Painting a Big Picture: Using Activity Counts and Savings Multipliers To Estimate State Energy Program Accomplishments

Martin Schweitzer, Oak Ridge National Laboratory, Oak Ridge, TN
Bruce E. Tonn, Oak Ridge National Laboratory, Oak Ridge, TN

Abstract

Oak Ridge National Laboratory (ORNL) recently completed an evaluation of the energy and cost savings and emissions reductions achieved by a wide variety of energy efficiency and renewable energy activities performed by the states and territories under the State Energy Program (SEP). For that study, ORNL developed a classification scheme for describing the various activities supported by SEP funds, focusing almost exclusively on activities for which energy savings could be quantified. Eighteen distinct project areas were identified and a total of 32 specific performance metrics were developed within those broad areas.

In response to a request for metrics data, all 50 states, the District of Columbia, and four of the five U.S. territories provided information on their relevant SEP-supported activities. Estimates of the savings resulting from each activity were developed for 17 of the 18 project areas using the findings from recent evaluations, and those energy-savings coefficients were multiplied by the activity counts provided by the states to calculate energy savings. Those energy savings, in turn, were used to estimate cost savings and emissions reductions.

Estimated annual energy savings from the relevant activities performed by the states and territories during their 2002 program year totaled approximately 48 trillion source BTUs, and cost savings exceeded $333 million. Slightly more than three-fourths of those total savings occurred in five project areas: Workshops and Training; Codes and Standards; Energy Audits; Retrofits; and Technical Assistance.

The ORNL study represents an economical approach to estimating the outcomes achieved by an extremely broad range of energy efficiency and renewable energy activities undertaken at the state level under the umbrella of a single federal program.

Introduction

The U.S. Department of Energy's (DOE's) State Energy Program was established in 1996 by merging the State Energy Conservation Program and the Institutional Conservation Program, both of which had been in existence since 1976 (U.S. DOE 2001a). The SEP provides financial and technical assistance for a wide variety of energy efficiency and renewable energy activities undertaken by the states and territories. The program provides money to each state and territory according to a formula that accounts for population and energy use. In addition to these "Formula Grants," SEP "Special Project" funds are made available on a competitive basis to carry out specific types of energy efficiency and renewable energy activities (U.S. DOE 2003a). The resources provided by DOE typically are augmented by money and in-kind assistance from a number of sources, including other federal agencies, state and local governments, and the private sector.

The states' SEP efforts include several mandatory activities, such as establishing lighting efficiency standards for public buildings, promoting car and vanpools and public transportation, and establishing policies for energy-efficient government procurement practices. The states and territories also engage in a broad range of optional activities, including holding workshops and training sessions on a variety of topics related to energy efficiency and renewable energy, providing energy audits and building retrofit services, offering technical assistance, supporting loan and grant programs, and encouraging the adoption of alternative energy technologies. The scope and variety of activities undertaken by the various states and territories is extremely broad, and this reflects the diversity of conditions and needs found across the country and the efforts of participating states and territories to respond to them.

Over the last several years, ORNL staff have developed and refined a classification scheme for describing the various activities supported by SEP funds. This involves describing a number of distinct project areas into which the states' various SEP efforts can be placed and identifying specific performance metrics within those broad areas that allow program accomplishments to be systematically measured. Each performance metric is a key action taken by the program (e.g., number of printed materials distributed; number of energy audits performed) or a direct customer response to those actions (e.g., number of materials downloaded from state websites; number of persons attending workshops). Under the current framework there are 18 distinct project areas and 32 performance metrics. The project areas are: (1) Mass Media; (2) School Education Programs; (3) Workshops and Training; (4) Retrofits; (5) Energy Audits; (6) Procurement of Energy-Efficient Products by Government Agencies; (7) Technical Assistance; (8) Loans and Grants; (9) Codes and Standards; (10) Rating and Labeling; (11) Home Energy Rating Systems (HERS) and Energy Efficiency Mortgages (EEMs); (12) Financial Incentives; (13) Interest Reduction Programs; (14) Alternative Energy; (15) Energy Emergency Planning; (16) Tax Credits; (17) Traffic Signals and Controls; and (18) Carpools and Vanpools.

