United States Environmental Protection Agency

Office of Atmospheric Programs
Air and Radiation
(6202J)

EPA-430-B-07-001
July 2007

Climate Protection Division

Creating an Energy Efficiency and Renewable Energy Set-Aside in the NOx Budget Trading Program:

Evaluation, Measurement, and Verification of Electricity Savings for Determining Emission Reductions from Energy Efficiency and Renewable Energy Actions

July 2007

Preface

This guidance document was written in 2004, peer-reviewed, and subsequently updated in 2006[1]. It is the third of three NO_x SIP Call guidance documents that the U.S. Environmental Protection Agency (EPA) is issuing to help states capture the air quality benefits of energy efficiency and renewable energy (EE/RE) actions. It is intended to assist states with the design of their EE/RE evaluation, measurement and verification requirements of their emissions control programs.

In 1998, the EPA promulgated a rule, commonly known as the NO_x SIP Call, to address regional transport of ground-level ozone, the main component of smog. Ground-level ozone is transported by the wind, and tends to be a problem over broad regional areas, particularly in the eastern United States. Emissions of Nitrogen Oxides (NO_x) react in the atmosphere to form compounds that contribute to the formation of ozone. These compounds, as well as ozone itself, can travel hundreds of miles across state boundaries to affect public health in areas far from the source of the emissions. Thus, regions with "clean" air – those that meet or attain the national air quality standards for ozone – may be contributing to a downwind region's ozone problem because of transport.

The Clean Air Act requires that a State Implementation Plan (SIP) contain provisions to prevent a state's facilities or sources from contributing significantly to air pollution problems "downwind," specifically in those areas that fail to meet the national air quality standards for ozone. By reducing emissions of NO_x, the transport of ground-level ozone across state boundaries can be reduced. The NO_x SIP Call includes a model NO_x Budget Trading Program that allows states to achieve the required emissions reductions in a cost-effective manner.

Policies that promote EE/RE actions can reduce emissions of pollutants, including NO_x. These emissions reductions can be recognized in a state's SIP through the use of the voluntary Energy Efficiency and Renewable Energy Set-Aside Program. An EE/RE Set-Aside is a pool of allowances that are awarded to energy efficiency and renewable energy projects that reduce electricity generation. The Set-Aside comes from within the state's NO_x allowance budget to ensure that the total number of allowances in circulation do not exceed the allowable maximum. The Set-Aside Program focuses primarily on end-use electricity efficiency and renewable energy actions, since the amount and source of electricity consumed by end-users affects the quantity of NO_x emitted at an electricity generating unit (EGU).

The Set-Aside Program is one example of how EPA is giving states guidance and flexibility in meeting their air quality attainment goals. The Program is consistent with two EPA goals: (1) reducing the total economic cost of meeting the proposed NO_x cap and (2) encouraging the adoption of EE/RE practices and technologies.

While this guidance is intended for use with the NO_x Set-Aside Program, the basic principles can be applied to other programs that include EE/RE actions as an emission mitigation strategy. It is important to note that actual emissions reductions in a cap and trade program (i.e., reductions beyond the capped level) occur only if the allowances allocated to an efficiency or renewable energy activity are retired.

---

[1] The National Action Plan for Energy Efficiency is developing a "Model Energy Efficiency Program Impact Evaluation Guide" that will be available in Fall 2007. For more information, see: http://www.epa.gov/cleanenergy/actionplan/eeactionplan.htm

Acknowledgments

This document was prepared for the U.S. Environmental Protection Agency by Steven Schiller of Schiller Consulting, Inc. (steve@schiller.com) under contract to Stratus Consulting. EPA's project manager is Nikolaas Dietsch. He can be contacted at dietsch.nikolaas@epamail.epa.gov.

This work includes significant contributions from evaluation, measurement, and verification guidelines prepared by other organizations including the Efficiency Valuation Organization (the International Performance Measurement and Verification Protocol); American Society of Heating, Refrigerating and Air-Conditioning Engineers; FEMP; California Measurement Advisory Council; World Resources Institute and World Business Council for Sustainable Development, and Lawrence Berkeley National Laboratory.

A draft version of this document underwent a Technical Peer Review coordinated by Perrin Quarles Associates (PQA) in 2004. The EPA project manager for that version of the document was Edgar Mercado. Thirteen reviewers provided comments with particularly detailed and helpful suggestions provided by John Cowan, Satish Kumar, Laura Vimmerstedt, and Ed Vine. Debra Jacobson and Art Diem provided valuable comments on Chapter 8.

