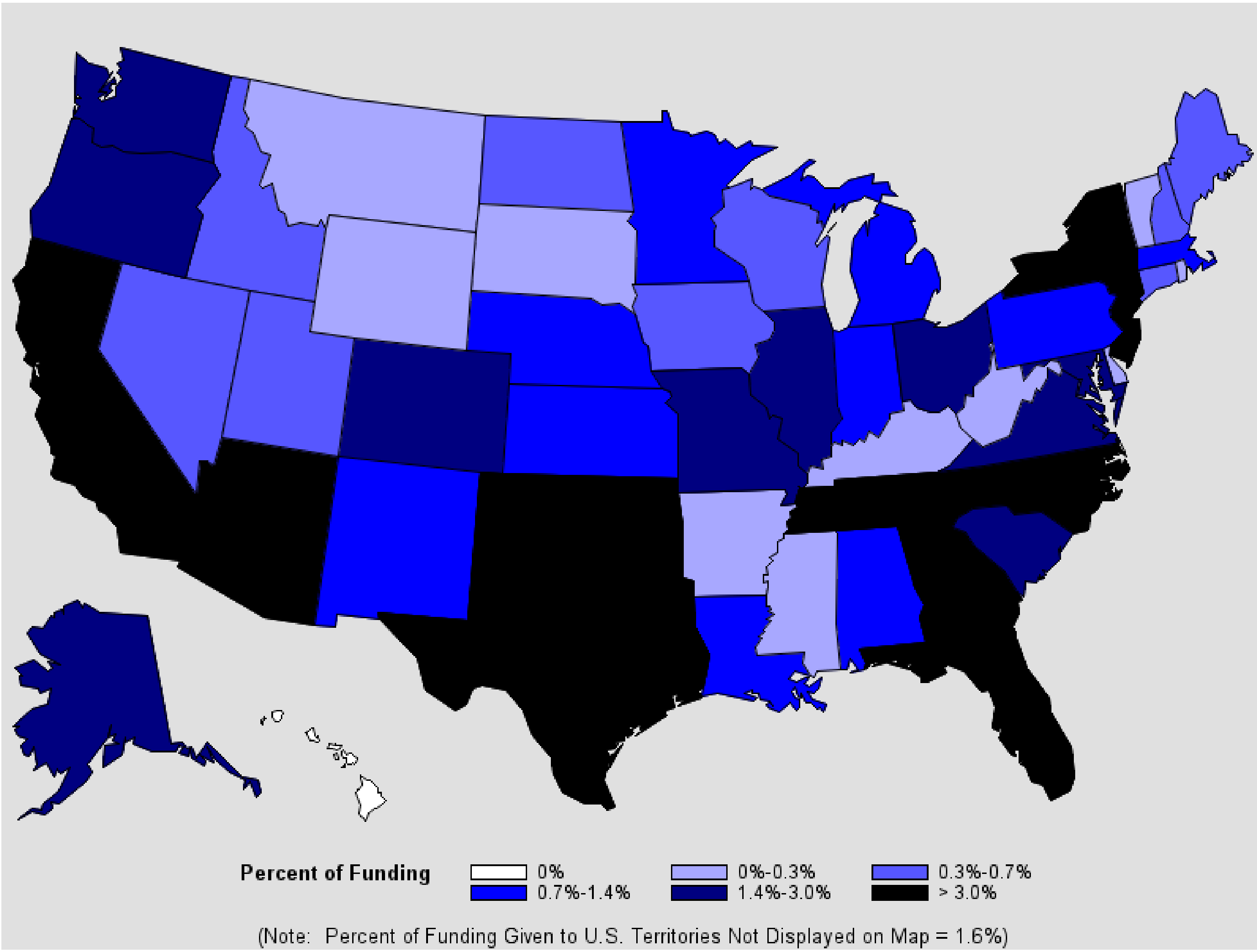

Figure 12: BPA=energy efficiency and conservation strategy (direct grants), type=direct, percent of funding by state

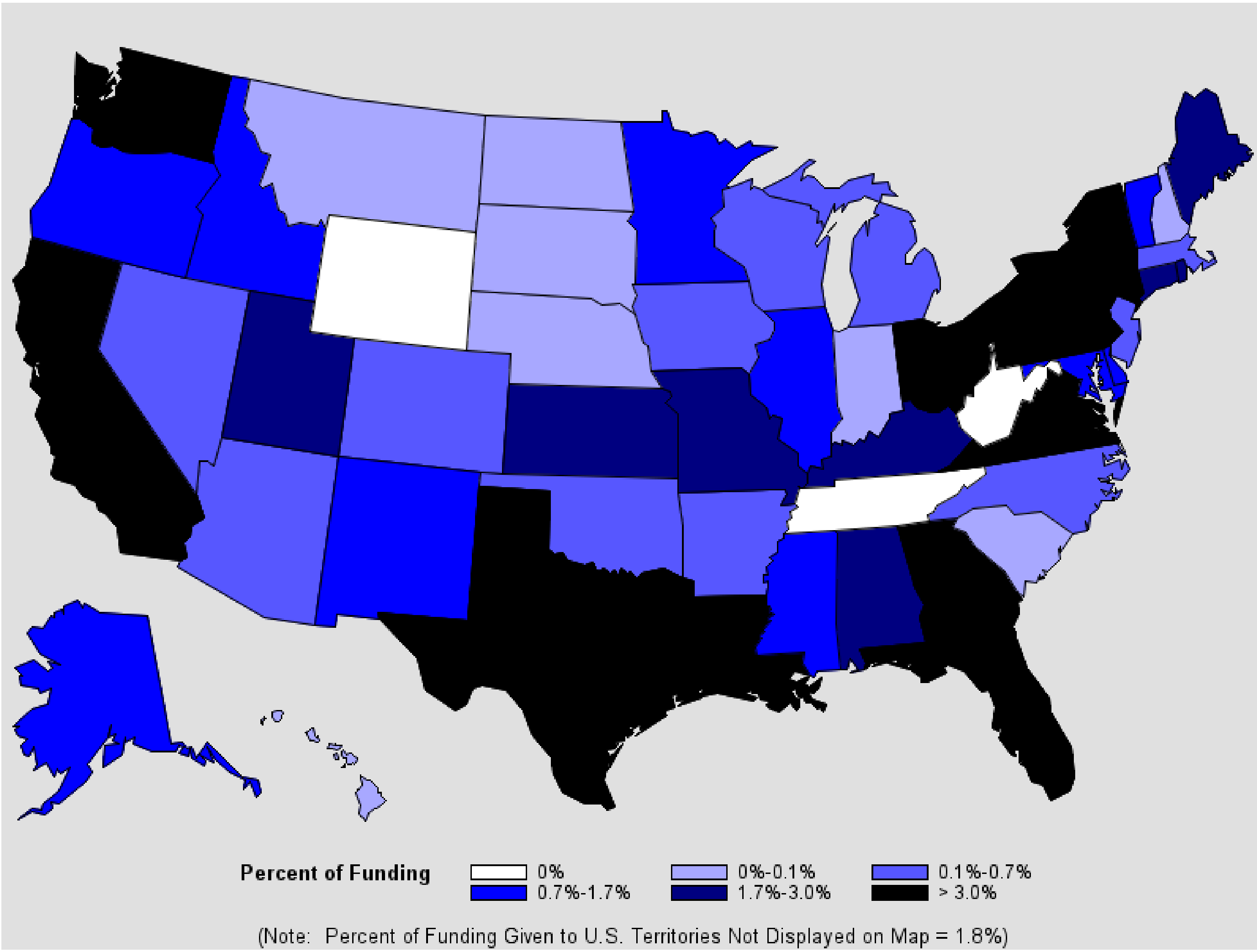

Figure 13: BPA=financial incentive program, type=total, percent of funding by state

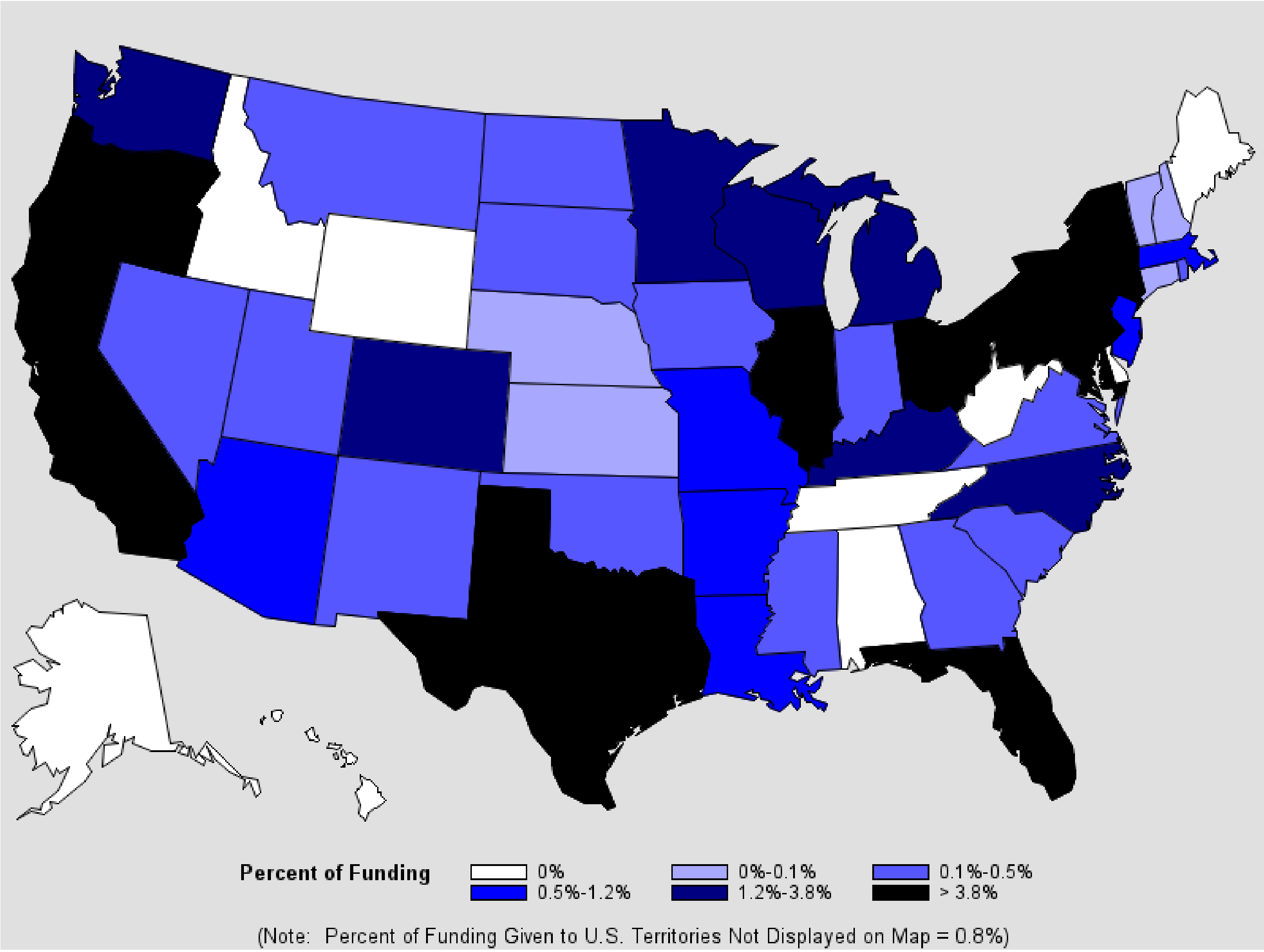

Figure 14: BPA=financial incentive program, type=direct, percent of funding by state

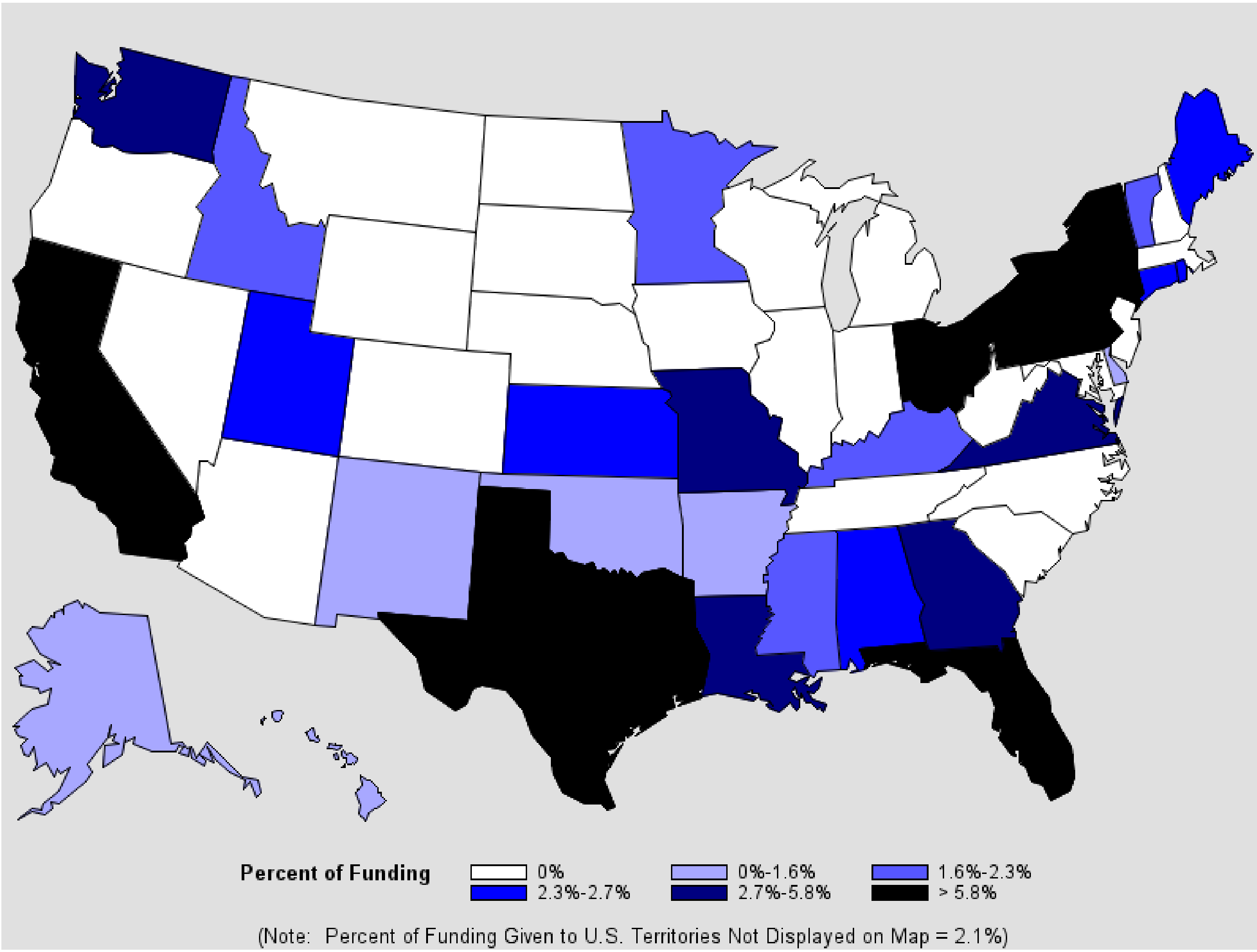

Figure 15: BPA=financial incentive program, type=indirect, percent of funding by state

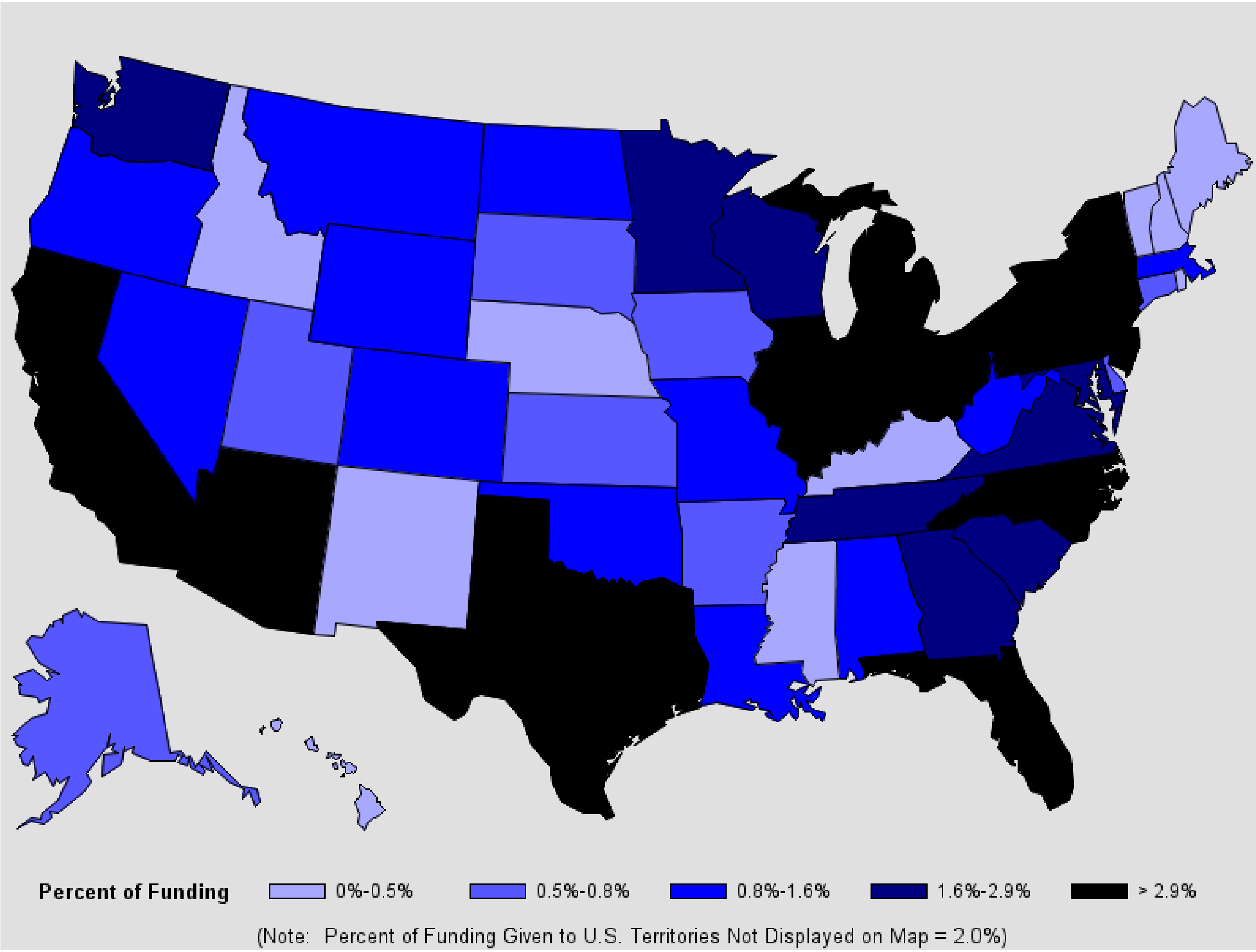

Figure 16: BPA=energy efficiency retrofits, type=total, percent of funding by state