Our classification scheme focused almost exclusively on activities for which energy savings could be quantified, which make up a substantial but partial subset of all SEP activities. It should be noted that quantifying savings for a number of the project areas included in this study is difficult. In particular, activities that are designed to influence participant behavior through information and education (e.g., Mass Media; School Education; Workshops and Training) are challenging for evaluators because of the difficulty in clearly establishing a link between information and action.

In addition to the 18 areas listed above, there are other types of energy efficiency and renewable energy activities in which the states and territories have engaged. These include: strategic planning and climate change planning efforts; policy development and energy legislation; telecommuting programs; waste management and recycling efforts; and water system efficiency projects.

Methods

If the full effects of every SEP-supported action taken by each state and territory were thoroughly examined and directly measured, and the influence of the State Energy Program was isolated from all other influences on the observed outcomes, the reported impacts of the program could be accepted with certainty. However, such an undertaking would require a massive state-by-state and project-by-project data collection and analysis effort which would far exceed the resources available for the current study. Instead, this study estimated the probable outcomes of state actions based on the past performance of similar types of efforts and state-provided counts of common activities.

ORNL prepared a set of 18 spreadsheets, one for each broad project area, which elicited information on the number of activities performed under each performance metric. The states and territories were instructed to report all SEP project activities (those supported by Formula Grants and those utilizing Special Projects funds) that were performed during their 2002 program year, along with all funding used to support those activities. For most states and territories, the SEP program year lags the federal fiscal year by nine months, so their 2002 program year covered the period from July 2002 through June 2003. In most cases, separate information on the activities performed was requested for each of the major energy-use sectors served (e.g., residential, commercial, institutional). Based on our experience with a previous study of the program (Schweitzer et al., 2003), a precise definition of what constitutes SEP projects and what non-SEP funding sources should be counted (which was developed with substantial input from the states) was provided to respondents[1].

In early June of 2004, the National Association of State Energy Officials (NASEO) sent an electronic version of the data collection spreadsheets to the appropriate staff in each state and territory, along with a request to provide the designated information in a timely manner. By mid August of that year, all 50 states, the District of Columbia, and four of the five U.S. territories had provided the requested data for the study. This means that we essentially have a census (i.e., the full population) as opposed to a sample. This allows us to draw conclusions about the State Energy Program without having to draw inferences or extrapolate from a subset of the entire population.

NASEO sent the completed spreadsheets to ORNL as soon as they were received, and ORNL staff examined all the state-provided data. Follow-up calls were made to a number of states and territories, as necessary, to clarify responses or elicit additional information. Also, a number of calls were made to states to check on outliers (i.e., unusually large numbers). The information provided by the states in response to the follow-up contacts were used to revise (or confirm) the numbers contained in the final data set.

For the previous SEP evaluation, ORNL staff had developed estimates of energy savings[2] resulting from the activities covered by the performance metrics in 14 different project areas. These savings estimates were expressed in terms of the amount of energy saved for a single activity (e.g., per residential energy audit; per dollar of industrial sector grant). In this paper, these savings estimates are referred to as "per-unit savings multipliers" or "energy-savings coefficients," because they can be multiplied by the total number of activities performed to yield estimates of overall savings for a given performance metric.

The energy-savings coefficients described above were taken from recent evaluations (e.g., Feldman and Tannenbaum 2000; Lew and Wang 1998; NYSERDA 2001; Webber, Brown, and Koomey 2000) that focused on the effects of various state energy efficiency and renewable energy programs. A number of articles published in journals and conference proceedings were reviewed, and findings were extracted from those that were relevant to the SEP and employed rigorous and well-accepted research methods. We made an effort to keep the energy-savings coefficients that we developed conservative by adjusting them downward to account for factors such as installation, savings-realization, and compliance rates, where appropriate.