Table of Contents

List of Tables

List of Figures

List of Acronyms

AAR	Authorized Account Representative
ASHRAE	American Society of Heating Refrigeration and Air-Conditioning Engineers
BAU	“Business-as-usual” or baseline
CAA	Clean Air Act
CHP	Combined Heat and Power
CVP	Conservation Verification Protocol
DOE	United States Department of Energy
DSM	Demand Side Management
EE/RE	Energy Efficiency and Renewable Energy (as in EE/RE projects)
ESCO	Energy Services Company
EGU	Electricity Generating Unit
EPA	United States Environmental Protection Agency
FEMP	United States Federal Energy Management Program
HVAC	Heating Ventilation and Air Conditioning
IPMVP	International Performance Measurement and Verification Protocol
kWh	kilowatt-hour
MWh	Megawatt-hour
M&V	Measurement and Verification
NAAQS	National Ambient Air Quality Standards
NATS	NO_x Account Tracking System
NO_x	Oxides of Nitrogen
SIP	State Implementation Plan

Executive Summary

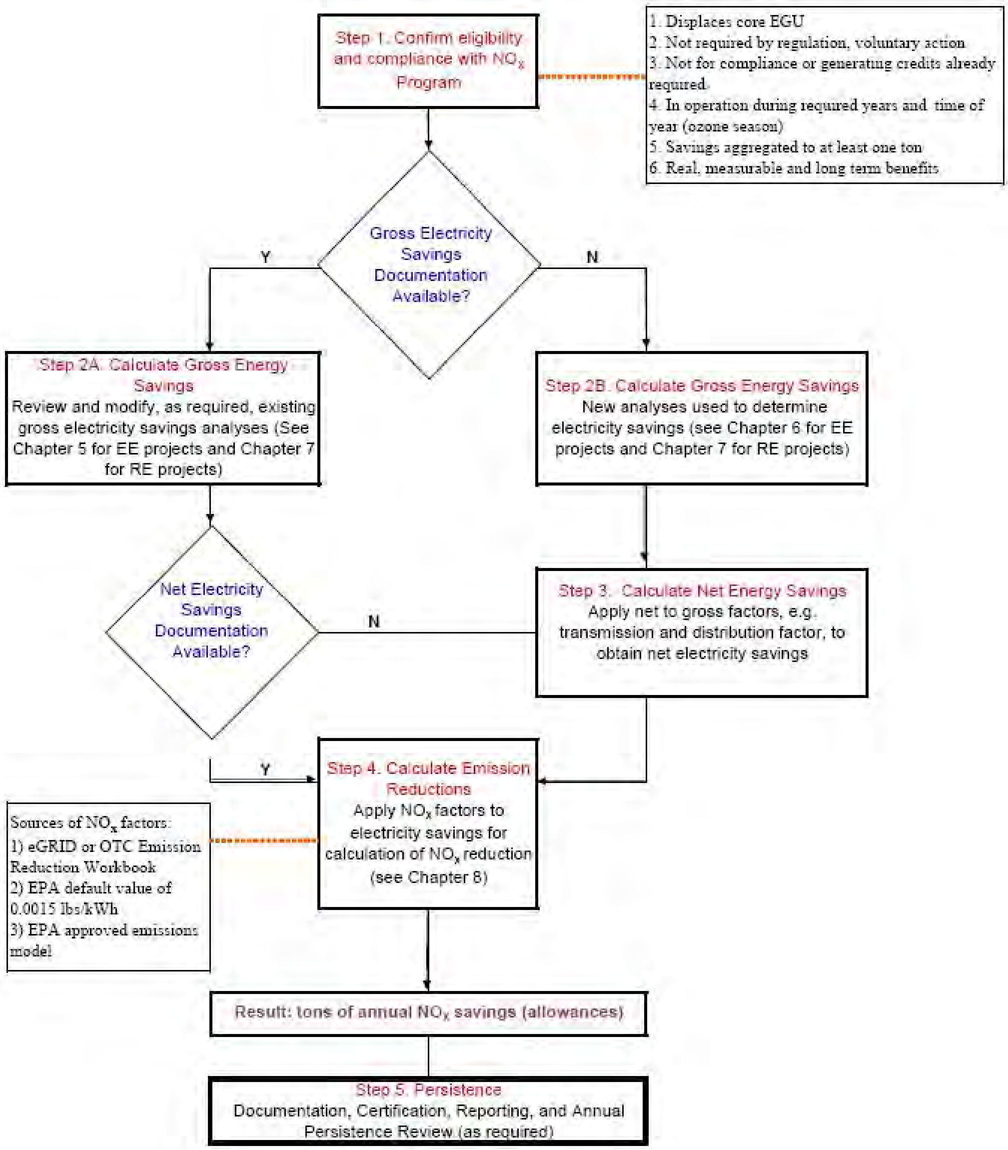
INTRODUCTION AND SUMMARY OF EVALUATION APPROACH

This guidance describes best-practice approaches for documenting electricity savings and resulting NO_x reductions from EE/RE projects or programs. It provides background, discussion of relevant issues, and a recommended process. Unfortunately, this guidance document, and all similar manuals, does not offer specific step-by-step instructions for all project types and circumstances. This is because (a) there are many variables associated with the myriad EE/RE technologies and applications, and (b) deciding "how accurate is accurate enough" varies for different applications. What this guidance document does provide is an overall best-practice approach for calculating electricity savings, resources that provide electricity savings calculation details for common project types, information on options for calculating NO_x savings from kWh savings, and guidance on what to include in reports submitted for allowance documentation.

When implementing an EE/RE Set-Aside, states need to define an evaluation process for qualifying projects that takes into account the range of possible measures, while balancing transaction costs (for both the State and the applicants) with documentation, accuracy and precision requirements. To this end, states can develop a procedures manual that describes the steps or tasks necessary for proper documentation of NO_x reductions.