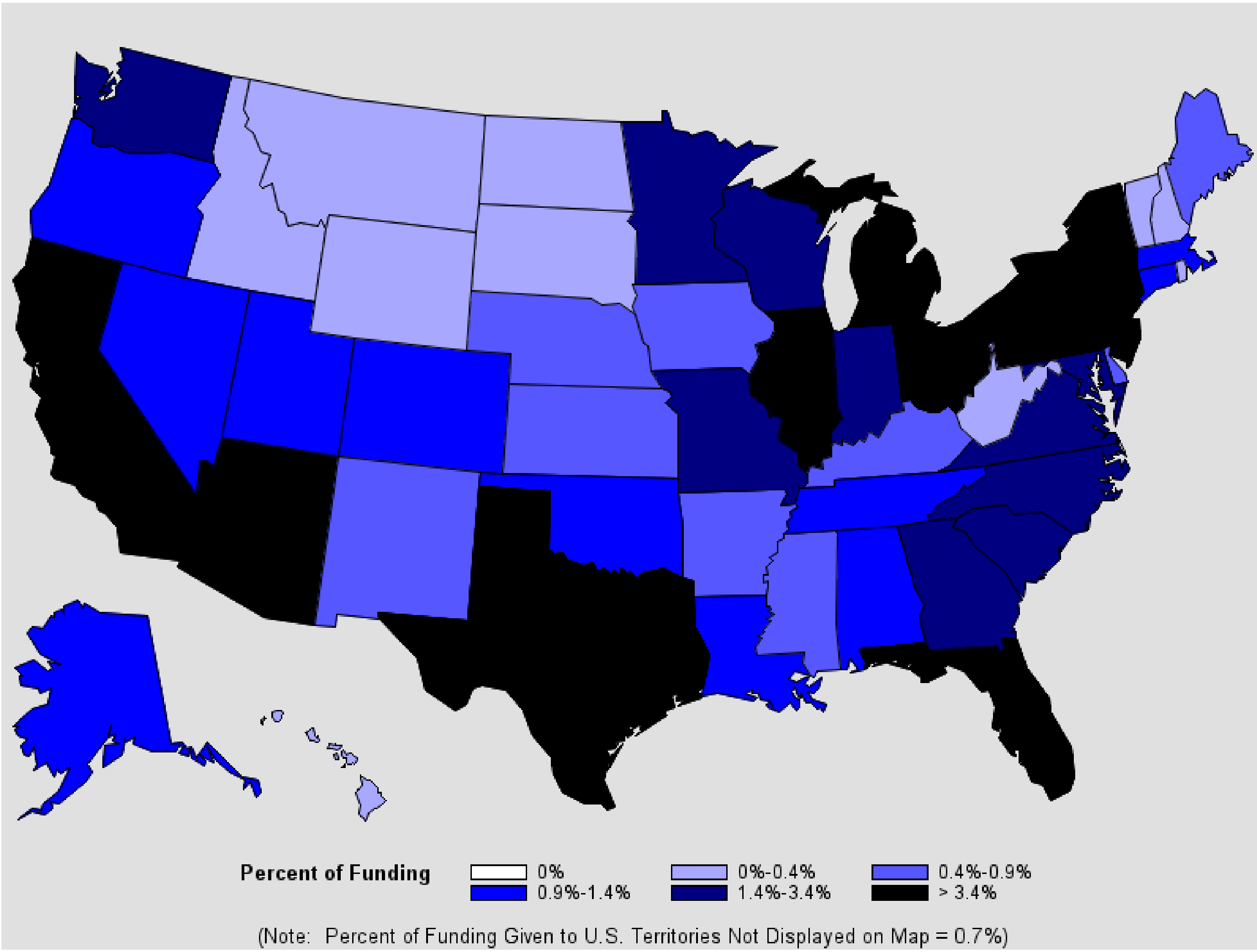

Figure 17: BPA=energy efficiency retrofits, type=direct, percent of funding by state

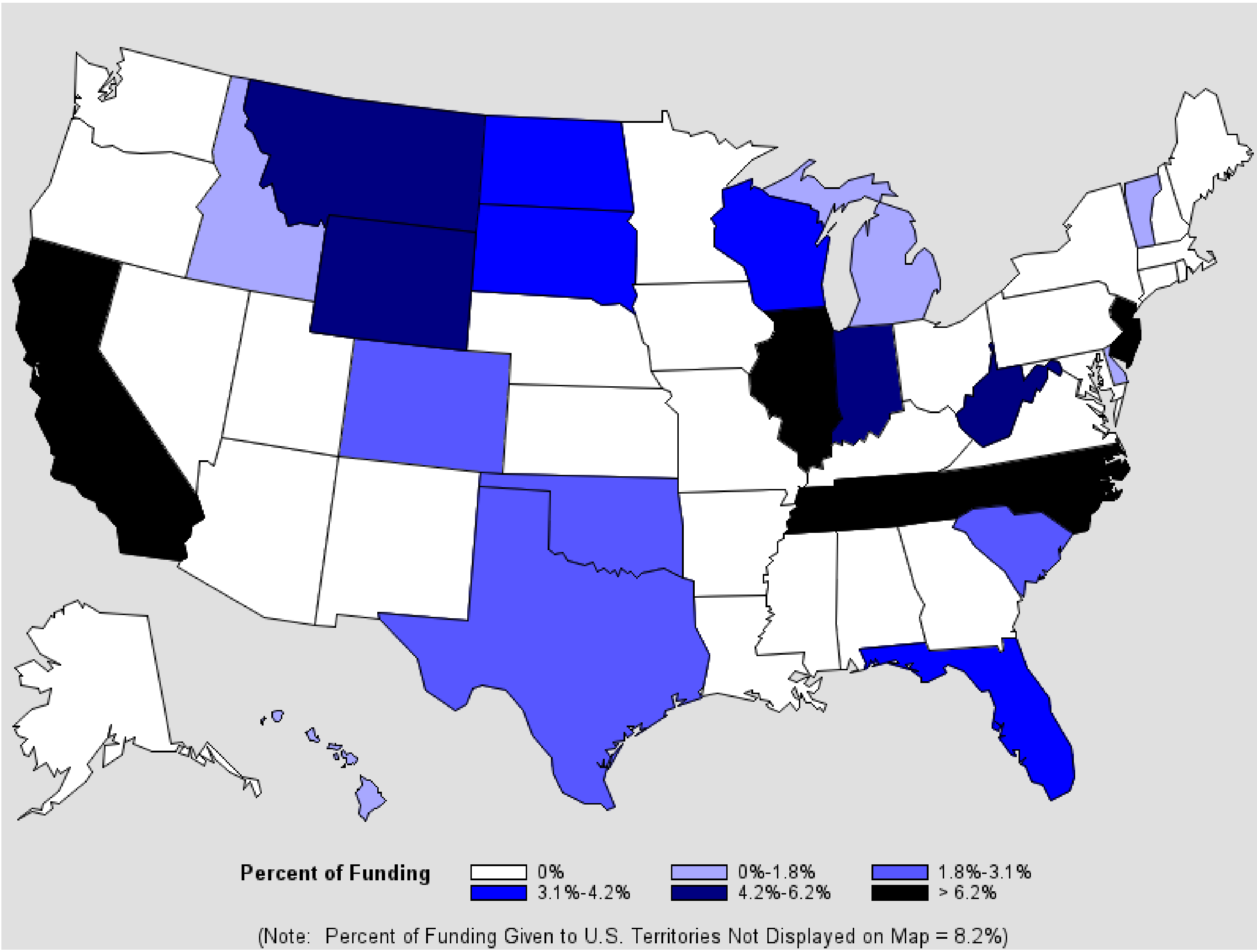

Figure 18: BPA=energy efficiency retrofits, type=indirect, percent of funding by state

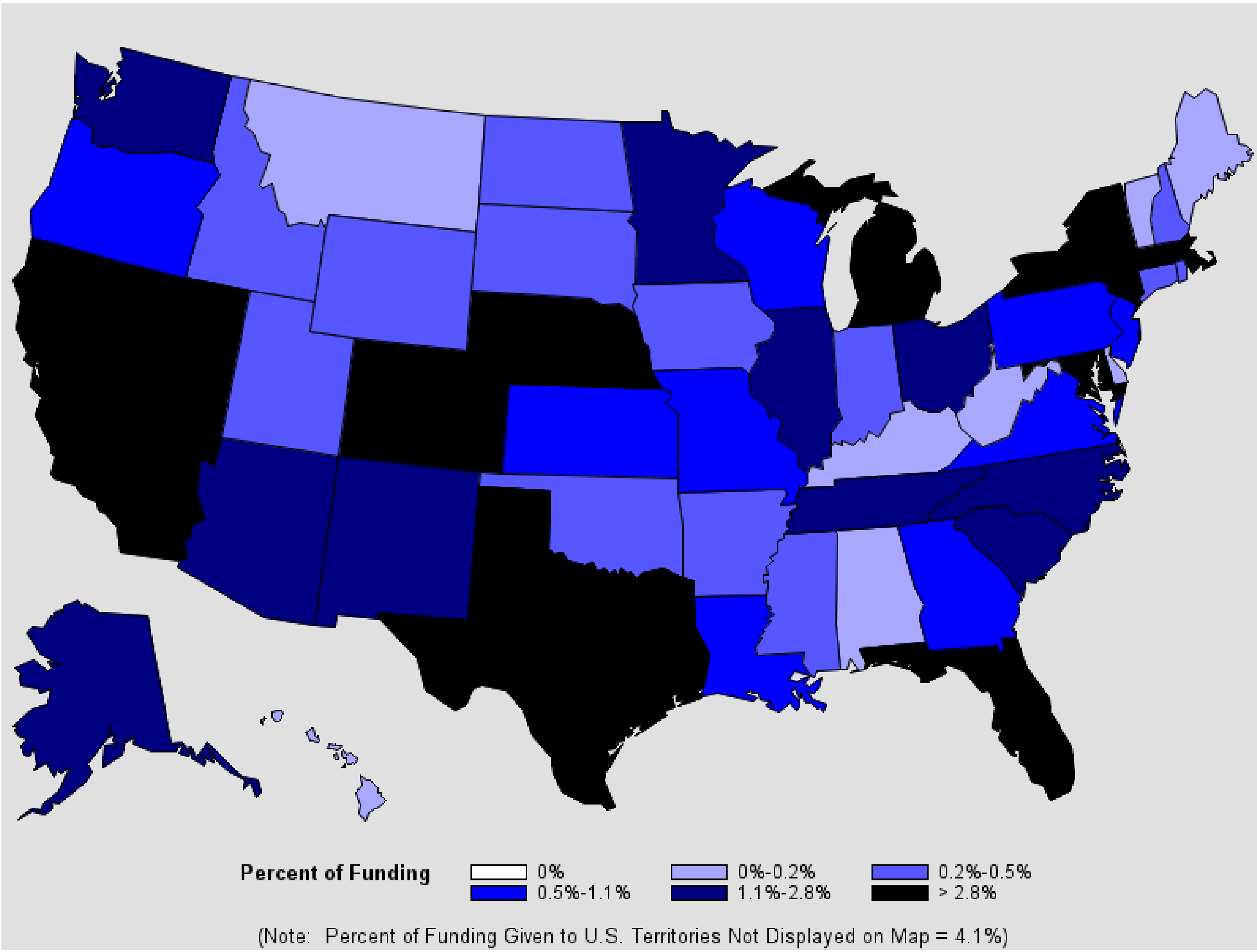

Figure 19: BPA=buildings and facilities, type=total, percent of funding by state

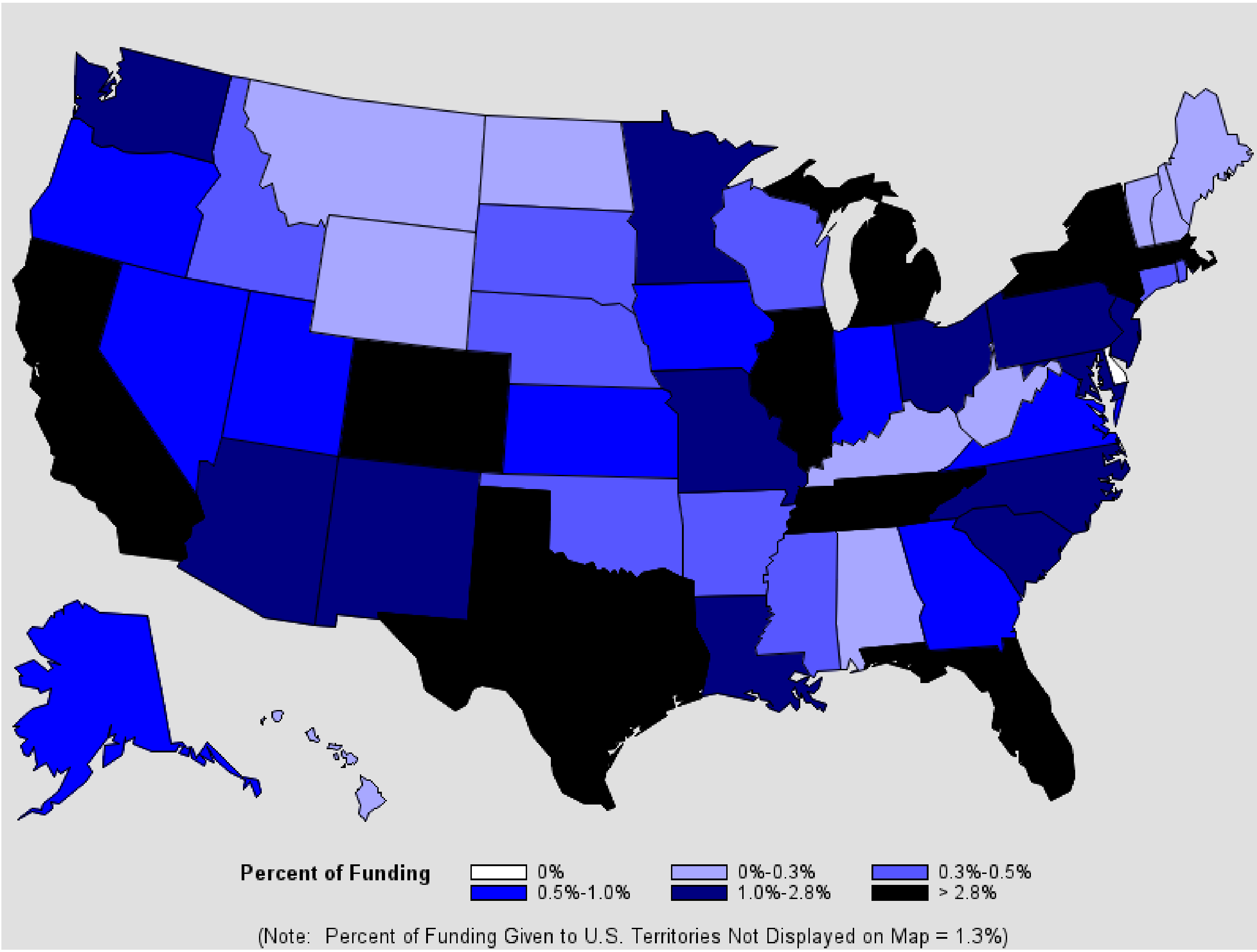

Figure 20: BPA=buildings and facilities, type=direct, percent of funding by state

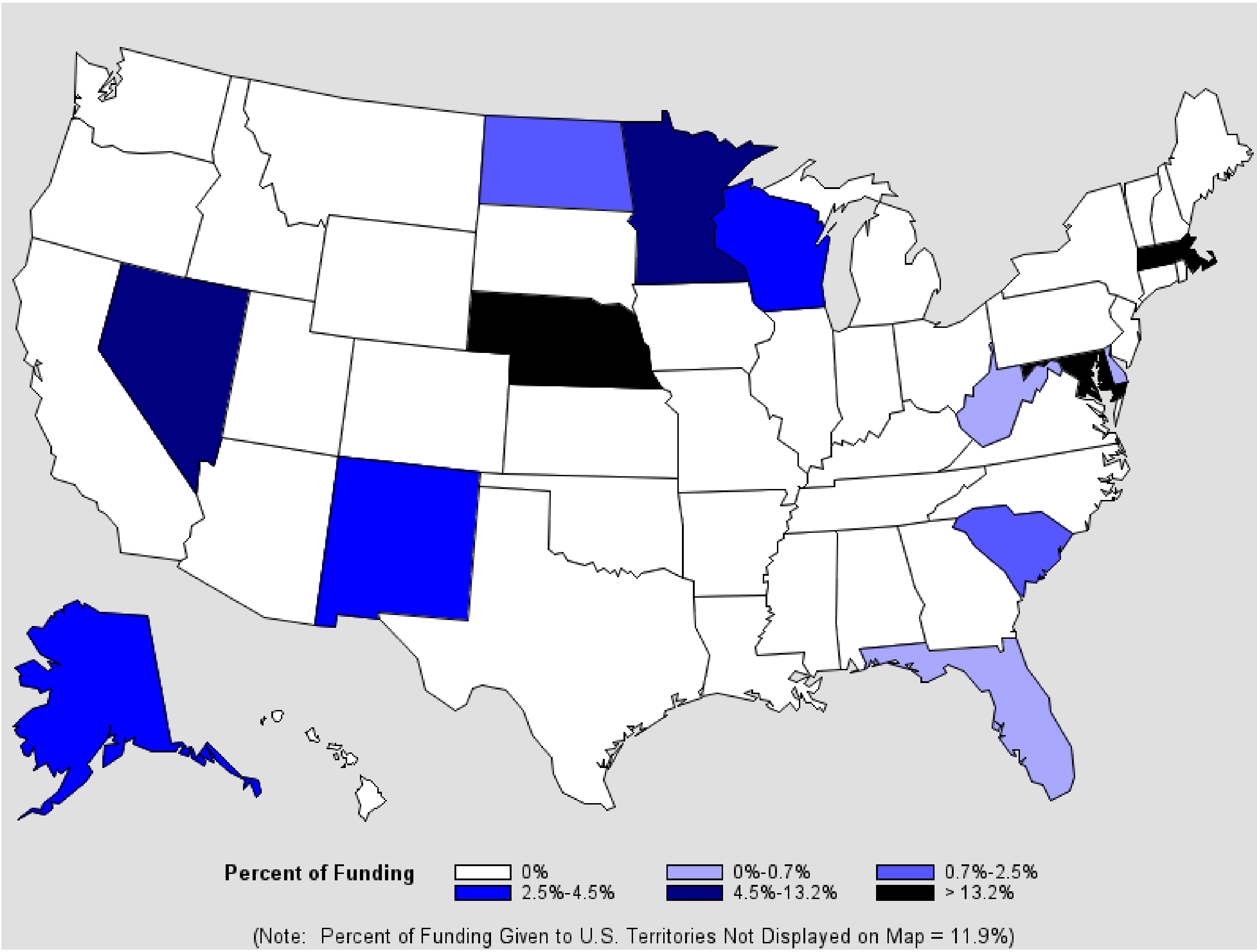

Figure 21: BPA=buildings and facilities, type=indirect, percent of funding by state