For the current study, ORNL staff reviewed all of the energy-savings coefficients used in the previous study in light of the latest available data (e.g., Energy Design Resources 2004; Lucas 2002; Pacific Gas and Electric Company 2004) and revised them as necessary. We also developed coefficients for three additional project areas using a variety of new sources (e.g., EIA 2002a; Tools of Change 2004;

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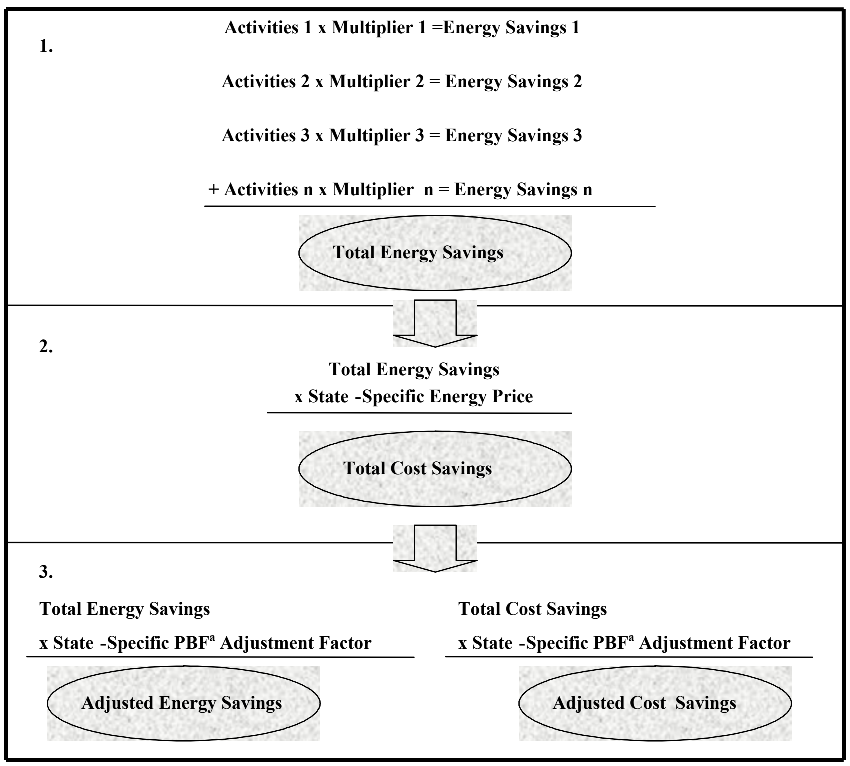
[1] In the spreadsheets, it was clearly stated that, in order to be considered an SEP project, a project must be included in the State Plan submitted to SEP or be considered eligible for the State Plan if it was initiated after the plan was already submitted. Also, SEP funds must be used to support the project and the SEP contribution should be important (although it is possible that the project might still exist, but in diminished form, in the absence of the SEP contribution). The states were instructed to report *all* resources used to support their SEP projects.

[2] Energy savings were expressed in terms of millions of British Thermal Units (BTUs), regardless of the fuel involved, to allow the combination of savings by different fuel types. Where the fuel in question was electricity, kilowatt hours were converted to *source BTUs* (i.e., the amount of energy required at the power plant to produce a specified amount of usable energy), using the formula: one kWh = 0.010883 million source BTUs. If electricity savings were expressed in site BTUs, they were converted to source BTUs by multiplying by 3.189 to account for the substantial amount of energy lost in electricity generation as well as losses occurring during transmission and distribution. Source BTUs were used as the common unit of measurement to reflect the *total* amount of energy saved.

U.S. DOE 2003b). In addition, within the previously-addressed project areas, savings estimates were developed for a number of energy-use sectors that had not been covered in the first study. As a result, we were able to calculate energy savings for 17 of the 18 project areas (all except Energy Emergency Planning[3]) and for every energy-use sector in nearly all of those 17 areas. A detailed discussion of each energy-savings coefficient is presented in the ORNL report documenting this study (Schweitzer and Tonn 2005).