In this document, *evaluation* is the term used for the overall process of determining the potential emission reductions resulting from displaced electricity generation requirements at core-source electricity generating units (EGUs). *Measurement and verification* (M&V) is a component of the evaluation process that is associated with documenting electricity savings (efficiency projects) or production (renewables projects) at a particular project site. The recommended evaluation process consists of: (a) confirming that the EE/RE project or program meets the basic requirements of the Set-Aside Program, (b) calculating net electricity (kWh) savings at the EGU, and (c) converting these savings to NO_x emission allowance values. In addition, each state may want to have a *persistence* analysis process to ensure that the savings continue through the term of the allowance allocation. Figure ES-1 summarizes the evaluation process.

Figure ES-1: Evaluation Process for NO_x Set-Aside Program



Confirming that individual projects or programs meet the basic Set-Aside Program requirements is accomplished through a checklist process. Calculating electricity savings is done through either (a) evaluating the documentation and accuracy of M&V activities that have already been completed as part of an EE/RE project or program implementation, or (b) conducting new M&V activities specifically for determining Set-Aside Program emissions reductions. If an existing M&V analysis is allowed, the state may employ an independent review of the documentation, set minimum accuracy standards, and consider adopting discount factors to reduce the risk of electricity savings uncertainty.

Of particular concern is whether the *baseline* conditions assumed for the savings calculation are consistent with the NO_x SIP Call Program baseline, or business as usual, requirements. A proper baseline definition is needed in order to ensure that NO_x reductions are in addition to what would have occurred in the absence of the subject project or program. If the electricity savings are calculated at a site level, the state may wish to add a transmission and distribution loss factor.

Calculating the quantity of NO_x allowances allocated to qualified projects or programs can be done using either the EPA default allocation factor (indicated in the NO_x SIP Call as 0.0015 lbs/kWh), a system average emissions rate, or an avoided marginal emissions rate. If the allowance allocation rate is based on the emissions rate at which EE/RE projects displace pollution from EGUs, then the number of awarded allowance approximates the potential emissions reduction (assuming allowances are subsequently retired). Several approaches for calculating system average and marginal displaced emissions rates are discussed in Chapter 8.

The following are examples of allowance calculations for an energy efficiency program and a renewable energy project. These are presented to illustrate how the evaluation process discussed in this document can be applied to determine energy savings or generation, and the resulting quantity of allowances. More detailed versions of these examples are included in Chapter 3.