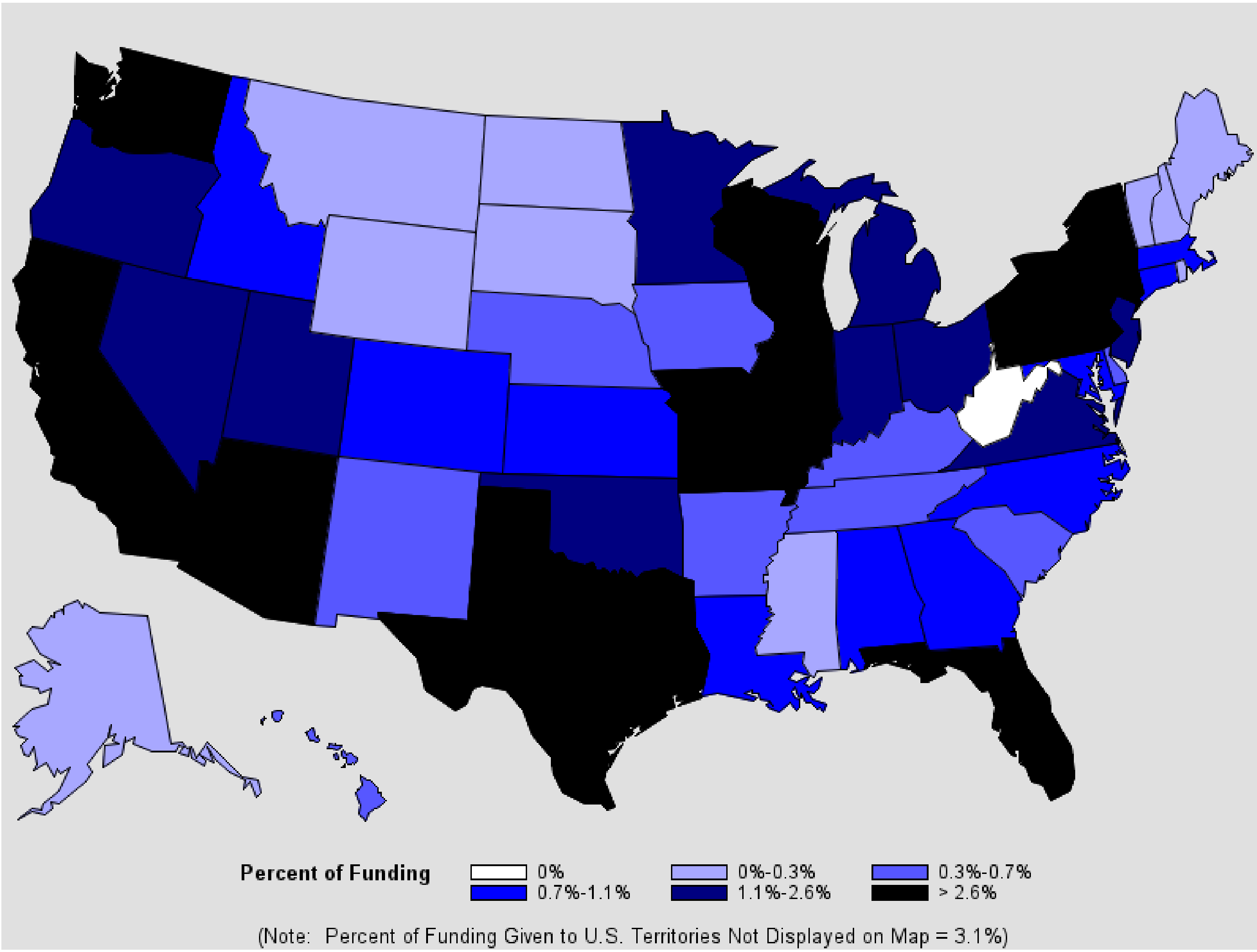

Figure 22: BPA=lighting, type=total, percent of funding by state

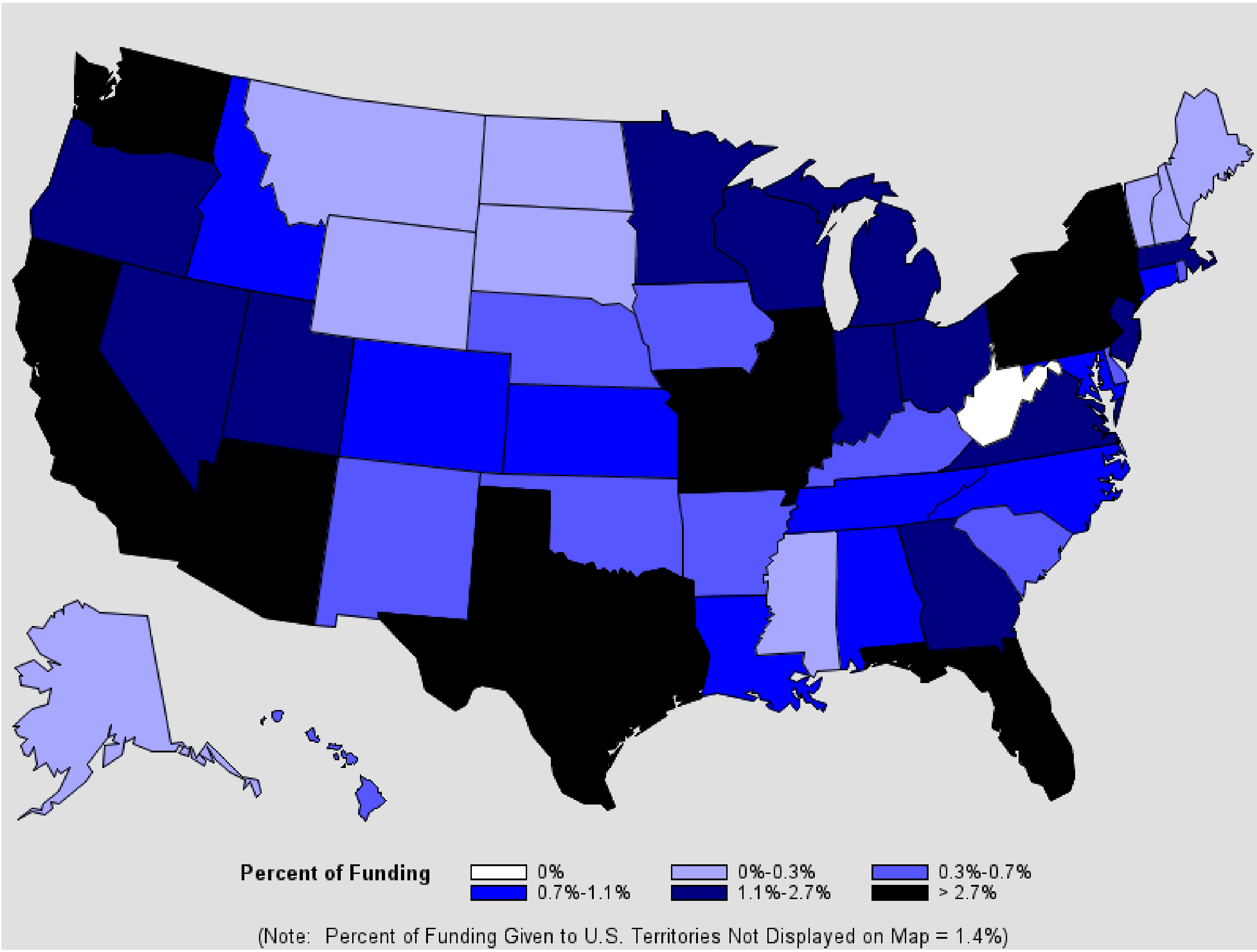

Figure 23: BPA=lighting, type=direct, percent of funding by state

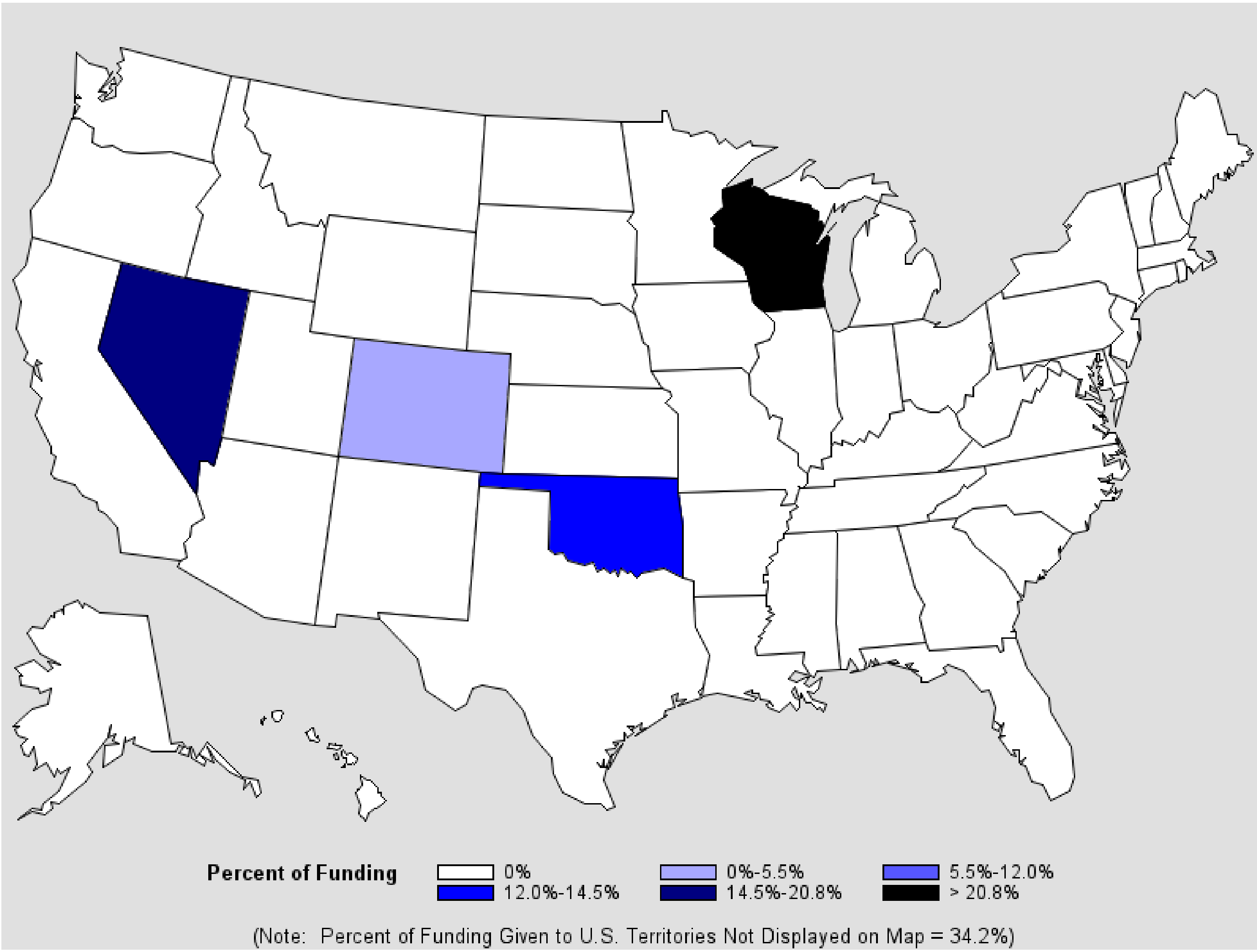

Figure 24: BPA=lighting, type=indirect, percent of funding by state

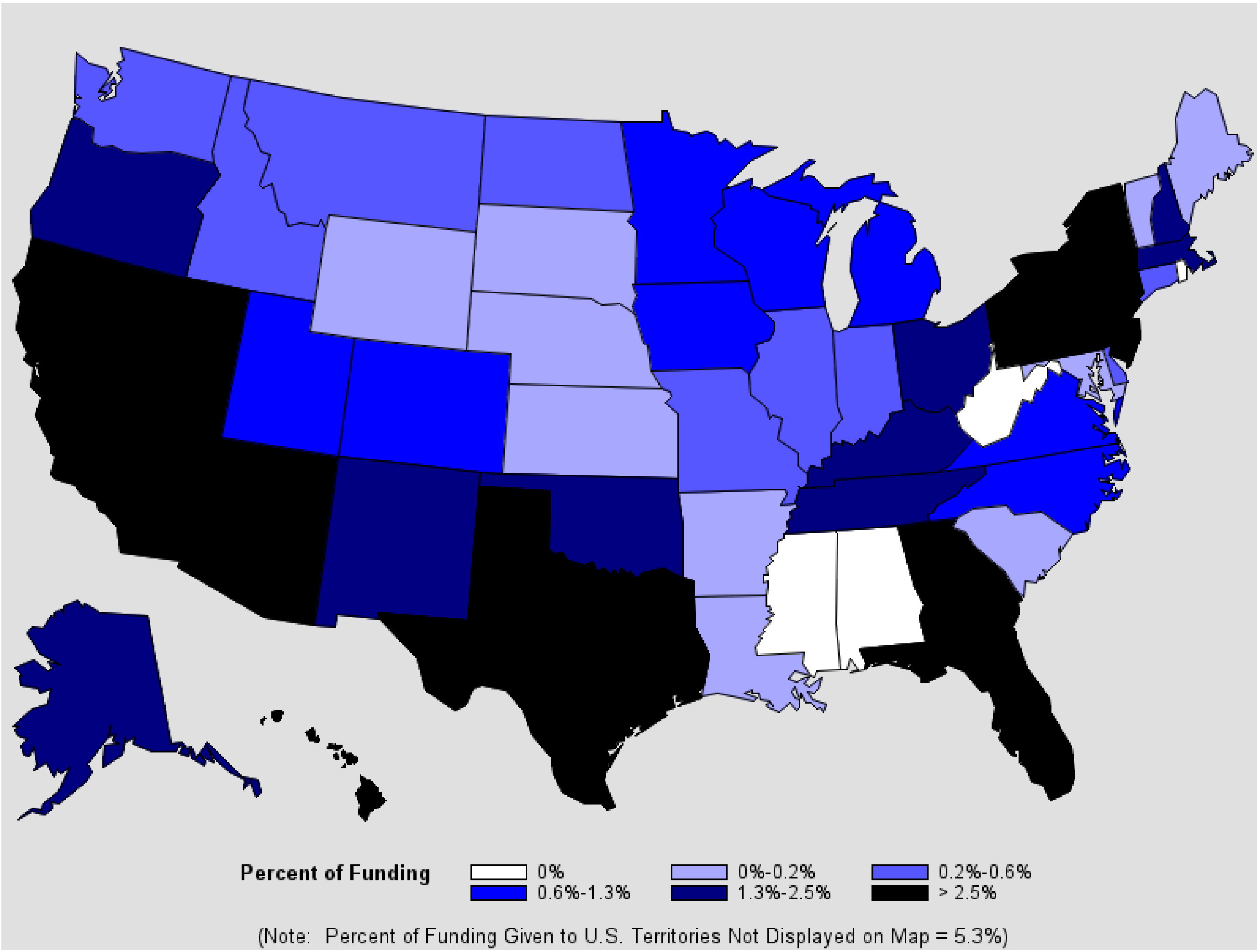

Figure 25: BPA=on-site renewable technology, type=total, percent of funding by state