Figure 1 presents a conceptual diagram of how energy and cost savings were calculated from the counts of program activities and the energy-savings coefficients for a single project area in a single state. To start, the number of reported activities of a single type (e.g., institutional retrofits performed) was multiplied by the associated per-unit savings coefficient. Even in those project areas that had only one performance metric, it was common for there to be more than one activities number and associated coefficient, because activities were disaggregated by the energy-use sector addressed and the multipliers typically varied by sector. Once all of the activities in the project area were multiplied by the appropriate coefficient to yield savings estimates, all of those savings numbers were summed to give total energy savings. This energy savings number for the project area, expressed in millions of source BTUs, was then multiplied by the state-specific energy cost (Energy Information Administration 2003a), expressed in dollars per million source BTUs, to produce an estimate of total cost savings. Finally, the energy and cost savings estimates were each multiplied by a state-specific Public Benefits Fund (PBF) adjustment



[a]Note: PBF = "Public Benefits Fund"

Figure 1. Calculating Energy and Cost Savings for a Single Project Area in a Single State

[3] We were not able to locate good data on the magnitude of energy savings associated with the development of energy emergency plans, probably because the primary focus of such efforts is on helping state and local governments deal with supply shortages and interruptions rather than reducing energy consumption.

factor to yield adjusted savings numbers[4]. The PBF adjustment factor removed the savings associated with a state's Public Benefits Fund expenditures, which was considered necessary because of their extremely large magnitude relative to SEP funding in many states that have a PBF. In many cases, PBF expenditures reflect plans and priorities that are established independently of the State Energy Program. Accordingly, including these funds and the resulting savings in this study would substantially overstate SEP effects.

The savings numbers calculated in the above manner for a single project area and state provide the building blocks for a number of different summations that can be performed. Using these numbers, totals can be calculated for a given project area for all states combined, for all project areas for a single state, and for all project areas for all states. This study was not designed to distinguish the outcomes achieved as a result of SEP support and influence from those outcomes that would have occurred even without the stimulus provided by the State Energy Program. However, it should be noted that the states and territories were instructed to report only their SEP projects and, to be classified as such, the SEP contribution must be "important."

Emissions reductions were calculated directly from the energy-savings estimates discussed above. Essentially, the amount of savings achieved by each state within each project area and energy-use sector was multiplied by coefficients representing average emissions per million source BTUs for that project area and sector for six different emissions types: Carbon; Nitrogen Oxide (NO_x); Sulphur Dioxide (SO_2); Volatile Organic Compounds (VOCs); Carbon Monoxide (CO); and Fine Particulate Matter (PM10) (U.S. DOE 2001b, EIA 2002b, EIA 2003a, USDA 2004). For each project area, the emissions reductions of each type achieved by the various sectors were summed to get total emissions reductions for that area. Then, the project area emissions for all states were summed to yield total emissions reductions for all states combined.

After all data were collected and analyzed, a draft report was prepared documenting the study findings and the methods used to develop them. The discussion of methods contained in that report (including a detailed appendix describing how each energy-savings coefficient was developed) was reviewed by the Board of Directors of the International Energy Program Evaluation Conference, Inc. (IEPEC), a group of highly-qualified professionals with extensive experience in evaluating energy efficiency programs. The six-member panel provided an objective third-party peer review of the performance metrics used in the ORNL study (Vine et al. 2005). In response to comments provided by the IEPEC review panel, we made adjustments to the energy-savings coefficients associated with nine performance metrics in eight of the project areas.

It must be noted that, in a study of this type, there are a number of factors that introduce uncertainty into the estimates of energy savings and, consequently, into the cost savings and emissions reductions numbers which are derived from them. The four major factors related to uncertainty of results in this case are: (1) imprecision of the energy-savings multipliers used; (2) incomplete coverage of state activities; (3) lack of attribution of savings; and (4) the exclusion of certain benefits from the analysis.

"Imprecision of the energy-savings multipliers" refers to the fact that, in most cases, those multipliers were taken from a limited number of recent evaluations of state efforts and an average

[4] The PBF adjustment factor was calculated by taking the amount of total funding for a given project area (SEP plus all non-SEP) and subtracting the amount of PBF funding from it. This number was divided by total funding to get a factor representing non-PBF funding as a proportion of all funding. This factor was then multiplied by total savings to yield an estimate of the amount that was generated without PBF money, based on the assumption that the amount of savings generated by PBF funds is roughly proportional to the amount of funding provided by that source. In reality, determining the attribution of savings is a more complicated matter, but the method described here was used because it was all that the available data would allow.