- A utility has a program that pays incentives for energy-efficient lighting in new construction projects built by its customers. The utility reports that it has calculated savings during the ozone season of 2,190 MWh and has requested NO_x Set-Aside Program allowances. The utility program meets the eligibility requirements of the Set-Aside Program since, although the utility has generating units, the lighting projects are for its customers. The 2,190 MWh savings value needs to be reduced though, because it was calculated with the assumption of baseline lighting that is less efficient than current state code requirements. The state code requirements were considered when EPA made the statewide NO_x allocation. In addition, the savings reported by the utility were audited by the state utility commission and were found to over estimate savings by 10%. Combined, the audit and baseline corrections reduce the savings value to 1,750 MWh. These savings are calculated on a site level and can be increased, in this example by 5%, to account for transmission and distribution losses, bringing the net savings eligible for allowances to 1,837 MWh or 1,837,000 kWh. Using the EPA's default value of 0.0015 lbs of NO_x per kWh results in 1.38 annual tons of NO_x reductions or one NO_x allowance for the utility's program.

- A private developer installs a wind turbine farm. A metering report indicates that the wind farm generated 3,500 MWh of electricity during the ozone season. The project is eligible for the Set-Aside Program and because the turbines do not use fuel, the baseline energy consumption is zero and thus the wind generators' output is the savings. An audit by an independent consultant indicates that the metering reports for several of the individual wind turbines were incomplete and spot testing of some electricity meters indicates accuracy problems as high as 5%. Therefore, the consultant suggested discounting the reported savings by 5%. The net savings eligible for allowances are therefore calculated as 3,325 MWh. Using the EPA's eGRID electricity and emissions model indicates that the emission factor, for where the wind turbines are located, is

0.002 lbs of NO_x per kWh – resulting in 3.325 tons of reductions. Thus, three annual tons of NO_x allowances are allocated to the wind turbine program.

CONTENTS OF DOCUMENT

This document includes eight chapters and an appendix that provide information about: (a) the Set-Aside Program, (b) the fundamentals of evaluation and M&V, (c) calculating emission allowance allocations for EE/RE activities, (d) a recommended approach for determining emission allowances in the Set-Aside Program, and (e) resources for additional information. The "Key Issues" sections in Chapter 2 describe the distinction between allowance allocations and actual reductions of emissions, as well as issues such as *additionality* and determining the appropriate level of analysis *rigor*. The "Resources" include a wealth of information that can be used by a state to prepare its guidelines, or by participants as they implement their own EE/RE projects or programs and apply for allowances. The "Resources" include other EPA documents on the Set-Aside Program, general and specific resources on M&V from the EE/RE industry, emission factor calculation methods, general resources on how emission reductions are calculated for other programs, and Web sites with information on EE/RE projects and technologies.

Chapter 1 Introduction

1.1 EPA NO_X SIP CALL AND THE EE/RE SET-ASIDE PROGRAM

1.1.1 Background

The Clean Air Act Amendments of 1990 and the Pollution Prevention Act (PPA) of 1990 recognize the significant role that energy efficiency and renewable energy resources can play in reducing pollution and achieving the nation's environmental goals. The 1990 CAA enlists greater use of market-based controls and incentives for implementing energy-efficient technologies and practices. One example is the successful ENERGY STAR voluntary programs. It also promotes reliance on pollution prevention strategies, such as the encouragement of energy conservation and renewable energy resources in the Acid Rain Program. In addition, the 1990 PPA promotes source reduction by facilitating the adoption of particular techniques by businesses, including increasing efficiency in energy use, substituting environmentally benign fuels, and using design approaches that reduce energy demand.

Through voluntary programs, EPA has shown that energy efficiency and renewable energy resources are an effective means for reducing environmental pollution while increasing economic benefits. Many economic studies have recognized that energy efficiency and renewable energy investments provide broad societal benefits, both economic and environmental, that are not all rewarded in the revenue streams derived by investors in these projects. A major study by the U.S. Department of Energy[2] (DOE) also shows that accelerated adoption of energy efficiency is an economically sound means to reduce emissions while developing the U.S. economy.

Energy efficiency and renewable energy resources can result in reductions of fossil-fuel energy use, which are a primary cause of pollution emissions. As greater penetration of energy-efficient products and renewable energy resources occurs through a number of programs and other policies, the air pollution reduction impact has become significant. However, the air pollution emission reductions from energy efficiency and renewable energy have not been systematically recognized in air quality attainment processes.

The EPA has provided states with the option of including energy efficiency and renewable energy in the NO_x Budget Trading Program in order to (1) reduce the total economic cost of meeting the proposed NO_x cap; (2) encouraging the adoption of energy efficiency and renewable energy practices and technologies; and (3) reduce future pollution related liabilities by recognizing the positive impacts of energy efficiency and renewable energy on emissions reductions.