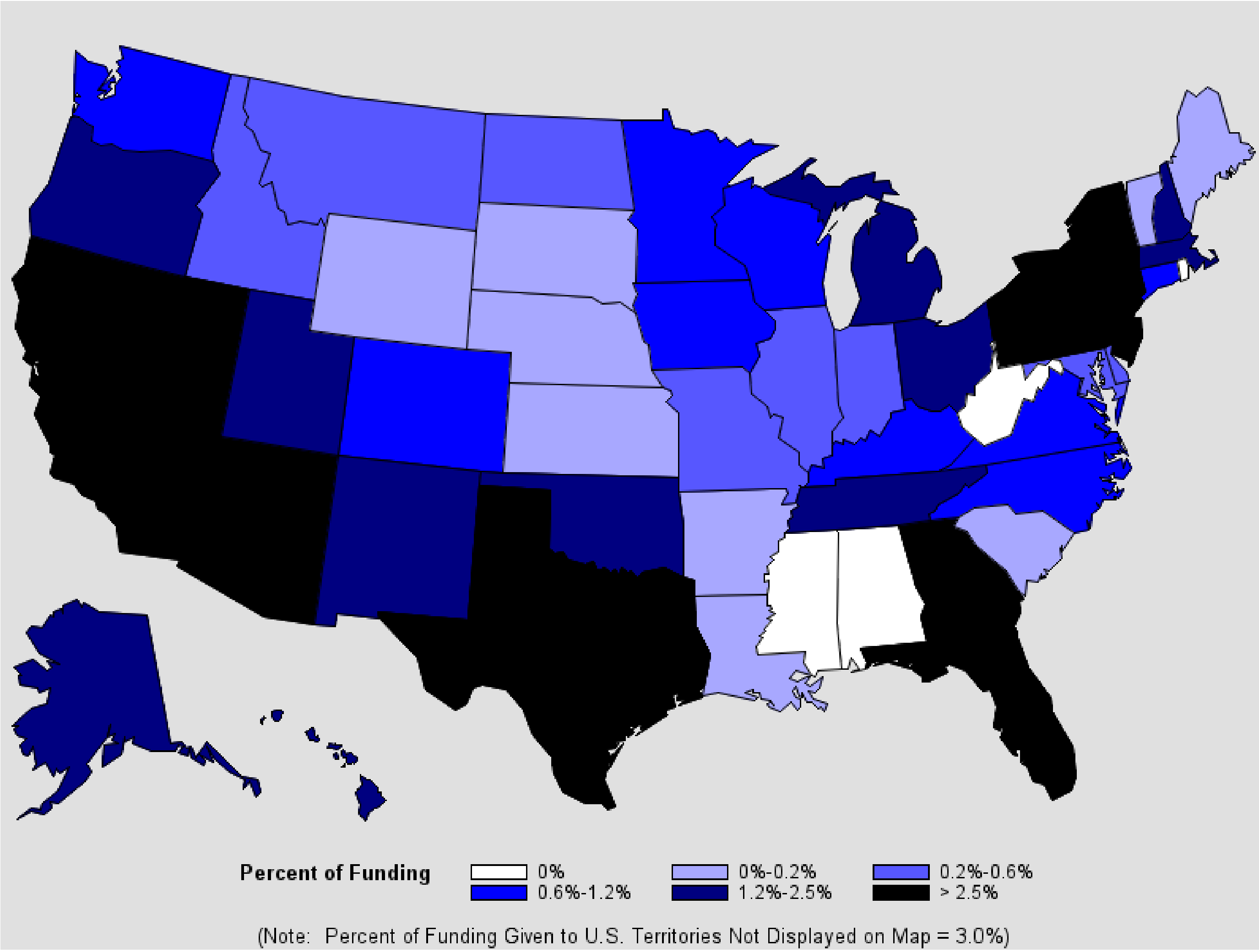

Figure 26: BPA=on-site renewable technology, type=direct, percent of funding by state

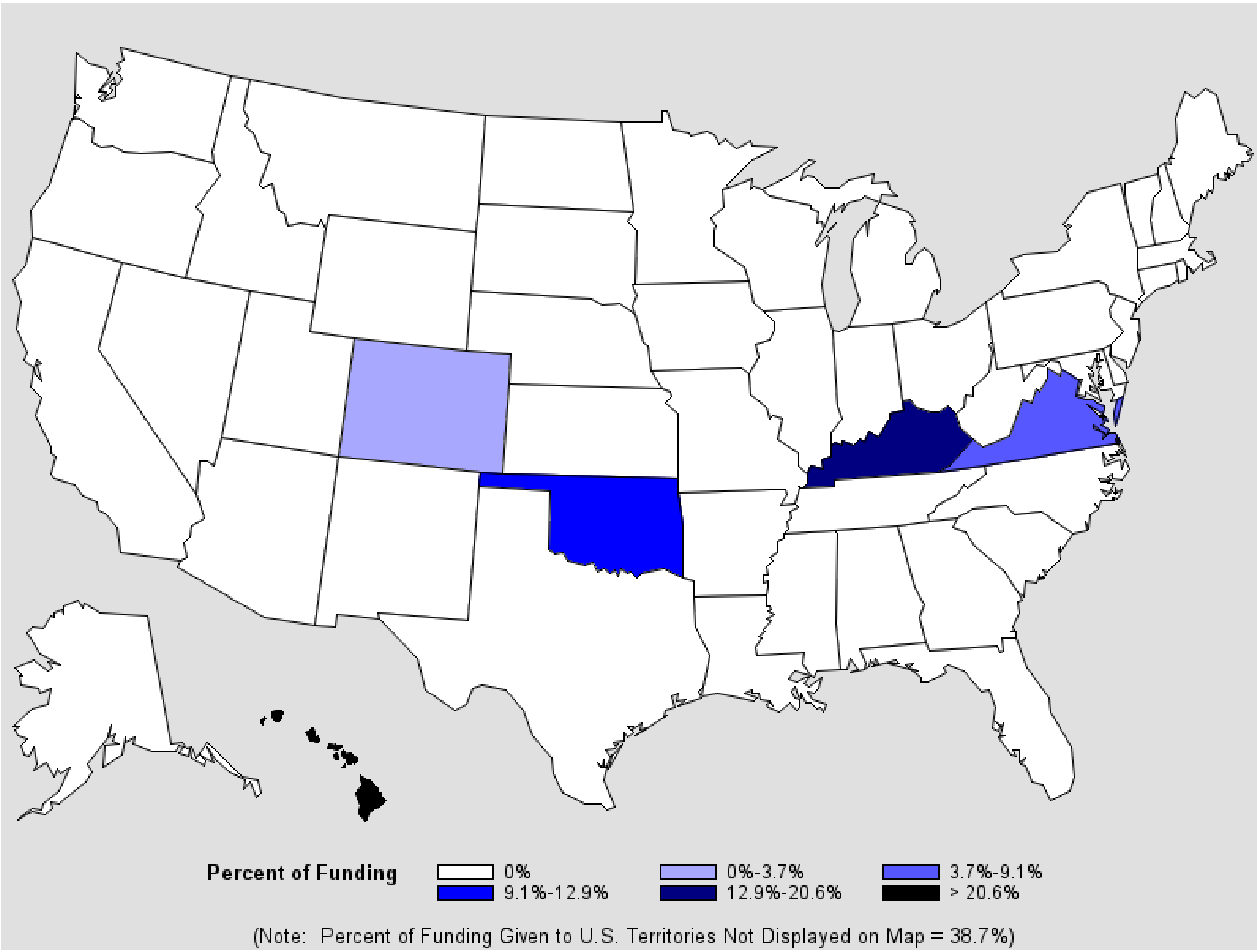

Figure 27: BPA=on-site renewable technology, type=indirect, percent of funding by state

H.5. REFERENCES

Binder, D.A. (1983). "On the variances of asymptotically normal estimators from complex surveys." International Statistical Review, 51, 279-292.

Tepping, B.J. (1968). "The estimation of variance in complex surveys." Proceedings of the Social Statistics Section of the American Statistical Society, pp 11-18.

Wolter, K.M. (1985). Introduction to Variance Estimation. New York: Springer-Verlag

APPENDIX I. DETAILED LABOR IMPACT METHODOLOGY

I.1. INTRODUCTION

The purpose of this section is to describe how employment impacts evolve from (1) direct spending from EECBG activities nationwide and, (2) the direct energy saving outcomes from those completed projects net of participants' project-related costs (up-front or loan repayment costs).

Employment impacts reflect jobs created or retained. A multi-regional macroeconomic impact forecasting model of the United States called the REMI model[26] was used to gauge the annual job changes based on (i) initial EECBG spending that is domestically supplied, and (ii) the effects from net energy bill savings within different customer segments. Spending consists of program administration costs and costs tied to incremental costs for equipment above the base case technology. For household (and institutional public) participants, the savings after paying any costs related to their energy improvements (net savings) will drive more household (public sector) spending. For all other types of participants, the net savings are a reduction in the cost-of-doing- business. The latter exerts a unique response (specific to each NAICS code activity) on the ability of businesses to expand their sales into domestic and foreign markets.

Within the REMI model, the resultant impacts from (i) and (ii) not only reflect a "direct" job equivalent, but also jobs from the multiplier effect on direct jobs and the consequences of energy savings moving through the economy. Hence, the nature of the annual job change is a total impact comprised of a direct element and a non-direct element. The latter represent two types of employment: the indirect (the local supply chain reaction that is initiated by the direct spending that is locally fulfilled) and the induced economic transactions (initial "after-tax" wages driving consumer purchases). The EECBG attributable impact results from this modeling exercise are defined as the change relative to the REMI base case economic projection in any particular year.

Findings are presented by BPA. Key impact metrics from this analysis are as follows:

- Direct jobs and job years produced – These are the short-term jobs that represent the number of people whose work is directly billed to an EECBG construction project. These jobs may be part-time or full-time, but for each year, they are reported against a non-EECBG baseline. In other words, they are not intended to be cumulative.
- Total employment over the life of the program's impacts – this metric represents direct jobs and employees working for producers of materials, equipment, and services that are used on the EECBG-supported construction project, such as steel producers or producers of accounting services. It also includes those jobs created when employees (working on EECBG-funded construction projects) spend their increased incomes on consumer goods and services.
- Incremental employment impact by sector – this metric shows the composition of total employment created by EECBG spending. For example, short-term employment tends to be concentrated in the construction sector as projects are being implemented. Later, spending and employment move to other sectors as the initial project spending moves through the economy.

I.2. METHODS

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[26] Produced by Regional Economic Models, Inc. (REMI), of Amherst, MA. (www.remi.com)

The jobs analysis presented in this report was determined by the nature of EECBG-related spending and subsequent changes in costs through more efficient consumption of energy products. Consequently, we followed the Renewable Energy Efficiency Mapping (REEM) framework developed by the Economic Development Research Group to analyze the ways in which EECBG dollars are injected into the economy and how they influence economic outcomes in different market segments.[27]

REEM is used with information and assumptions from the contractor team as a preprocessor to ensure that data reflecting energy policy and program implementation activities are characterized thoroughly and properly. While REEM can perform key allocation mapping, many of the REEM inputs and industrial sector mappings were developed by the contractor team as part of the EECBG program evaluation and cost-effectiveness analysis. Sectors receiving funding were known, and project cost allocations between labor and equipment were assigned based on factors developed from each PA.

The resulting expenditure allocations were inputs for the REMI model to explore their short-term direct and subsequent multiplier effects on each of the regional economies. The REMI model is capable of capturing how short-term and longer-term cost changes in the commercial (including private institutional) and industrial customer segments affect their product sales, which impacts job retention and creation. For example, commercial or industrial customers with a lower energy bill has lower costs of doing business in their region and, as a result, are more competitive within local markets or domestic and international 'extra-regional' markets where the customers compete for business. This cost-competitiveness response, unique to each NAICS code of the Commercial or Industrial energy customer, grows sales, along with jobs, labor income, and value-added product. In addition, households have more disposable income to spend on other goods and services when they are able to lower their energy consumption.[28]

In addition, this activity may reduce energy generation that would have implicitly sent some dollars out of the nation for fuel imports.[29] Domestic displacement that results along the energy generation supply-chain and the foregone foreign fuel imports are replaced in part with locally provided services (to install and maintain lower energy using dwellings or facilities), and some locally sourced equipment, components, and installation services. In Figure 28, the left portion of the diagram portrays the set of direct effects that are possible with a broad range of energy-related investments and objectives. This analysis addresses program administration in addition to household, business, and institutional spending and energy savings.

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[27] Economic Development Research Group. Renewables & Energy Efficiency Impact Model. http://www.edrgroup.com/tools/reem-renewables-energy-efficiency-impact-model/

[28] A large part of the model's econometric equation structure is defined at the industry level to forecast or *predict impacts* in annual dollars of output (production), annual dollars of value-added on that production, the annual employment needed, and the annual labor income generated. Apart from what the model structure can account for, if there are *effects* from *emerging technology* the model does not internally account for this. As such, the REMI model should never be construed as an 'expert system' of microeconomics for any single industry (e.g., it is not a load-dispatch model determining prices and labor requirements for the electric utility generation and transmission distribution sector).

[29] This is unless new export demand can be identified to absorb that generation.

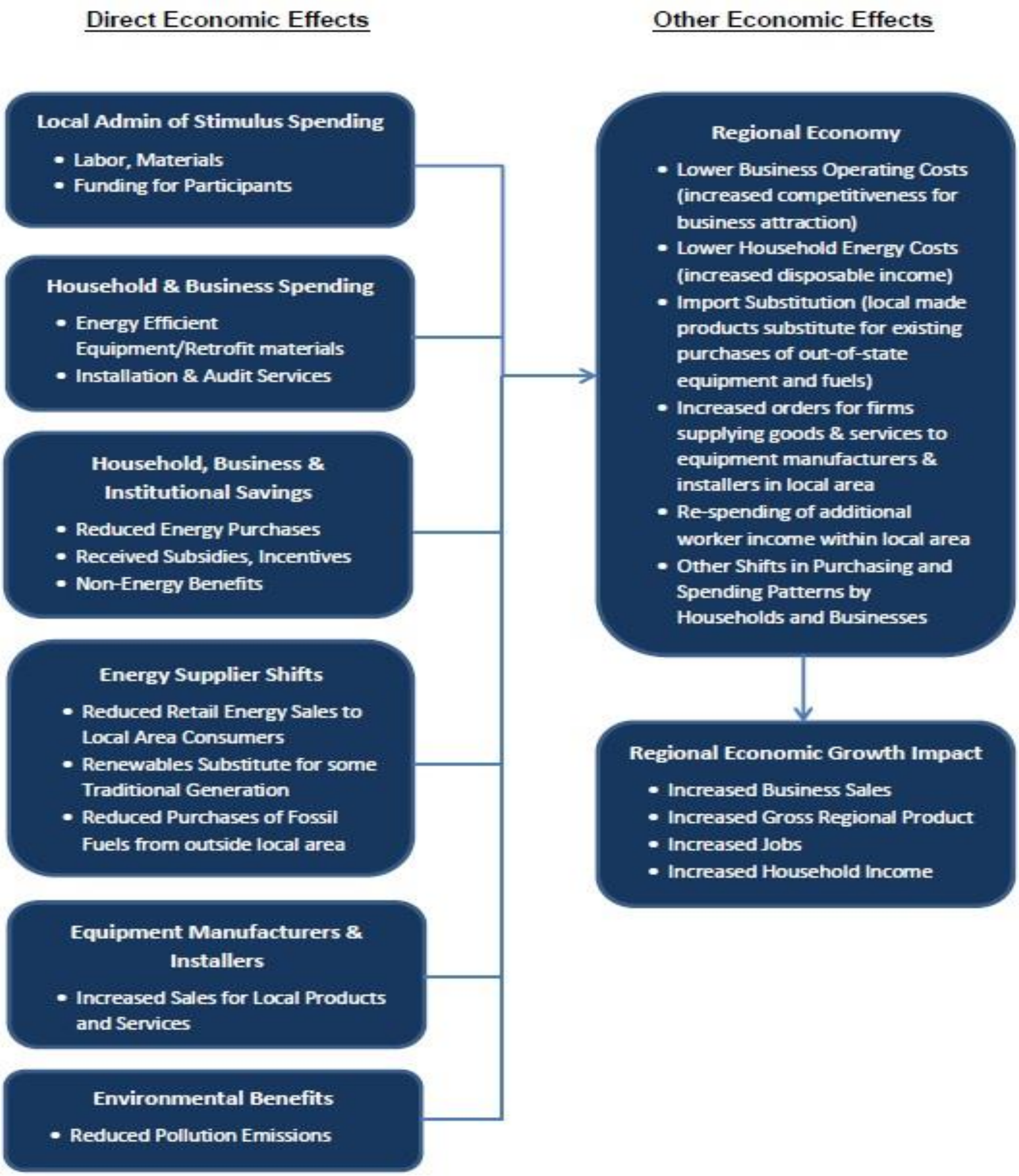

Figure 28: REEM framework for energy impact analysis

Source: ©2005-2014 Economic Development Research Group, Inc.

I.2.1. Energy Investments and Macroeconomic Responses

The four major categories of direct effects associated with energy policies or investments and their potential to initiate macroeconomic responses are described in this section. In addition, the analysis requires tracking these activities by the geographic regions where the expenditures occurred and by the type of activity (e.g., energy audits and assessments, energy efficiency upgrades, or on-site renewable electricity generation). The four direct effects categories are described below.

I.2.1.1 Local administration of stimulus spending

These dollars are spent to operate the EECBG activities. This spending includes incentives and loans disbursed to business and household participants, as well as expenditures for program management, marketing and participant information, workforce development and training, and quality assurance and control.

I.2.1.2 Household, business, and institutional energy bill savings

These savings include estimated energy bill savings by commercial or industrial businesses, agencies, and households from reductions in energy consumption and additional on-site generation capacity realized because of the EECBG-funded activities. The estimated dollar savings for a participant are the recurring energy bill savings minus the out-of-pocket expenditure (explained next) for the energy upgrade project. Changes in net energy savings create changes in discretionary funds available for households to spend on additional goods and services in current and future periods. For participating commercial or industrial facilities, the estimated net energy bill savings lower operating costs. For participating government facilities, the net energy bill savings augment public spending.

I.2.1.3 Household and business expenses

Participating households and businesses incur additional expenses related to making improvements. These expenses, net of rebates and incentives, are associated with the incremental cost of purchasing and installing energy retrofits and upgrades, including efficient equipment or on-site renewable electricity generation. Participants' net expenses alter current spending behavior of households and profitability of businesses.

For example, if a project has an incremental cost of $100,000, this is the level of expenditure (demand) introduced into the regional economy. However, in this hypothetical case, the participant's cost is $100,000 minus EECBG payments ($50,000), minus leveraged rebates attributed to the program ($40,000). Accordingly, the participant's out-of-pocket expense in this instance would be $10,000.

I.2.1.4 Equipment manufacturers and installers

The incremental cost of a project (referenced in I.2.1.3) includes all necessary expenditures, regardless of who pays for them. Some portion of the new demand for equipment will be fulfilled locally through either local manufacturing or through a local wholesale (and possibly retail) distributor channel if components are manufactured out of region.