energy savings number was applied to the activities reported by all states. This means that the resulting savings estimates are unlikely to reflect the exact results achieved in each individual case. "Incomplete coverage of state activities" means that the classification scheme used in this study did not cover all SEP-supported activities performed by the various states and territories, and that any savings produced by activities falling outside the categories used here were not captured. "Lack of attribution" means that a focused effort was not made to separate the savings directly generated by the State Energy Program from those savings due to other influences. It is true that the states and territories were asked to report their activities only for "SEP projects," which were defined as those for which the SEP contribution was "important," but the activities in question often received funding and in-kind support from other sources so it cannot be assumed that SEP is responsible for all the savings achieved. "Exclusion of certain benefits" means that the ORNL study did not address some factors that contribute to the value of energy efficiency and renewable energy programs. Most notable among those are the spillover and networking effects that occur when participants apply new knowledge and skills to other situations or pass them on to others, and a host of non-energy benefits such as positive effects on national security and the economy.

The imprecision of the energy-savings multipliers can introduce error into the reported findings; the overall effect of that can be to either exaggerate or understate actual savings, although efforts were made throughout the study to keep the energy-savings multipliers conservative. The incomplete coverage of state activities and the exclusion of certain benefits both have the effect of underestimating actual savings. And the fact that the current study did not address the attribution of benefits means that the State Energy Program cannot be assigned sole credit for all the observed outcomes. The combined effect of all these factors is that the savings numbers presented here should be treated as estimates of the outcomes associated with the State Energy Program rather than as definitive measures of program accomplishments. Despite this uncertainty, the previously-mentioned review of this study's methods that was conducted by the Board of Directors of the International Energy Program Evaluation Conference concluded that this effort "provides a reasonable estimate of the impacts of the SEP programs" (Vine et al. 2005, p. 7).

Findings

Table 1 presents estimates of the annual nationwide energy and cost savings achieved in each of the 17 project areas for which savings could be quantified. Workshops and Training accounted for slightly more than 22% of total energy savings, while the area of Codes and Standards was responsible for nearly 20% of the savings that occurred. Energy Audits accounted for almost 16% of overall savings, Retrofits provided roughly another 11%, and Technical Assistance contributed an additional 7% of the total annual savings achieved by the states. Between them, these five areas generated slightly more than three-fourths of total savings. The next five highest energy-saving areas were Traffic Signals and Controls; Financial Incentives; Alternative Energy; Mass Media; and Tax Credits. Savings in the top 10 areas combined accounted for more than 94% of total energy savings.

It is not surprising that Workshops and Training and Codes and Standards were the two highest-saving areas because, in addition to being addressed by a majority of the states and territories, each has a built-in mechanism for multiplying the savings achieved. In the case of Workshops and Training, recipients of program services in most energy-use sectors are expected to apply the lessons learned several times (e.g., each institutional trainee is expected to influence energy savings in four different buildings). For Codes and Standards, the adoption of a single code typically influences thousands of new structures every year, so the savings achieved can be considerable even if per-unit savings are

Table 1. Estimated Annual Nationwide Energy and Cost Savings, by Project Area

Project area	Number of states	Estimated annual energy savings (million source BTUs)	Estimated annual cost savings ($)	Estimated energy savings as percent of total savings in all project areas (%)
Workshops/Training	54	10,500,000	75,700,000	22
Codes and Standards	28	9,400,000	63,700,000	20
Energy Audits	40	7,600,000	50,900,000	16
Retrofits	36	5,200,000	38,900,000	11
Technical Assistance	49	3,400,000	23,600,000	7
Traffic Signals and Controls	9	3,100,000	20,800,000	6
Financial Incentives	11	1,700,000	12,500,000	4
Alternative Energy[a]	41	1,500,000	10,700,000	3
Mass Media	49	1,300,000	9,200,000	3
Tax Credits	10	1,100,000	7,800,000	2
Loans and Grants	34	830,000	5,800,000	2
Rating and Labeling	7	750,000	5,900,000	2
School Education Programs	38	660,000	4,500,000	1
Carpools and Vanpools	9	350,000	2,100,000	1
Interest Reduction Programs	5	160,000	1,100,000	<1
Procurement	14	50,000	350,000	<1
HERS and EEMs	4	10,000	50,000	<1

[a]In addition to the energy savings shown above, Alternative Energy activities also reduced petroleum consumption by approximately 210,000 barrels.

relatively modest. For the other three project areas in the top-five savings group, all had participation by at least 65% of the states and territories and one (Technical Assistance) tends to amplify its savings because participants in most sectors are expected to influence several different buildings or vehicles.