[2] Inter-laboratory Working Group, 2000

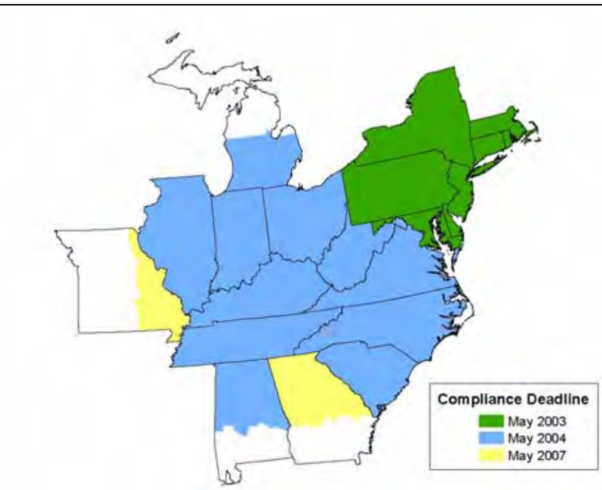
1.1.2 NOx SIP Call

In September 1998 EPA promulgated a rule to address regional transport of ground level ozone, which is the main component of smog. Ground-level ozone is transported by the wind, and tends to be a problem over broad regional areas, particularly in the eastern United States. Emissions of NO_x react in the atmosphere to form compounds that contribute to the formation of ozone. These compounds, as well as ozone itself, can travel hundreds of miles across state boundaries to affect public health in areas far from the source of the emissions. Thus, regions with "clean" air, those that meet or attain the national air quality standards for ozone, may be contributing to a downwind region's ozone problem because of transport.

The Clean Air Act requires that a state implementation plan (SIP) contain provisions to prevent a state's facilities or sources from contributing significantly to air pollution problems "downwind," specifically in those areas that fail to meet national air quality standards for ozone. Based on this authority, EPA issued the final rule, commonly known as the NOx SIP Call in 1998. The rule initially required 22 states and the District of Columbia to submit SIPs that address the regional transport of ground-level ozone through reductions in NO_x. The states subject to the final action were: Alabama, Connecticut, Delaware, Georgia, Illinois, Indiana, Kentucky, Massachusetts, Maryland, Michigan, Missouri, North Carolina, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Virginia, West Virginia, and Wisconsin.

The rule required states to submit their SIPs by September 1999 and to put reduction measures in place by May 1, 2003. The District of Columbia and other Ozone Transport Commission (OTC) states in the Northeast, with the exception of New Hampshire, began monitoring NOx in 2002 and implemented programs in 2003. Compliance in most other NOx SIP Call states was delayed by litigation until May 31, 2004, with required monitoring beginning in 2003. Because of the litigation, the compliance dates in affected portions of Georgia and Missouri are delayed until May 2007 and, for 2004 only, limited to May 31 to September 30 in eleven states. In addition, Wisconsin was removed from the reduction requirements.

Figure 1.1: Compliance Dates in the NO_x SIP Call Region



Under the NO_x SIP call, EPA set an ozone season NO_x budget for each affected state, essentially a cap on emissions from May 1 to September 30 each year. States had the option of participating in the NO_x

Budget Trading Program to meet NO_x SIP Call requirements. The NO_x Budget Trading Program sets emissions limits for the affected sources in the form of NO_x "allowances" for each state during each ozone season. One allowance authorizes the emission of one ton of NO_x. Under the NO_x Budget Trading Program, EPA provides a specific number of allowances per year to each state. The states then determine how to allocate the allowances. States may hold back a portion of their allowance budget to set aside allowances for new sources, energy efficiency and renewable energy, or other purposes.

In order to demonstrate compliance, budget sources must monitor and report their actual emissions to EPA. Under the trading program, most sources use continuous emissions monitoring systems. Units that operate infrequently ("peaking" units), or units with low NO_x emissions may use simpler estimation methods. Regardless of the method used to determine emissions, the data used to support these determinations is reported to EPA electronically (by July 30 for the months of May and June, and by October 30, for the months of July, August, and September).

Sources demonstrate their compliance by holding enough allowances in their accounts to cover their ozone season emissions. If sources do not have enough allowances to cover their emissions based on their initial allocation, they may take advantage of the flexibility provided by the allowance market and buy allowances. Sources have until November 30th of each year, two months after the end of the ozone season, to ensure that they hold adequate allowances. The EPA verifies that sources hold adequate emissions allowances through standardized monitoring and reporting procedures.