Items that are locally transacted in the model trigger a particular set of economic linkages associated with energy upgrade products purchased from a wholesale distributor or manufacturer located within one of the eight regions defined in the model. Regions are multi-state aggregate economies and therefore exhibit diverse economic activity. Therefore, for most energy upgrades, the purchase region is the same as the region where the upgrades were installed. The next important issue is whether the local purchase is supported by a manufacturer or a distributor.

Items that are locally manufactured in the model trigger a different set of economic linkages associated with equipment manufactured in various regions. This is because each region has its own level and mix of manufacturing. Most U.S. manufacturing for energy efficiency and generation occurs in regions 3, 4, and 5 (Great Lakes, Plains, and Southeast, respectively).[30,31] One example is Trane in Wisconsin (region 3). Examples of manufacturing outside these regions are heating and cooling equipment manufactured by Goodman in Texas (region 6), and by Carrier in New York (region 2). REMI model data inputs for equipment investments are described as follows:

- Labor cost by type (e.g., auditing or construction) will be sourced entirely within each region where the labor demand increases
- "Locally manufactured or procured" building equipment (e.g., windows, insulation, HVAC, and motors) or production system components (e.g., solar panel assembly tables, injection molding and cutting machines, chemical baths, and furnaces) is allocated to the region of manufacture, determined by the Regional Greenhouse Gas Initiative.
- Equipment investment associated with institutional public sites will use manufactured components that reflect 97% American manufacturing (the remaining 3% is assumed to be imported) as a result of the Buy American policy that was put in place at the start of the ARRA-period[32]
- Equipment investment associated with all other customer segments will reflect content of 70% from the United States (based on the REMI model's U.S. manufacturing regional purchase coefficient averaged between 2009 and 2013)
- Based on the contractor team's research on the U.S. manufacturing landscape for energy efficient devices and renewable system components, the U.S. orders arising from the EECBG equipment demand are allocated across the eight sub-regions as follows:

Table 25: Percent of U.S. orders by region

Region	Percent U.S. Orders
New England	4%
Mideast	11%
Great lakes	21%
Plains	9%
Southeast	25%
Southwest	14%
Rocky Mountain	3%
Far West	14%

Source: U.S. Census of manufacturing value for NAICS 331-335

[30] U.S. Census Bureau, series 12s1012, https://www.census.gov/compendia/statab/cats/manufactures/manufactures--establishments_shipments_employees_payroll.html
[31] Helper, Susan, Timothy Krueger, Howard Wail, "Locating American Manufacturing: Trends in the Geography of Production," Brookings Institute, April 2012 http://www.brookings.edu/research/interactives/manufacturing-interactive
[32] Email correspondence between Joseph Schilling, U.S. DOE and Martin Schweitzer, ORNL, February 24, 2014.

I.2.2. Modeling Approach

The model used for this analysis was the REMI Policy Insights Plus (PI+).[33] It depicts an eight-region model of the national economy with detail to address impacts on the residential household sector and 21 additional sectors (17 private-sector non-farm NAICS, a farm sector, two Federal government sectors, and a combined state/local government sector).

The model integrates input-output, computable general equilibrium, econometric, and economic geography methodologies[34] into an annual forecasting system capable of doing analysis through 2060. Results are reported for the United States as a whole through 2050, but the model includes the ability to adjust a full range of variables to introduce direct elements of an activity or policy change and assess economic impacts for a targeted region.

The analysis models one case for the EECBG program administered during the ARRA-period. The model uses inputs specified by the user to make an alternative forecast to the baseline. For this period, the baseline is the status quo (i.e., what would have occurred without ARRA funding).

The model generates a default baseline level of economic activity based on regional industry and labor market interactions, and relative prices. When model inputs are changed, (e.g., a change to participant energy-bill savings), the model recalculates economic flows and presents results in terms of change from the baseline. The steps used to calculate labor impacts are as follows:

1. Define the desired set of direct project effects for analysis.
2. Develop the macroeconomic model with required responses. REMI calibrates these by region and by industry, and the output becomes the baseline scenario forecast.
3. Map region-specific, project-specific direct effects into economic changes to be used as inputs to the model.
4. Adjust the model to reflect these program-related economic changes, and rerun the model.
5. Extract the resulting regional annual total employment impacts (total equals direct plus indirect plus induced impact cycles) and sum for national level result.

To estimate employment effects and other macroeconomic changes from EECBG spending, key information was assembled from the BPA impact estimation process. For example, estimated energy bill savings, incremental project costs, and direct expenditures for program operations and support services were used as key input data to the macroeconomic analysis.

Changes in the model output from the baseline represent the change caused by the introduction of the additional EECBG spending and the ensuing cycle of net energy savings by different customer segments. The impact is the resulting estimated annual change in employment from what it would have been without the program. The change can be shown as a difference from the baseline or as a percentage change. Figure 29 depicts this sequence of analysis.

[33] Amherst, Massachusetts. www.remi.com.
[34] REMI PI+ V1.6 model equations, 2014 Regional Economic Models, Inc., http://www.remi.com/products/pi.

In a multiregional REMI model, an economic event in one region will have varying spillover effects on surrounding regions. Triggered by the investment or policy under study, these effects result from preexisting patterns of labor flows, interregional business transactions, and changes in relative competitiveness.

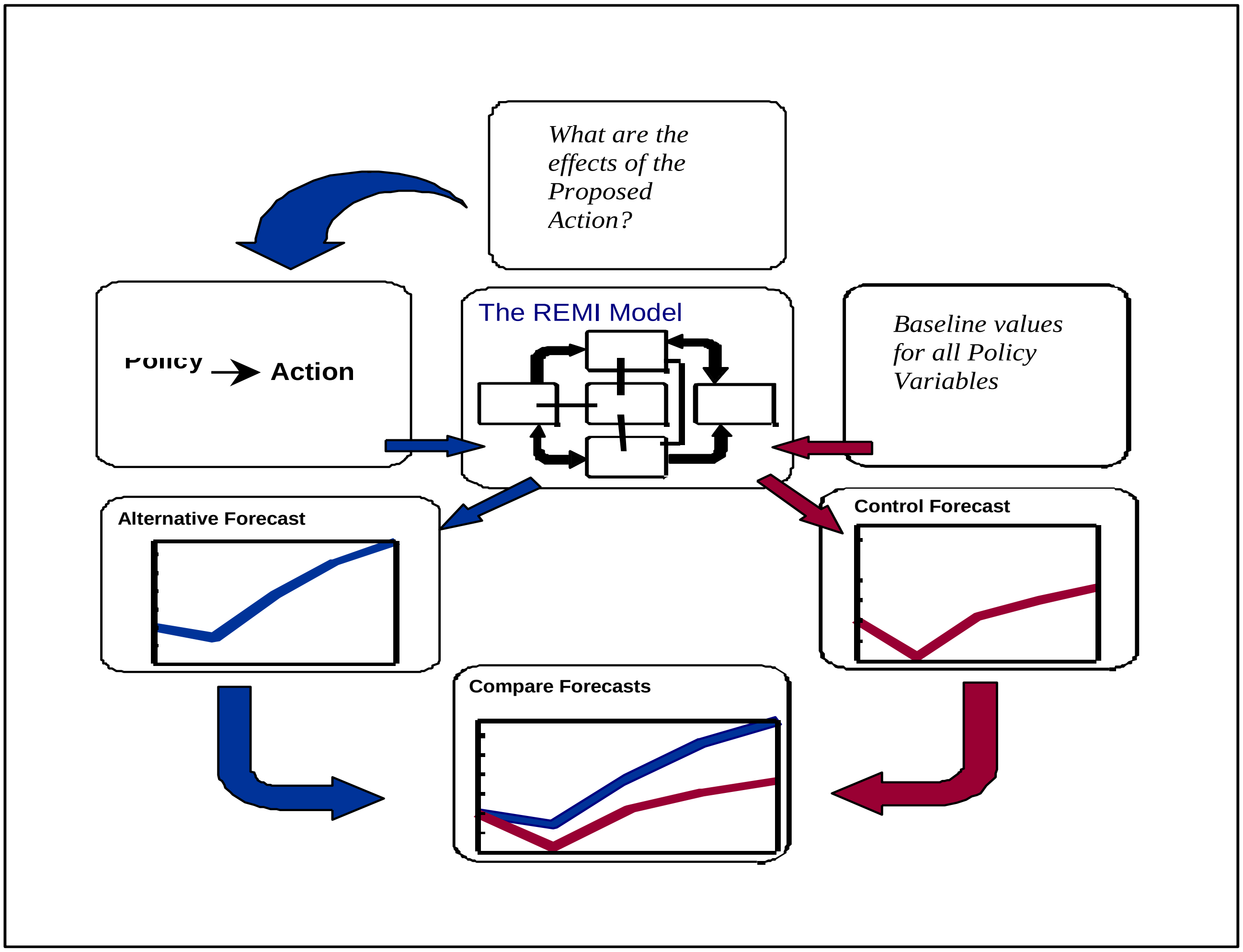

Figure 29: Identifying annual economic impacts from EECBG activities with the REMI model

I.2.2.1 Analytical process

The contractor team developed a series of expenditures and bill savings representing a time series (for the interval 2009 through 2050) for each activity in each BPA. To support the macroeconomic analysis, program activities were divided into customer segments (residential, commercial, industrial, public institutional, and private institutional) and then by region. A high-level flowchart of this process is shown in Figure 30.

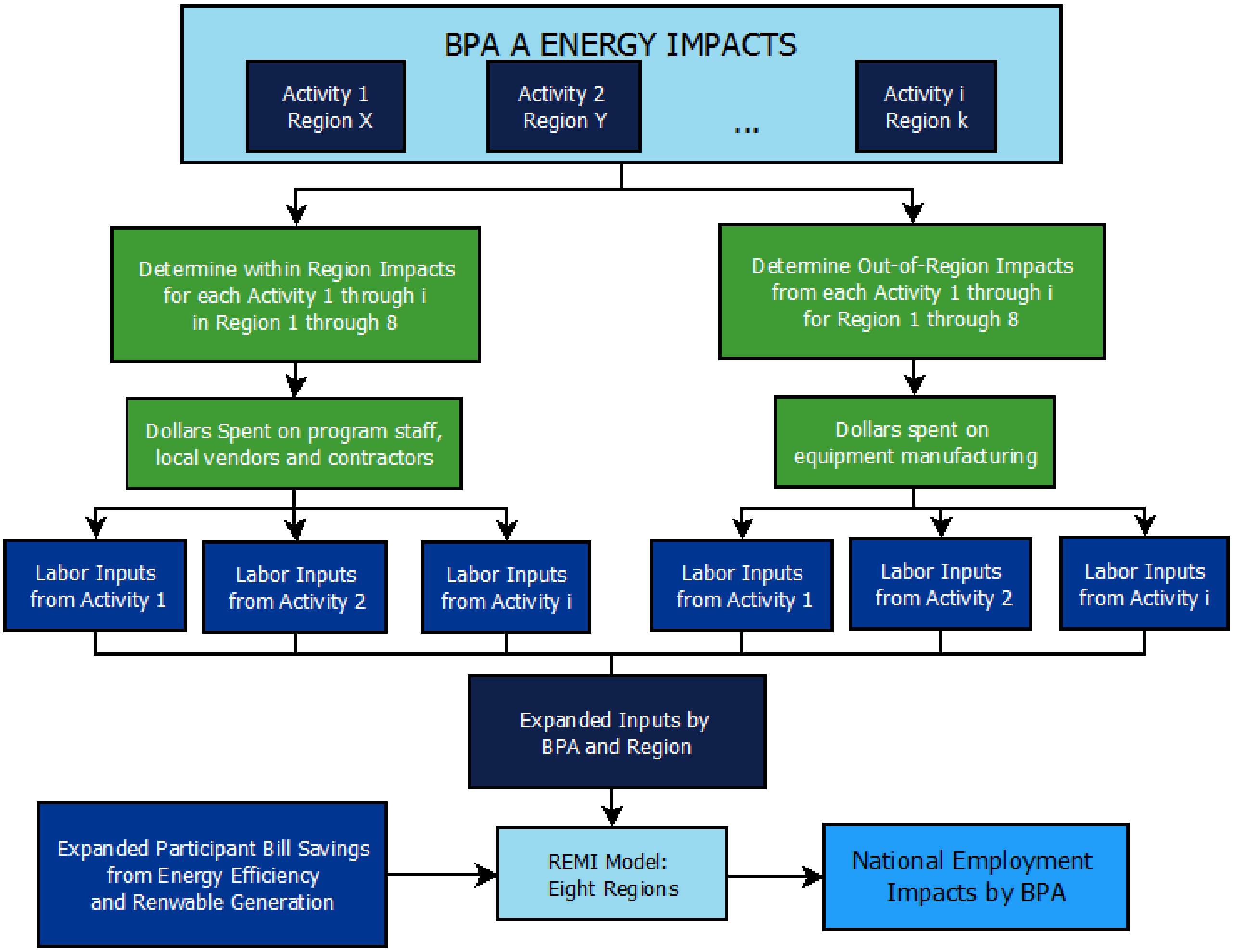

Figure 30: Calculating national employment impacts by BPA from activity-level data

The dataset for each BPA contains administrative costs, incentive and rebate costs, incremental project costs, loan costs, and estimated energy bill savings from reduced electricity, natural gas, or other fuel consumption. Incremental project costs were broken out into labor and equipment spending by BPA. The development of these inputs is detailed in section I.3.

The contractor team used an eight-region model rather than a 51-state model to calculate labor impacts. Using an eight-region model reduced the challenges associated with expanding sample derived, activity-specific impacts into workable economic regions for the macroeconomic impact analysis. Instead of looking at out-of-state impacts at the individual state level, we looked at impacts by major economic regions defined by the U.S. Bureau of Economic Analysis. These regions are broken up into groups of states that are geographically and economically similar. The contractor team assigned labor and equipment costs and the effects of fuel displacement as “within region” or to one of the remaining seven economic regions.

Applying a set of assumptions to the steps in Section I.2.2 made it possible to map or translate these concepts into a set of interactions initiated by the activities that alters the baseline macroeconomic trajectory across each region.

I.2.2.2 Modeling EECBG activities in REMI

To create a macroeconomic forecast across the eight sub-national regions, costs and economic benefits associated with EECBG activities were entered into the REMI analysis model for each BPA as described:

- Labor dollars for the installation of any project were considered local labor compensation payments by sector (defined at the two-digit NAICS code level). The projects supported under EECBG rely on labor-intensive activities such as retrofits and retrofit-related BPAs, construction labor (NAICS code 23), and professional and technical services (NAICS code 54).
- Equipment dollars represented the energy upgrade measures installed through the EECBG program. U.S.-made equipment is procured across the eight model regions' manufacturing sectors according to allocations presented previously
- Incentives and rebate dollars were applied to project costs to reduce the cost of projects to participants.
- Financing cost payment flows were determined using program-specific interest rates and loan durations. Energy savings associated with future loans were dollar constant based on initial program loan dollar to energy savings ratios. For example, if each loan dollar generated 200 kWh in savings, that same ratio was applied for each reloan period.
- Financing cost flows were deducted from estimated energy bill reductions to determine net energy-bill dollar flows, which affect changes in the cost of living in the residential segment and the cost of doing business in the commercial, industrial, and institutional private customer segments.
- Incremental project costs were converted to net project costs by deducting incentives and rebates.
- Program operations spending (apart from incentives and financing) included state government employee compensation for day-to-day program activities.
- Renewable manufacturing labor costs resulting from expanded operations were treated as wages rather than participant costs.

I.3. ASSUMPTIONS

Key assumptions in the analysis of labor impacts using the REMI model are listed below:

- All analyses were standardized on and reported as 2009 dollars.
- Revolving loan program interest rates and terms varied across regions according to program documentation. The reloan period was standardized at one year and we assumed funds were recirculated for 20 years. Principal and interest collected was reloaned each year for the same term and interest rate determined for each activity. In addition, energy savings remained at the same loan dollar to energy savings ratio as the original loan. Loan repayment begins one year after loan disbursement.
- Gross project cost was the basis for creating the "demands" allocated between energy-efficient (or renewables) equipment and labor for installation/inspection/audit activities.
- Each region contained an allocation of EE manufacturing activity for sourcing equipment as explained in section I.2.1.4

- Program-administration costs (net of the incentive and financing budgets) were modeled as labor payments for state and local government employees to run day-to-day aspects of the program.

- Participant estimated net energy bill savings were specified after considering any future stream of loan repayment cost. Loan repayments began one year following disbursement of funds.

- Net energy-bill savings streams for programs were estimated over the period of analysis, which for most programs is consistent with the program's savings-weighted average measure life.

- Bill savings were calculated using actual and EIA forecast state-average retail rates by sector and fuel type.

- Direct expenditures on project labor occurred in the region where the project was implemented. The contractor team developed these allocations by BPA and sector as inputs to the REMI modeling process. Data sources included; the DEER database, prior DNV GL research reports, expert interviews, NREL reports, and PNNL models. The final allocations are shown in Table 26 that provides the percentage of project spending that was allocated to equipment costs.

Table 26: Equipment and labor cost allocations

BPA	Residential	Commercial	Industrial	Institutional-Public	Institutional-Private
1. Energy Efficiency and Conservation Strategy	0.65	0.60	0.60	0.60	0.60
3. Residential and Commercial Buildings and Audits	0.65	0.60	0.60	0.60	0.60
4. Financial Incentive Program	0.65	0.60	0.60	0.60	0.60
5. Energy Efficiency Retrofits	0.65	0.60	0.60	0.60	0.60
6. Buildings and Facilities	0.65	0.60	0.60	0.60	0.60
12. Lighting	0.70	0.70	0.70	0.70	0.70
13. On-site Renewable Technology	0.86	0.86	0.86	0.86	0.86

- Participant costs (out-of-pocket costs for energy retrofit and upgrade projects) were the incremental project costs minus any rebate or other form of incentive. In most cases, these data were not available or were incomplete. To overcome this lack of cost data, the contractor team developed a model incremental-cost calculator to estimate the incremental project costs based on reported incentives, bill savings, and assumed payback periods for each Subcategory. These incremental equipment and labor costs along with the energy and bill savings datasets.