The smallest amount of energy savings occurred in the areas of HERS and EEMs, Procurement, Interest Reduction Programs, and Carpools and Vanpools. In all cases, activities in these project areas were undertaken by approximately one-fourth of fewer (usually much fewer) of the responding states, and the amount of SEP funding allocated to them was relatively small.

Estimated emissions reductions are based directly on the energy savings described above. Accordingly, the rank order of the project areas, and the relative magnitude of the outcomes achieved in each one, are the same for emissions reductions as for energy savings.

As shown in Figure 2, estimated annual nationwide energy savings totaled approximately 48 trillion source BTUs for all 17 project areas for which outcomes were quantified. Those savings were calculated from the activities performed by the states and territories during their 2002 program year. For the same activities, estimated annual cost savings exceeded $333 million. These annual energy and cost savings are likely to continue over time, because the effects of most of the SEP-supported energy-saving measures tend to last for many years. The total savings reported here are somewhat higher than the national totals documented in the previous study (approximately 41 trillion source BTUs and $256 million), which is not surprising because the current evaluation calculated savings for three project areas and some project-specific end-use sectors that were not covered in the first study.

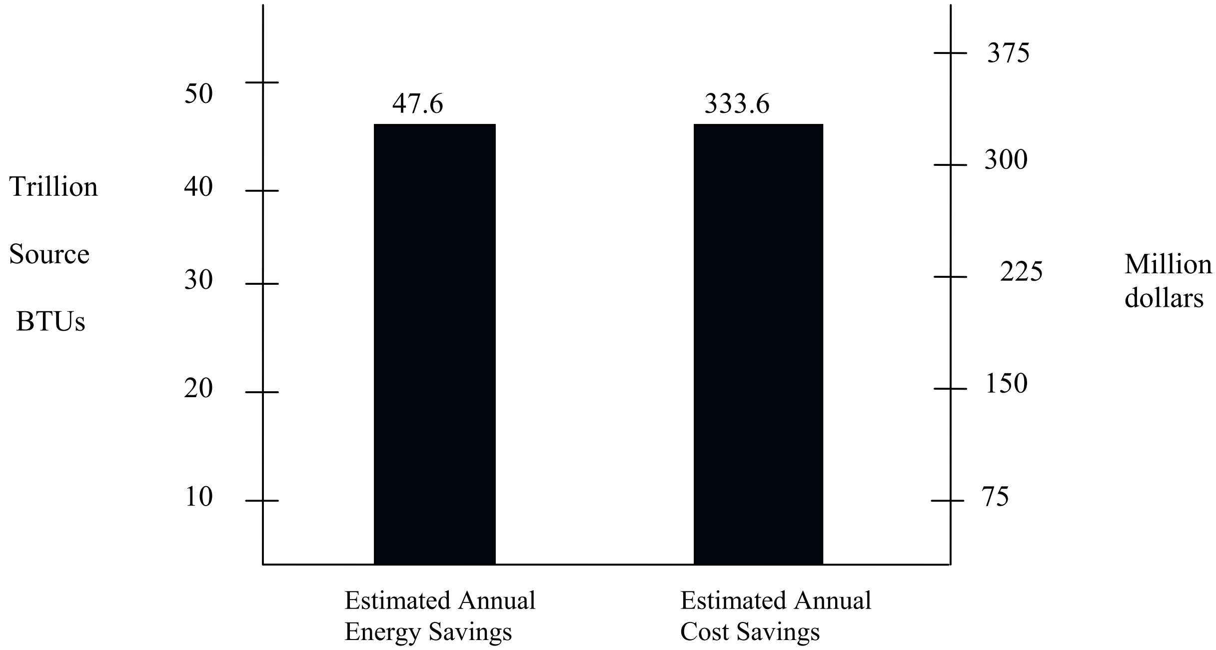


Figure 2. Estimated Annual Nationwide Energy and Cost Savings for 17 Project Areas Combined

It is estimated that annual nationwide carbon emissions were reduced by a total of 826,000 metric tons in the 17 project areas for which energy savings were quantified. The magnitude of emissions reductions was much smaller, but still considerable, for the other substances studied. Sulphur dioxide emissions were reduced by 8,500 metric tons per year, nitrogen oxide emissions decreased by more than 6,200 metric tons annually, and carbon monoxide reductions totaled approximately 1,000 metric tons each year. Emissions of fine particulate matter and Volatile Organic Compounds were reduced by approximately 160 and 130 metric tons per year, respectively.

Conclusions

The estimates given here of SEP-supported accomplishments during the 2002 program year are based on counts of project activities provided by virtually every state and territory in the nation and on estimates of energy savings per action taken. The major strength of this approach is its ability to estimate the savings associated with a very large and complex national program at a fraction of the cost that would be required for the direct measurement of state-by-state and project-by-project savings. The major drawback is the higher uncertainty that must be accepted.

The estimated overall annual energy saving of approximately 48 million source BTUs reported in this paper is equivalent to the average amount of energy used for all non-transportation applications in more than 289,000 U.S. households over the course of an entire year (EIA 2003b). And the annual carbon reduction of 826,000 metric tons is the same as all the carbon emissions produced by over 582,000 passenger cars in a one year period (U.S. EPA 2000).

Moving beyond overall accomplishments to examine individual project areas, it is clear that the types of projects vary considerably among themselves. Some generate substantial amounts of energy and cost savings, while the savings associated with others are considerably more modest. These differences can be due to a variety of project characteristics, such as whether the effort represents a one-time stimulus or requires other actions to achieve the intended outcome, how many energy-consuming units are directly influenced by the action taken or by those receiving program services, and whether the project deals with mature technologies or tries to encourage new ones and build the associated infrastructure. It seems to us that no single type of project, regardless of how impressive its outcomes, is appropriate for all situations. Rather, there is a very broad array of valuable project types, each of which serves important needs and is part of a balanced energy efficiency and renewable energy portfolio that is likely to vary from state to state and year to year. The flexibility that SEP gives the individual states to determine what types of projects to support allows them to engage in those efforts that best fit the most pressing needs at hand.

Because the individual savings estimates that formed the basis of this study's savings calculations generally were taken from a limited number of studies, we recommend that findings from new evaluation studies be examined as they become available and that additional evaluations of selected SEP activities be undertaken to adjust (or corroborate) the existing savings numbers and to check key assumptions (e.g., responses to specific program services by end-use sector) that were used to calculate savings. Subject areas with the greatest need for closer examination are those for which predicting savings tends to be most difficult (e.g., Mass Media; School Education) and those for which savings were found to be largest (e.g., Workshops and Training; Codes and Standards).

In addition, future evaluations could be improved by more fully accounting for variations among participants that affect energy savings. The key drawbacks to this more disaggregated approach are the increased time and resources required to develop the necessary multipliers and apply them to the activities data provided by the states and territories as well as the greater reporting burden for respondents.

The next study of the SEP should address the issue of "attribution" and attempt to identify the proportion of observed savings that are due to the support of the State Energy Program as opposed to other influences. Future studies should also address the issue of persistence of energy savings so that lifetime benefit-cost ratios can be calculated that account for the length of time that project-induced savings last. In addition, a fuller picture of the outcomes associated with the State Energy Program would be provided by adding an examination of non-energy benefits and spillover effects.

In light of the fact that the performance metrics used in the current study are likely to be employed in future SEP evaluations, the individual states and territories would probably benefit from keeping track of their accomplishments using this study's key metrics. Initially, some states could require additional training or other types of assistance to establish the new tracking procedures. However, it is expected that the states' future reporting burden would be eased because the information requested for subsequent evaluations would be readily available, and that the participating states would be more aware of key program outputs as they occur.

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