- The contractor team's approach to calculating incremental costs relied on the available data and assumptions on typical participant simple payback grounded in evaluation experience. Given an assumed typical payback period, the calculator solves for incremental costs using participant out-of-pocket expenses after rebates. Formally the equation is,

Total Incremental Costs =

$$\sum_{i \to all\ program\ years} \left[\left(\left(\frac{SEP\ Attributable\ Incentives_i}{Total\ SEP\ Attributable\ Incentives} \right) \times \sum_{Payback\ period} Net\ Measure\ \$\ Savings\ (Bill\ Savings) \right) + SEP\ Attributable\ Incentives_i \right]$$

i= specific program year

Table 27 shows the assumed payback period used as the default value in the incremental cost calculator. When information was available and documented for a specific activity, those data were incorporated into the incremental equipment and labor calculations.

Table 27: Default payback period assumptions for incremental cost calculator

BPA	STANDARD PAYBACK ASSUMPTIONS (in years)
1. Energy Efficiency and Conservation Strategy	4
3. Residential and Commercial Buildings and Audits	4
4. Financial Incentive Program	4
5. Energy Efficiency Retrofits	4
6. Buildings and Facilities	4
12. Lighting	3
13. On-site Renewable Technology	14

I.4. REFERENCES

Helper, Susan, Timothy Krueger, Howard Wail, "Locating American Manufacturing: Trends in the Geography of Production," Brookings Institute, April 2012 http://www.brookings.edu/research/interactives/manufacturing-interactive

Regional Economic Models, Inc. REMI PI+ V1.6 model equations, 2014. http://www.remi.com/products/pi.

U.S. Census Bureau, Manufactures: Manufactures—Establishments, Shipments, Employees, Payroll, series 12s1012, https://www.census.gov/compendia/statab/cats/manufactures/manufactures--establishments_shipments_employees_payroll.html

APPENDIX J. DETAILED CARBON IMPACT METHODOLOGY

Annualized CO_2 reductions achieved because of EECBG-funded efforts were calculated and reported for each year over the EUL of the measures evaluated. When the consumption of energy from fossil fuel resources is reduced from energy efficiency, the CO_2 emissions that would have resulted from burning those fuels are avoided. Likewise, when renewable energy is used as an alternative to fossil fuels, the CO_2 emissions associated with the replaced fuels are avoided. The evaluation team reviewed the use of biofuels for energy generation and incorporated additional CO_2 savings for instances where the biomass source represents a carbon sink before being harvested for use in energy generation.

Findings are presented by BPA and study period. Key avoided carbon emissions impact metrics are as follows:

- Avoided annual carbon emissions in million metric tons of carbon equivalent (MMTCE) (2009-2050)
- Lifetime avoided carbon emissions in MMTCE by sector
- Lifetime avoided carbon emissions in MMTCE by program mechanism
- Avoided annual (2009-2050) social costs in U.S. dollars ($2009)
- Lifetime avoided social costs of carbon emissions in U.S. dollars ($2009) by sector
- Lifetime avoided carbon emissions in U.S. dollars ($2009) by program mechanism

J.1. METHODS

J.1.1. Analysis Approach

Carbon impacts were calculated by applying the appropriate emission rates to the verified net energy impacts from each BPA. 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 other 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 net energy savings from energy efficiency or renewable generation and aggregated to the BPA level.

Emissions from energy efficiency, renewable generation, and direct carbon impacts were then aggregated to determine the total carbon impact for each BPA. This process is shown in Figure 31.

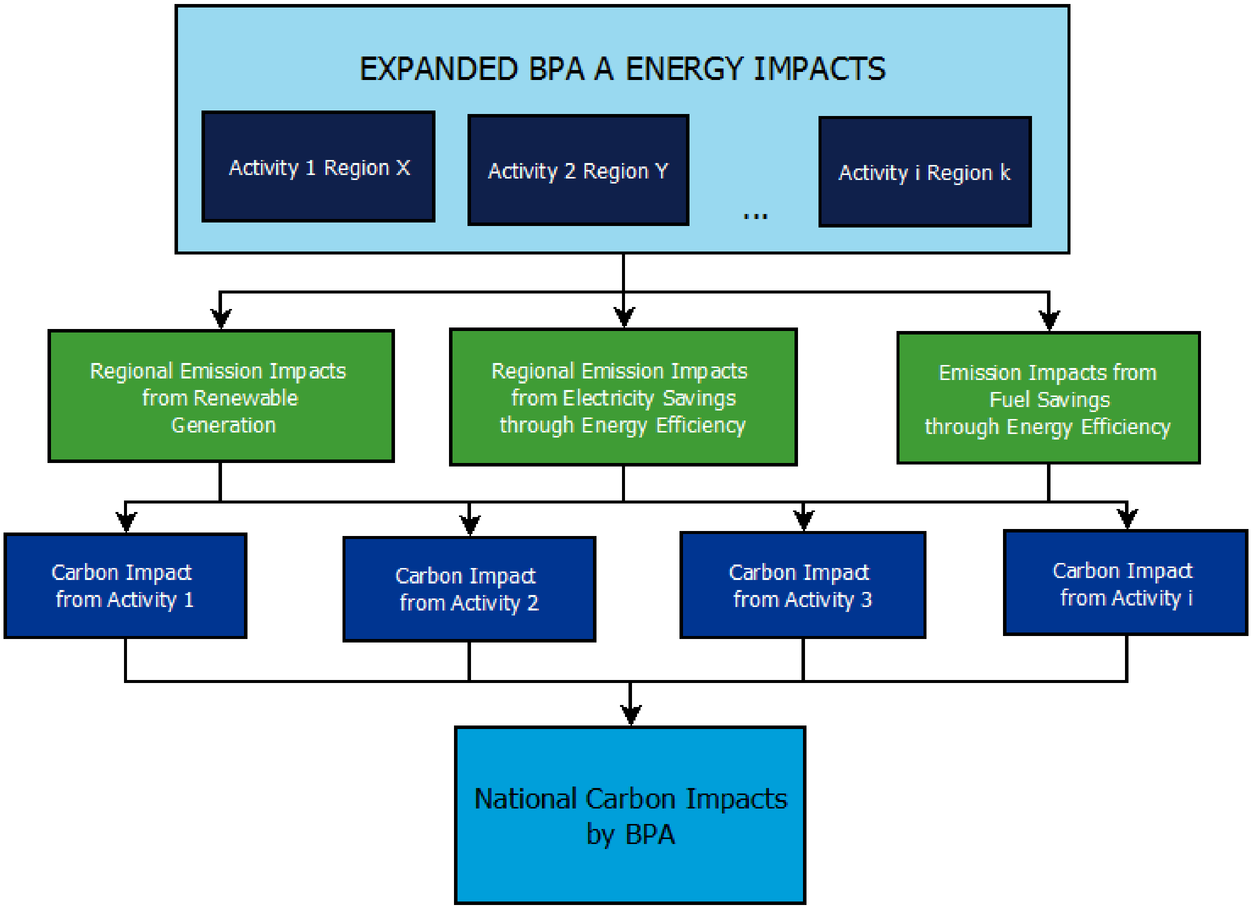

Figure 31: Analysis approach for national carbon impacts by BPA

J.2. ASSUMPTIONS

J.2.1. Electricity Impacts from Energy Efficiency

EPA recommends[35] that non-baseload emission rates be used to estimate emission savings resulting from energy efficiency and renewable energy programs. Non-baseload emission rates estimate the emissions from marginal generation units, which are those most likely to be displaced by electricity energy efficiency and/or renewable energy programs and projects. As such, the non-baseload emission rates used for this evaluation were derived from the EPA's 2009 Emissions & Generation Resource Integrated Database (eGRID) that provides non-baseload emission rates by state and emission type. The carbon dioxide equivalent emission rates used for this evaluation were calculated using the state-level carbon dioxide, methane, and nitrous oxide emission rates included in this database.

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

eGRID only reports emission rates for the 51 states; U.S. Territories are not included. Emission rates from the 51 states were not used as a proxy for the territories because the energy generation mix of the states was not comparable with the territories. Instead, the evaluation team used territory-specific 2010 total facility emissions from EPA's Greenhouse Gas Reporting Program[36] and 2010 net electricity generation from EIA[37] to calculate an average lb/MWh. Given the data limitations, it was not possible to calculate non-baseload emission rates. Furthermore, these data were only available for Guam, Puerto Rico, and the Virgin Islands; the calculated Guam emission rate was also used for The Mariana Islands and American Samoa based on their proximity to each other.

Electricity savings from energy efficiency and on-site generation only represents what is saved by the consumer. Those savings do not include electrical line losses from transmission and distribution to the grid, and therefore do not equal the total amount of energy displaced. The evaluation team adjusted these savings estimates to reflect the amount of energy saved at the generator by applying regional line-loss factor[38] from eGRID year 2009 data to the state-level energy savings. We used the line loss factor from Hawaii for the territories. The line loss factors used for this evaluation are shown in Table 28.

Table 28: eGRID estimated electrical line-loss factor

Region	Line Loss Factor (%)
Eastern	5.82
Western	8.21
ERCOT	7.99
Alaska	5.84
Hawaii/U.S. Territories	7.81
United States	6.50

J.2.2. Other Fuel Impacts from Energy Efficiency

Emission rates from other fuels (e.g., natural gas, oil, and propane) do not vary regionally like emission rates associated with electricity generation. As such, we used one national level emission rate for all fuels. Fuel emission rates were derived from the carbon dioxide, methane, and nitrous oxide emission rates included in EPA's Climate Leaders Greenhouse Gas Inventory Protocol.[39] Line losses of 7% were added to the natural gas savings as well.[40]

J.2.3. Impacts from Renewable Generation

We determined what sort of conventional energy generation was displaced by all renewable energy generation to better determine what carbon impacts were associated with these programs. eGRID emission rates were applied to grid electricity displaced by renewable generation, as recommended by EPA. The same process described above was used to create emission impacts from electricity displacement. Similarly, we

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[36] U.S. Environmental Protection Agency. GHG Reporting Program Data Sets, http://www.epa.gov/ghgreporting/ghgdata/reportingdatasets.html. May 2014.

[37] U.S. Energy Information Administration, International Energy Statistics, 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. May 2014.

[38] A line loss factor is a multiplier that can be used to extrapolate energy saved at the generator level from energy saved at the consumer level.

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

[40] U.S. Energy Information Administration, Annual Energy Review, August 19, 2010.

used the fuel emission rates developed for energy efficiency savings when estimating the carbon impacts from renewable generation that displaced other fuel use.

Typically, it is assumed that biomass generation is carbon neutral because the source would have emitted the same greenhouse gases through decay that were emitted when burned for generation purposes. As such, energy displacement due to biomass generation was evaluated in the same way as other renewable generation—emission factors were applied to the displaced energy. However, in some instances, the evaluation contractor team felt that the biomass source was not carbon neutral and recorded the difference as a direct carbon impact. More information on these calculations is included in the next section.

J.2.4. Directly Measured Carbon Impacts

Whether there was an additional carbon impact where biomass generation was supported was considered. In cases where biofuels represented a carbon sink, the DOE National Energy Technology Laboratory Unit Process Library was used to calculate the direct carbon impact associated with the particular biomass source under review.[41]

J.3. AVOIDED SOCIAL COSTS OF CARBON IMPACTS

J.3.1. Methods and Assumptions for Social Cost of Carbon Impacts

This evaluation also considered the monetary impact associated with carbon emissions. Carbon impacts associated with EECBG-funded programs were monetized using the social cost of carbon from the following sources:

- 2009: Evaluating Realized Impacts of DOE/EERE R&D Programs: Standard Impact Evaluation Method, which provided the appropriate social cost of carbon values for 2009,[42]
- 2010-2050: Technical Support Document - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866[43]

The social cost of carbon estimates provided in the technical support document were developed by modelling the economic impacts associated with increases in temperature due to incremental carbon emissions. Estimates were derived from three integrated assessment models: DICE,[44] PAGE,[45] and FUND.[46] While the methodology and calculations behind each model vary, the economic impacts are generally a function of climate processes, economic growth, and feedback between the climate and global economy. As shown in Table 29, the costs increase over time. This is due to the increased strain each marginal metric ton of carbon dioxide will have on the system; the three models assume that incremental emissions in later years cause more damage than previous emissions since they are being added to an already stressed system.

[41] http://www.netl.doe.gov/research/energy-analysis/life-cycle-analysis/unit-process-library
[42] The technical support document only provides social cost of carbon values for 2010-2050.
[43] http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf
[44] DICE: Duration, Integrity, Commitment and Effort, http://dice.bcg.com/
[45] PAGE: http://www.jbs.cam.ac.uk/fileadmin/user_upload/research/workingpapers/wp1104.pdf
[46] FUND: Climate Framework for Uncertainty, Negotiation, and Distribution. http://www.fund-model.org/

Table 29: Social cost of carbon (2009 $/$MMTCO_2$)[47, 48, 49]

Discount Rate	5%	3%	2.5%	3%
Year	Average	Average	Average	95th Percentile
2009	11	32	51	87
2010	11	33	52	90
2015	12	38	58	109
2020	12	43	65	129
2025	14	48	70	144
2030	16	52	76	159
2035	19	57	81	176
2040	21	62	87	192
2045	24	66	92	206
2050	27	71	98	221

The evaluation team used the social cost of carbon estimates associated with the 2.5% social discount rate. This rate adjusts future dollar-value benefits and costs to a present day value. The 2.5% rate was chosen because that is closest to the 2.7% discount rate being used in the rest of the evaluation.

The annual monetary impacts of carbon emissions by BPA were calculated after the annual energy impacts by BPA were determined. The annual carbon impact by BPA was multiplied by the social cost of carbon value for each year to create annual cost estimates.

[47] Dollars were converted to 2009 using the following Inflation Adjustment Formula: Current Year Price x (Base Year CPI ('09)/ Current Year CPI); where CPI is GDP Chain-type Price index as reported by EIA for 2011 and 2012.

[48] The average options represent the average dollar economic impacts expected in each model. The 95th percentile option represents the social cost of carbon (with a 3% discount rate) from less likely, but more damaging, economic impacts resulting from increases in global temperature.

[49] The discount rates used in this table are social discount rates. A higher discount rate implies consumers place a lower value on the future impacts of carbon

J.4. REFERENCES

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

NETL. Unit Process Library. http://www.netl.doe.gov/research/energy-analysis/life-cycle-analysis/unit-process-library

Ruegg, R., A. O'Connor, and R. Loomis, Evaluating Realized Impacts of DOE/EERE R&D Programs: Standard Impact Evaluation Method, August 2014.U.S. Environmental Protection Agency. GHG Reporting Program Data Sets, http://www.epa.gov/ghgreporting/ghgdata/reportingdatasets.html. May, 2014.

U.S. Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=2&aid=12&cid=AQ,GQ,RQ,IQ,U.S.,VQ,&syid=2010&eyid=2010&unit=BKWH. May, 2014.

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

U.S. Energy Information Administration, Annual Energy Review, August 19, 2010.

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. http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf, May 2013.

APPENDIX K. DETAILED BILL SAVINGS AND COST-EFFECTIVENESS METHODOLOGY

K.1. INTRODUCTION

This section describes the methods, metric inputs, assumptions, and sources for customer-bill savings estimation and cost-effectiveness analysis. Findings throughout this report are presented by BPA and study period. Key indicators used in this report are as follows:

- Annual customer bill savings (2009-2050) and total customer bill savings by fuel and sector
- Recovery Act cost (RAC) test
- Present value ratio comparing total non-discounted bill savings to program expenditures

K.1.1. Customer Bill Savings Estimation

Customer bill savings were estimated for energy savings and on-site generation by first estimating energy and generation impacts for each BPA at the state level, and then applying appropriate retail energy rates. Retail rates for electricity, natural gas and other fuels are sourced from the EIA's State Energy Data System (SEDS).[50] These rates include fees, surcharges, and taxes collected by the utility even those taxes eventually remitted to a government authority.[51] All bill savings are expressed in constant 2009 dollars and are the same bill savings streams used in the labor and economic impacts analysis.

K.1.2. EECBG Performance Metrics

The EECBG Program was designed to allocate ARRA funds to activities that could be started and completed expeditiously. However, ARRA goals went beyond energy savings to include other goals such as accelerating near-term deployment of energy efficiency and renewable technologies and some U.S. energy security goals. ARRA goals also aim to promote economic vitality, improve environmental quality, and develop and adopt leading market transformation initiatives. Multiple metrics were developed to assess these activities:[52]

1. Jobs created
2. GHG emissions reduced (CO_2 equivalents)
3. Energy (e.g. kWh, therm, gallon, and Btu) saved
4. Renewable energy installed capacity and generation
5. Energy cost savings

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[50] U.S. Energy Information Administration's (EIA),
Electricity Prices http://www.eia.gov/state/seds/
Natural Gas Prices - http://www.eia.gov/dnav/ng/ng_pri_sum_a_epg0_prs_dmcf_a.htm

[51] U.S. Energy Information Administration, State Energy Data 2012: Prices and expenditures. Section 3. Natural Gas, page 29. Section 6. Electricity, page 119. www.eia.gov/state/sep_prices/notes/pr_elec.pdf

[52] U.S. Department of Energy, Financial Assistance Funding Opportunity Announcement, State Energy Program Formula Grants, American Recovery and Reinvestment Act (ARRA), CFDA Number: 81.041, State Energy Program, March 12, 2009, p.24; http://www.energy.ca.gov/recovery/documents/SEP_Recovery_Act_Guidance_DE-FOA-00000521.pdf (accessed December 12, 2013).

6. Funds leveraged

This section addresses BPA metric 5, energy cost savings.[53] The first calculation discussed below is the RAC test. The second is a ratio of the present value of savings over program funding (present value ratio or PVR). The flow chart in depicts how collected data flows into each metric.

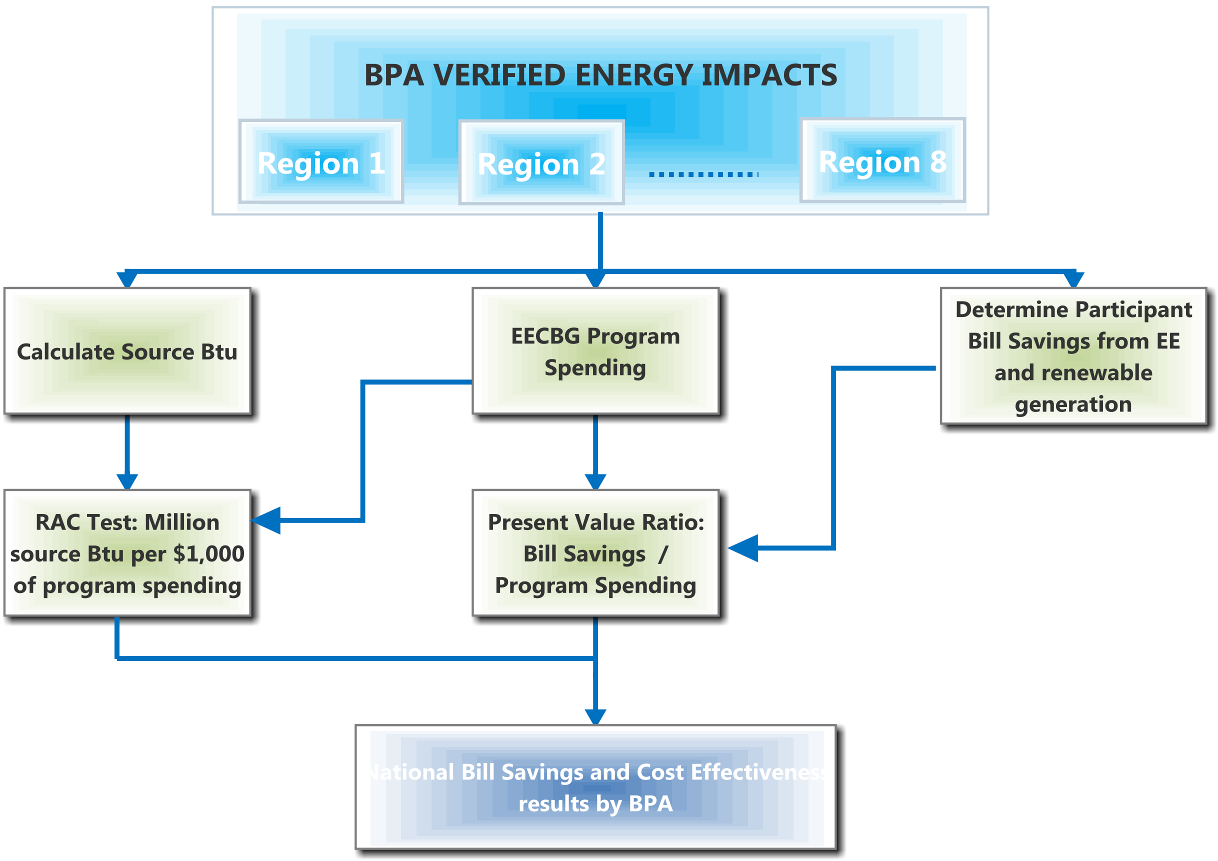

Figure 32: Flow from data to metrics

K.1.3. EECBG Recovery Act Cost Test

The RAC test was created by U.S. DOE for states to use when designing and evaluating their program portfolios under ARRA specifically with respect to the State Energy Program (SEP).[54] The EECBG cost

[53] Metrics 1 and 2 (jobs created and avoided carbon emissions, respectively) are addressed separately. Metric 6 is not addressed in this study.

[54] "There are no other cost-effectiveness test requirements for SEP Recovery Act project portfolios. The cost-effectiveness test normally required in state regulatory environments focuses on least cost, net-present-value energy supplies and do not apply to SEP Recovery Act projects. DOE's objective is to achieve deep lasting savings that provide net energy efficiency, renewable energy, carbon

effectiveness analysis applies the same methodology as was specified by U.S. DOE for evaluating the SEP. For the RAC test only, program expenditures and annual source Btu savings were included in the calculation. Funds leveraged from other programs, such as utility or municipal programs, were not included. Using source Btu provides a consistent way to measure portfolio cost-effectiveness across regional fuel mixes. According to DOE guidance, the ratio was to be applied during pre-implementation planning[55] and post-implementation evaluation at the portfolio, not program, level. This evaluation reports RAC test results applied to the six EECBG BPAs included in this evaluation.

The RAC test is expressed in million Btu (MMBtu) of source energy saved or generated per year, per $1,000 of program expenditures. Site to source conversion values are presented inTable 31. To be considered cost-effective by DOE, portfolios (not individual programs) should achieve annual savings of at least 10 MMBtu per $1,000 of EECBG expenditures.

For this analysis, representative one-year Btu savings initially are calculated at the measure level and converted to source Btu by fuel type. These are expanded to the regional level by BPA and added together to produce the national level.

The formula for the single year RAC is,

$$\text{RAC BPA1} = \frac{MMBtu_a}{PgmExp}$$

Where,

$MMBtu_a$ = Sum of BPA annual source MMBtu savings

PgmExp = Administration + Grants + Rebates.

Loans are not included as a program expense since those dollars are returned to state energy office in the form of principal and interest loan repayments.

For the RAC, MMBtu are calculated at the source level. 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.

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reductions, and job impacts into the future. SEP Notice 1-001 and EECBG Program Notice 11-001, January 21, 2011. http://energy.gov/sites/prod/files/2014/01/f7/11_001_eecbg_sep_building_best_practice.pdf (accessed April 29, 2014).

[55] U.S. Department of Energy, Financial Assistance Funding Opportunity Announcement, State Energy Program Formula Grants, ARRA, CFDA Number: 81.041, State Energy Program, March 12, 2009, p.28. http://www.energy.ca.gov/recovery/documents/SEP_Recovery_Act_Guidance_DE-FOA-00000521.pdf (accessed December 12, 2013).

K.1.4. Present Value Ratio

This approach creates a ratio that compares participant energy-bill savings (benefits) to program spending (costs). The BPA-level, estimated source Btu values used for the RAC test are allocated to individual states based on funding amounts for that BPA. State level, sector retail-rates are then applied to generate state-level bill savings. These state-level estimates are combined to create regional- and national-level bill savings estimates that are then compared to program verified funding. Both bill savings and program costs are discounted to 2009 dollars.

A ratio greater than 1.0 means the present value of the bill savings for the life of the installed equipment is greater than total program spending. A ratio less than 1.0 means that program spending is greater than any energy bill savings resulting from EECBG program activity.

The formula for this PVR is,

$$PVR = \frac{PV(B)}{PV(C)}$$

Where,

$$\mathrm{PV(B)} = \sum_{t=1}^{n} \frac{Part\_Bsvgs}{(1+d)^{t-1}}$$

Part_Bsvgs = the sum of participant annual energy saved or generated multiplied by state annual average retail rates by sector and fuel type, at the BPA level

$$\mathrm{PV(C)} = \sum_{t=1}^{n} \frac{Pgm\_spend}{(1+d)^{t-1}}$$

Pgm_spend = the sum of program spending due to program activities at the BPA level. Costs include expenditures for program administration, grants, incentives, and rebates.[56]

The PVR is reported under three discount rates to assess the sensitivity of the results. The primary discount rate used throughout the analysis is the average yield on the 30-year U.S. Treasury bond in 2009 (2.7%). Present value ratio also is calculated using discount rates of 0.7% and 4.7%.

K.2. KEY ASSUMPTIONS AND INPUTS

Many elements are used to perform the cost-benefit analysis described above. This section identifies these elements, their development, and proposed sources.

K.2.1. Energy Savings to Btu

The RAC test requires that all site energy savings and generation be converted to Btu for comparison purposes. To do this, the following multipliers in Table 30 are used.

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[56] Excludes non-EECBG funding (e.g. utility rebates that would have been issued independently of EECBG).

Table 30: Site energy savings to site Btu conversion factors

Site Converted Savings	Site Btu Equivalent
Electricity (1 kWh)	3,412 Btu
Natural Gas (1 Therm)	100,000 Btu
Oil (1 Therm)	100,000 Btu
Propane (1 Therm = 1.1 gallons)	100,000 Btu
Kerosene (1 Therm)	100,000 Btu
Wood (MBTU)	100,000 Btu
Diesel (MBTU)	1,000 Btu
Ethanol (MBTU)	1,000 Btu
Gasoline (MBTU)	1,000 Btu
Other (MBTU)	1,000 Btu

Furthermore, Btu savings at the site level are to be converted to source savings. Source energy is the amount of fuel required to generate the fuel use on the site; it includes all losses due to transmission, delivery, and production. Source savings also are expressed in Btu. Site Btu is converted to source Btu using the multipliers in Table 31.[57]

Table 31: Site to source Btu conversion factors

Fuel Type	Source-Site Ratio
Electricity (grid purchase)	3.34
Electricity (on-site solar or wind Installation)	1.00
Natural Gas	1.047
Fuel Oil (1,2,4,5,6, Diesel, Kerosene)	1.01
Propane & Liquid Propane	1.01
Ethanol	1.01
Gasoline	1.01
Wood/Coal/Coke/Other	1.00

K.2.2. Electricity and Gas Rates

Retail rates for electricity, natural gas and other fuels are sourced from the EIA's SEDS.[58] For the years 2009 through 2013, prices are derived from utility reports. For 2014-2040, retail rates are estimated using fixed growth rates. These are reported as average annual retail prices by state and sector in nominal dollars[59] (i.e. they have not been adjusted for inflation). For the analysis, all dollar values will be presented in terms of 2009 dollars.

K.2.3. Discount Rate

The discount rate adjusts future dollar-value benefits and costs to a present day value. Applying a discount rate to future dollars is necessary to compare costs that occur in the first year with dollars in savings that accrue anywhere from 1 to 30 years into the future. For this analysis, a discount rate of 2.7 percent is

[57] ENERGY STAR Performance Rating Methodology for Incorporating Source Energy Use, March 2011, https://portfoliomanager.energystar.gov/pdf/reference/Source%Energy.pdf?d340-895d

[58] U.S. Energy Information Administration's (EIA), http://www.eia.gov/state/seds/

Electricity Prices - Natural Gas Prices - http://www.eia.gov/dnav/ng/ng_pri_sum_a_epg0_prs_dmcf_a.htm

[59] Retail energy prices are not adjusted for inflation by EIA. http://www.eia.gov/totalenergy/data/monthly/#prices

applied. This rate is the "risk-free" real interest rate on the U.S. 30-year Treasury bond as of 2009.[60] To illustrate the potential effects of higher or lower interest rates, calculations are also performed with discount rates of 0.7% and 4.7%.

K.2.4. Inflation Rate

The inflation rate is applied to nominal dollars in future periods to adjust for changes in purchasing power. The OMB circular cited in the discount rate section includes nominal and real interest rates. The difference between the nominal interest rate and the real interest rate often is used for the inflation rate. For 2009 only, the implied inflation rate is 1.8 percent (4.5% - 2.7% = 1.8%). Since the analysis results are reported in 2009 dollars this inflation rate is applied to future years to adjust costs and benefits before discounting.

K.3. REFERENCES

American Wind Energy Association, *Wind Power's Consumer Benefits*, February 2014. http://awea.files.cms-plus.com/AWEA%20White%20Paper-Consumer%20Benefits%20final.pdf

ENERGY STAR Performance Rating Methodology for Incorporating Source Energy Use, March 2011, https://portfoliomanager.energystar.gov/pdf/reference/Source%Energy.pdf?d340-895d

Darghouth, N. et al., The Potential Impact of Increased Renewable Energy Penetrations on Electricity Bill Savings from Residential Photovoltaic Systems, Lawrence Berkeley National Laboratory. http://ases.conference-services.net/resources/252/2859/pdf/SOLAR2012_0146_full%20paper.pdf

OMB. Circular No. A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs", OMB Budget Assumption December 26, 2013 Budget Assumption http://www.whitehouse.gov/sites/default/files/omb/assets/a94/dischist-2014.pdf

U.S. Department of Energy, Financial Assistance Funding Opportunity Announcement, State Energy Program Formula Grants, American Recovery and Reinvestment Act (ARRA), CFDA Number: 81.041, State Energy Program, March 12, 2009, p.24; http://www.energy.ca.gov/recovery/documents/SEP_Recovery_Act_Guidance_DE-FOA-00000521.pdf (accessed December 12, 2013).

U.S. Department of Energy, Financial Assistance Funding Opportunity Announcement, State Energy Program Formula Grants, American Recovery and Reinvestment Act (ARRA), CFDA Number: 81.041, State Energy Program, March 12, 2009, p.28; http://www.energy.ca.gov/recovery/documents/SEP_Recovery_Act_Guidance_DE-FOA-00000521.pdf (accessed December 12, 2013).

U.S. Department of Energy. State Energy Program Notice 1-001 and EECBG Program Notice 11-001, January 21, 2011. http://energy.gov/sites/prod/files/2014/01/f7/11_001_eecbg_sep_building_best_practice.pdf (accessed April 29, 2014).

U.S. Energy Information Administration's (EIA), Electricity Prices, http://www.eia.gov/state/seds/

[60] Circular No. A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs", OMB Budget Assumption December 26, 2013 Budget Assumption http://www.whitehouse.gov/sites/default/files/omb/assets/a94/dischist-2014.pdf

U.S. Energy Information Administration's (EIA), Electricity Sales, http://www.eia.gov/electricity/data/eia826/

U.S. Energy Information Administration's (EIA), Natural Gas Prices. http://www.eia.gov/dnav/ng/ng_pri_sum_a_epg0_prs_dmcf_a.htm

U.S. Energy Information Administration, State Energy Data 2012: Prices and expenditures. Section 3. Natural Gas, page 29. Section 6. Electricity, page 119. www.eia.gov/state/sep_prices/notes/pr_elec.pdf

U.S. Energy Information Administration. Monthly Energy Review. http://www.eia.gov/totalenergy/data/monthly/#prices

APPENDIX L. ORGANIZATIONAL/OPERATIONAL FACTORS METHODOLOGY

L.1. OBJECTIVES

The objective of the performance analysis was to determine if there were organizational or operational aspects of the EECBG program that could be found to have a statistical relationship to the energy savings achieved per grant dollar spent. An understanding of the factors related to successful performance could be helpful to public policy makers, program managers, and other parties interested in allocating funding for the adoption and effective utilization of energy efficiency and renewable energy technologies. Using available program data and secondary sources, DNV GL used a regression framework to attempt to identify key organizational and operational characteristics that explain the relative level of savings achieved per grant dollar expended.

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

L.2. FINDINGS

The findings from the statistical regression modeling effort indicate some significant relationships between program performance, defined as EECBG-attributable energy savings per dollar spent, and selected performance factors. More specific findings are:

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

There are several possible reasons why we did not find more significant relationships for organizational and operational factors:

Low Sample Size - The evaluation produced energy savings results for 169 grant activities which constitutes the population of records available for the performance factors analysis. Of these 169 activities, complete data on organizational factors (primarily from the survey) were only available for 148 respondents. This constituted the final number of activities or records for inclusion in the performance analysis.

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

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

Future statistical studies of performance factors should aim to include a larger survey that focuses on capturing data related to organizational and operational factors with a more robust sample population of homogeneous projects for supporting subsequent analysis.

L.3. LITERATURE REVIEW

The study team started the investigation of performance factors by reviewing the literature for past studies that explored the relationship between energy efficiency program/project results and organizational and operational factors. The purpose of this review was to identify previous quantitative studies (regression analyses in particular) and to help develop a list of potential variables of importance. The study team completed this work in 2012 with a review of published proceedings and reports from the American Council for an Energy-Efficiency Economy (ACEEE), the International Energy Program Evaluation Conference (IEPEC), the California Measurement Advisory Council (CALMAC) and the New York State Energy Research and Development Authority (NYSERDA). Also reviewed as primary sources were Chapter 6 of the National Action Plan for Energy Efficiency (NAPEE), the National Energy Efficiency Best Practices Study (Itron, July 2008) and an accompanying literature review from 2003 (Energy Efficiency Best Practices Study, Appendix A, Quantum Consulting, 2003). A complete list of the documents reviewed in detail is provided at the end of this section.

The primary area of interest in reviewing these studies was to assess what previous quantitative work had been done to isolate variables that help predict program or project success, as defined by a high amount of energy savings per dollar spent.

No studies were found that met the above criteria – i.e., that the study included a quantitative analysis and that it used energy savings achieved in the definition of "best practice". This confirmed that the assessment of operational factors related to performance – defined as energy savings per grant dollar spent – is an untapped area for investigation. Most studies focused on qualitative reviews of best practices related to programs with high levels of energy savings, not necessarily energy savings per dollar spent. The most relevant reports involved meta-evaluations, or examinations of multiple programs. Very few studies in the energy efficiency field involved quantitative analysis and only one was found that attempted a statistical analysis. Most of the studies that examined a range of programs or projects were concerned with extracting qualitative indicators of best practice and did not involve the application or analysis of numerical measures. Rather they sought to group best practice by category for those programs that showed significant levels of energy savings (versus savings per dollar spent).

In spite of these limitations, the study team was able to extract several findings of interest from the reports that were useful in the development of operational variables. Below we summarize the top two studies of interest (literature reviews in themselves) that most closely reflected the objectives of our review.

U.S. Department of Energy and U.S. Environmental Protection Agency; National Action Plan for Energy Efficiency (NAPEE); Chapter 6: Energy Efficiency Program Best Practices; (2006)

The complete NAPEE report includes recommendations for promoting energy efficiency in utility ratemaking and revenue requirements, energy resource planning processes, rate design, and energy efficiency programs for consumers, institutions and businesses. Chapter 6 summarized key findings from a fairly comprehensive portfolio level review of long standing energy efficiency programs for the purpose of extracting best practices in a variety of areas, the most relevant to this study being "Program design and delivery strategies that can maximize program impacts and increase cost-effectiveness."

Key findings related to this dimension of best practice include:

- Energy efficiency programs, projects, and policies benefit from established and stable regulations, clear goals, and comprehensive evaluation.
- Energy efficiency programs benefit from committed program administrators and oversight authorities, as well as strong stakeholder support.

Most relevant to the design of the operational factors analysis were the following key elements determined to be important to the success of programs:

- Leadership – Championing energy efficiency at a high level
- Organizational Alignment - Existence of policies and enabling regulations to support energy efficiency
- Good planning – Conducting pre-program or project studies to know the energy efficiency potential, and developing long term plans
- Leverage other resources - Leveraging private sector expertise, external funding, and financing.

This study took all of these recommendations into account in developing the EECBG analysis.

National Energy Efficiency Best Practice Benchmarking Study sponsored by the California Best Practices Project Advisory Committee chaired by Rafael Friedmann of Pacific Gas & Electric.

This study includes a summary of reports identified in summer of 2003 by Quantum Consulting as part of a literature review of best practices. Most notable among the studies for relevance to the purposes of the EECBG evaluation was a study by Eto, J., S. Kito, L. Shown, and R. Sonnenblick of Lawrence Berkeley National Laboratory in 1995 called "Where Did the Money Go? The Cost and Performance of the Largest Commercial Sector DSM Programs." (LBL-38201). This report contained the only found reference to a regression analysis similar to the one designed for EECBG:

> *"None of the best practices studies reviewed thus far use any sort of formal metrics to score the programs selected. However, in their study of the performance of the largest Commercial Sector DSM programs, Eto et al. identify two variables (program type and program size) as statistically significant when analyzing regression equations for the Total Resource Cost. The program type variable distinguishes between direct install and rebates. The program size variable is a measure of the annual kWh saved. Note that the authors only find weak (not statistically significant) relationships between the TRC and the presence of shareholder incentives, the economic lifetime of savings, the savings per participant and the avoided costs."*

From the review of the various reports and studies the study team developed an initial list of 40 potential variables that previous studies have shown to be present in programs that result in high energy savings. There are listed in Table 32.

Table 32: "Best Practice" variables from literature review

1	**Size of the project in terms of dollars**	**21**	**Ability of project staff to carry out the project**
2	Scope of the project in terms of duration to complete	22	Level of activity undertaken with funding
3	Comprehensiveness of the project	23	Ability to undertake at the same level of activity without funding
4	Range and type of available technical assistance	24	Degree of internal support for the project
5	Type of technical assistance available	25	Degree of community support for the project
6	Use of technical assistance	26	Technical expertise of the project manager
7	Quality of technical assistance provided	27	Dedication of the project manager
8	Type of leveraged funding available	28	Amount of staff supporting the project
9	Use of leveraged funding	29	Use of vendors on the project
10	Amount of technical assistance obtained	30	Quality of work of staff
11	Influence of political institutions	31	Quality of work of vendors
12	Influence of non-political organizations	32	Training available to carry out the project
13	Adequacy of amount of ARRA/EECBG project funding provided	33	Use of training
14	Adequacy of total project funds obtained	34	Type of project undertaken
15	Conditions of use for leveraged funding (i.e., "strings-attached")	35	Type of market(s) served by the project
16	Adequacy of project administration budget	36	Type of buildings treated by the project
17	Amount of administrative burden	37	Types of energy efficiency measures implemented through the project
18	Amount of reporting requirements	38	Cost of energy efficiency measures implemented through the project
19	Data tracking needs of the project	39	Installation complexity of energy efficiency measures implemented
20	Data tracking system type	40	Quality of installation achieved

It should be noted that the list of variables considered here intentionally did not include the end uses addressed or types of energy efficiency measures installed, etc., since those kinds of variables directly contribute to the development of the dependent variable, the energy savings estimate. The focus here instead was on operational and organizational factors – outside of the actual measure installed – that may have contributed to a high level of savings per grant dollar spent.

This list was discussed and augmented by the project sponsors at ORNL in light of two important criteria:

1) Relevance to grant activities in the EECBG grant program (as opposed to utility or third party energy efficiency programs) and
2) Data availability or our ability to "operationalize" a definition for capturing the data through surveys

The factors for the regression analysis were based on the findings from the above-described literature review and the experience of ORNL advisors and senior DNV GL evaluation staff regarding determining factors from previous evaluations. An initial meeting with the project team was held to review the findings from the literature review and develop a preliminary list of variables for consideration. The approach was to conceptualize the variables early in the project so that data collection instruments could capture the necessary information to feed the model. The precise nature of key variables was determined for each sampled Activity through the review of Activity records and direct interviews with the involved parties (project manager, grant manager). Additional (exogenous) data for this analysis would be taken from outside sources such as the US Census.

L.4. REGRESSION MODELING APPROACH

The analysis for this task was based on a statistical linear regression model. A regression framework allowed identification of key organizational and operational characteristics that explain the variation in relative level of savings per grant dollar. Additional discussion on the dependent and independent variables considered in the model is provided below.

L.4.1. Dependent Variable

The dependent variable for an activity in this regression model was the ratio of energy impact in source MMBTU to funding (in thousands of dollars). Energy impact estimates and funding were available for 169 activity respondents. The distribution of the ratio of net savings to funding is right skewed as shown in Table 33 below. While 17% of activities have a ratio of zero and 60% of all 169 activity respondents have ratios less than 50, the remaining 40% of activity respondents have ratios that range from above 50 to as high as 6020.

Table 33 summarizes the distribution of the ratio of program impact in MMBtu to funding in thousands of dollars. As can be seen, the distribution has several extremely high values. It should be noted that the skewed distribution could limit the ability of the model to identify relationships between EECBG-attributable savings and operational factors for the activities with smaller savings.

Table 33: Distribution of ratio of program impact to funding in thousands

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

The natural logarithm of the ratio was considered because of the highly variable ratio values observed between grants.

$$\text{NET\_RATIO} = \ln\left(1 + \frac{Energy\ Impact_i}{Funding\ in\ Thousands_i}\right) \tag{1}$$

Note that a higher value for the ratio indicates that the activity exhibited relatively higher energy savings per dollar of EECBG funding. Figure 33 shows the distribution of NET_RATIO.

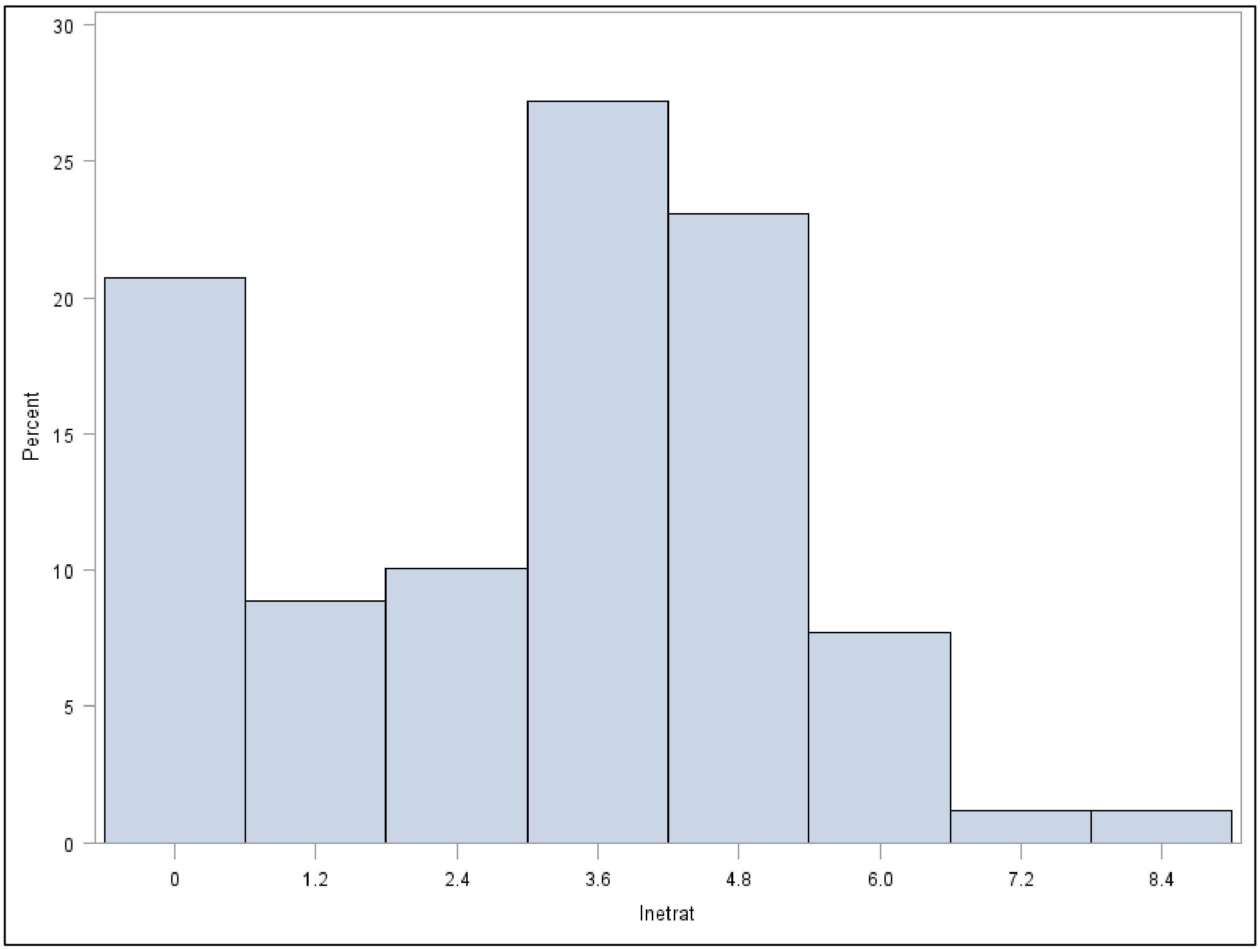

Figure 33: Distribution of the logarithm of ratio of program impact to funding in thousands

L.4.2. Independent Variables

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

- mix of measures implemented,

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

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

- the environment in which the program was implemented as indicated by the territory's/state's score per the 2014 American Council Energy Efficient Economy (ACEEE) Energy Efficiency Scorecard[61],
- annual heating and cooling degree days as measured by the National Oceanic and Atmospheric Administration (NOAA)[62] – this metric measures the variation in mean temperatures from the baseline temperature (generally 65 degrees for heating and cooling),[63]
- indicators related to energy costs such as average cost per kWh and/or cost per therm of natural gas, and
- the ability of the target audience to participate as indicated by the territory's/state's unemployment rates as reported by the U.S. Census Bureau[64].

A total of 75 independent variables were considered for the model. The final model specification included 22 potential explanatory/independent variables. These are shown in Table 34. The other independent variables were excluded from the model due to:

- missing data for a large number of telephone survey respondents or
- statistical correlation with the independent variable which would result in statistically biased results.

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

[62] http://www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/

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

[64] When a program is implemented in an area, we would hypothesize that higher unemployment rates could correlate with lower participation as this would be viewed as a discretionary expense and hence not be at the top of the priority list for consumers.

Table 34: Explanatory/Independent variables included in the organizational/operational regression model

	Variable Name	Variable Definition	Source
1	ACEEE	2009-2011 Average ACEEE Energy Efficiency Score	Exogenous
2	CDD	2009-2011 Total Cooling Degree Days (State level)	Exogenous
3	HDD	2009-2011 Total Heating Degree Days (State level)	Exogenous
4	UNEMP	2009-2011 Average Unemployment Score	Exogenous
5	BPA_NUM	Dummy variables for 6 BPAs (5 used in model)	Endogenous
6	TYPE	Direct/Indirect grant indicator	Endogenous
7	OP1	The activity used any financial or technical support programs offered by other sponsors, such as local utilities, industry associations, or government agencies	Endogenous
	AUDIT	Dummy Variable indicating if activity included an energy audit	Endogenous
9	VB1_1	The activity received a financial grant for measures installed or rebated	Endogenous
10	VB1_2	The activity received a subsidy for design or engineering work	Endogenous
11	VB1_5	Assistance in entering into performance contracts	Endogenous
12	VB1_6	The technical assistance in identifying & characterizing opportunities	Endogenous
13	VB1_7	Referrals to qualified vendors	Endogenous
14	VB1_8	General information on energy efficiency opportunities	Endogenous
15	VB1_9	Technical training	Endogenous
16	NVB6A	High level of support from local government	Endogenous
17	NVB6B	High level of support from internal staff	Endogenous
18	NVB6C	High level of support from the community	Endogenous
19	NVB6D	High level of support from the local utility	Endogenous
20	NVB6E	High level of technical support from EECBG	Endogenous
21	NVB6F	High level of external technical support	Endogenous
22	NVB6G	High level of support from management	Endogenous

L.4.3. Estimating Model Parameters

An iterative, linear model-building process was employed to arrive at the set of explanatory variables that could potentially account for variability in the dependent variable. The parameters of all models were estimated using a least squares estimation approach. A design-based variance estimator was used to estimate the variance and significance of each independent variable. The design-based variance estimator accounts for complex design features of this evaluation such as the stratification used to select the sample and unequal weighting. This method of estimating model parameters is commonly used with survey data.

The iterative model-building process seeks to minimize multi-collinearity and maximizes model fit and significance of parameter estimates. Table 35 summarizes a few of the models considered. The final model in this table (model #5) seemed to strike the balance that was sought between the fit of the model (as measured by the model's R-squared value), the number of parameters estimated (13 independent variables) and the total number of observations we were able to use to estimate model parameters (n=148). The 21 activities not used in the estimation process (169 - 148) were discarded because they had missing values for one or more of the independent variables.

Table 35: Summary of exploratory regression models

Model number	Independent variables considered	Number of independent variables	R-Square	Number of Activities Used to Estimate Model Parameters
1	Exogenous only	4	0.11	154
2	Endogenous only - all survey variables	22	0.62	153
3	Exogenous and Endogenous	25	0.67	141
4	Exogenous and Endogenous, insignificant variables with pval > .5 dropped	16	0.67	141
5	Exogenous and Endogenous, insignificant variables with pval > .2 dropped	13	0.64	148

L.5. DETAILED RESULTS

Table 36 displays the parameter estimates of the final regression model.

- BPAs rise to the top as significant, and within these, financial incentives and lighting have a relatively high positive impact on the ratio of net savings to funding. The direction and strength of this relationship with the dependent variable is echoed in the single variable regression model results (Table 37).

- Buildings and facilities and energy efficiency retrofit BPAs have a significant and relatively moderate positive impact on the outcome variable. These variables show up as insignificant in the single variable regression model results (Table 37). Our post hoc interpretation is that it is possible that these variables may be acting as suppressor variables[65] in the multivariate model. While the relationship between these and the dependent variable is relatively weaker, it could potentially be strengthening other independent variables by suppressing the residuals/error terms.

- Energy efficiency conservation strategy, purchase of renewable technology, grant type (direct), assistance entering into a performance contract, and ACEEE's state energy efficiency score average have a significant but relatively low impact on the outcome variable. These variables are marginally or strongly insignificant in the single variable regression model suggesting that findings with respect to these variables with these data are inconclusive.

[65] http://www.amstat.org/publications/jse/v22n2/ludlow.pdf

Also included in the multivariate model, but not statistically significant (.05 < p value < .20), are technical training received, audits conducted, use of financial or technical support programs offered by other sponsors, energy audit or other technical assistance in identifying and characterizing opportunities. Receiving a high level of support from the community has a weak but significant relationship in the multivariate model, but is insignificant in the single variable regression model.

Table 36: Parameter estimates of the final regression model

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

An additional estimate used to triangulate and assess the relative impact of each potential explanatory variable on the dependent variable is the R-square from models that regress just one explanatory variable against the dependent variable at a time. The R-square in this case is an indicator of the amount of variability in the dependent variable explained by just the variable under consideration, and it does not take into account other potential explanatory variables. Table 37 summarizes the explanatory power of the independent variables. It shows that several factors were found to have statistically significant relationships with program performance but no single variable explained more than 15% (R-square=.15) of the variance in the dependent variable. Similar to the multivariate regression results, the three variables with the greatest explanatory value were BPA categories. We also found that the number of cooling degree days, the use of energy audits, and a high level of support from local utilities were positively related to program performance and that each of those factors, by itself, explained between 7 and 8% of total variability in the dependent variable.

Table 37: Summary of single variable regression models

VARIABLE	LABEL	R-square	Parameter Estimate	p-value
RENEWTECHBPA	BPA = Renewable Technology	0.15	-1.05	<.0001
FININCBPA	BPA = Financial Incentive	0.14	0.94	<.0001
EECONSERVEBPA	BPA =EE Conservation Strategy	0.12	-0.44	0.03
CDD	Cooling Degree Days state 2009-2011	0.08	0.76	0.05
LIGHTINGBPA	BPA = Lighting	0.08	0.74	0.00
AUDIT	Audit = 1 if some kind of audit conducted, 0 otherwise (compound indicator from Q3 series)	0.08	0.64	0.03
NVB6D	High level of support from local utility	0.07	0.65	0.02
NVB6B	High level of support from internal staff	0.06	0.55	0.06
HDD	Heating Degree Days state 2009-2011	0.06	-0.61	0.10
NVB6A	High level of support from local government	0.04	0.50	0.11
ACEEE	ACEEE state EE score 2009-2011 average	0.04	-0.45	0.11
NVB6C	High level of support from the community	0.03	0.41	0.18
VB1_7	Referrals to qualified vendors	0.03	-0.48	<.0001
VB1_9	Technical training	0.03	0.42	0.29
NVB6G	High level of support from management	0.02	0.32	0.37
VB1_1	Financial grant for measures installed or rebated	0.02	-0.24	<.0001
BLDGFACBPA	BPA=Buildings and Facilities	0.02	0.28	0.18

VARIABLE	LABEL	R-square	Parameter Estimate	p-value
VB1_6	Energy audit or other technical assistance in identifying & characterizing opportunities	0.01	-0.30	0.16
NVB6E	High level of technical support from EECBG	0.01	0.33	0.24
VB1_5	Assistance in entering into performance contracts	0.01	-0.14	0.47
VB1_2	Subsidy for design or engineering work	0.01	-0.22	0.20
OP1	Use of financial or technical support programs offered by other sponsors, such as local utilities, industry associations, or government agencies	0.01	0.21	0.52
VB1_8	General information on energy efficiency opportunities	0.01	-0.22	0.41
NVB6F	High level of external technical support	0.01	0.18	0.50
OP3_1	Support from other programs - Information to guide project planning and equipment selection	0.00	0.13	0.50
UNEMP	2009-2011 Average Unemployment Score	0.00	-0.09	0.79
EERETROBPA	BPA=EE Retrofits	0.00	-0.04	0.90
DIRECT	Direct	0.00	0.02	0.93

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Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.