Allowances may be bought, sold or traded in a market-based program between the affected sources and other private parties. Trading allows industry flexibility while ensuring that overall emissions are reduced. For example, if one company finds the cost of reducing emissions to be relatively low, it may be able to reduce its emissions more than required. That company then could sell or trade "allowances" it does not need to a company for which reductions would be more expensive. Sources also may receive allowances for achieving reductions earlier than required and may "bank" the resulting allowances for future use.

When designed and implemented properly, a market-based cap and trade program offers many advantages over its traditional command and control counterpart, including (1) reduced cost of compliance, (2) creation of incentives for early reductions, (3) creation of incentives for emissions reductions beyond those required by regulations, (4) promotion of innovation, and (5) increased flexibility. A market system that employs a fixed tonnage limitation for a group of sources provides the greatest certainty that a specified level of emissions will be attained and maintained since a predetermined level of reductions is ensured. With respect to transport of pollution, an emissions cap also provides the greatest assurance to downwind states that emissions from upwind states will be effectively managed over time.

1.1.3 The Energy Efficiency and Renewable Energy (EE/RE) Set-Aside

An EE/RE Set-Aside is a pool of allowances that is reserved for energy efficiency and renewable energy projects that reduce fossil fuel electricity generation. The EPA suggests that 5% to 15% of a state's NO_x budget be made available for an EE/RE Set-Aside (the actual percentage is determined by individual states). An EE/RE Set-Aside comes from within a state's NO_x budget for core sources. EPA has defined two key principles that underlie the EE/RE Set-Aside Program within the NO_x Budget Trading Program: (1) encouraging energy efficiency and renewable energy actions that would not occur without a set-aside; and (2) doing so while maintaining the integrity of the NO_x budget.

EE/RE set-asides comes from within a state's NO_x budget to ensure that the use of these allowances will not cause a state to exceed its budget. It comes from the electricity budget in order to: (1) be consistent with the goal of awarding end user actions, and (2) avoid the possibility of double-rewarding allowances. This means that EE/RE set-aside allowances are not intended for actions that reduce or displace on-site fuel use. Rather, EE/RE allowances are intended to reward actions that result in a reduction in electricity generation at a core electric generating unit (EGU) through reductions in demand (e.g., efficiency project) or reducing the amount of electricity used from the grid (e.g., renewable generation project).

On-site fuel reductions at core sources that receive allocations are not eligible for the EE/RE Set-Aside Program because: (1) they are the result of supply-side management actions, and (2) they are self-rewarding. Supply-side efficiency improvements are not attributable to end user actions in the same way that DSM and other energy efficiency and renewable energy actions are in reducing electricity generation. To illustrate, a reduction in fuel use due to efficiency improvements at a core source boiler reduces NO_x generation at that boiler and frees up allowances for the core source to use elsewhere in that facility or in other company facilities, or to trade in the market. If additional allowances were awarded to this activity, then the owner or operator of the boiler would essentially be rewarded twice.

The EE/RE set-aside focuses primarily on renewable energy and end-user electricity efficiency actions because the amount and source of electricity that users consume affects the amount of NO_x emitted at a core source EGU. Rewarding an end use project that reduces or displaces electricity generation is very different from the situation described above for a core facility fuel efficiency project. Since the end user and the electricity generator are usually two different entities, the chance for double rewarding is minimized.

For example, take a situation in which a comprehensive energy efficiency retrofit project is implemented in a commercial building. The electricity generating facility will enjoy the benefit of the reduction in NO_x that the end user's efficiency improvement has achieved. The end user's action will therefore reduce the electricity generator's need for allowances; and potentially free up allowances for the generator to use otherwise or to trade in the market. However, the Set-Aside (set aside from those that would have been given to the core sources) allowance, for the actions taken, will go to the sponsor of the commercial building efficiency project, who is free to keep or trade the allowances in the market. This guidance is primarily for designing systems that reward this kind of end user activity.

The EE/RE Set-Aside Program is a means by which end users implementing these projects can receive some of the appropriate rewards for their role in providing a specific environmental benefit – preventing NO_x emissions – while broadly benefiting the economy. States which choose to incorporate a set-aside into the NO_x Budget Trading Program can expect to realize economic benefits as a result of reduced electricity consumption and reduced need for expenditures on pollution control equipment, both of which can lead to lower electricity rates. These projects can also lead directly to job creation and growth in gross state product. Energy efficiency and renewable energy deployment benefits can accrue to electricity consumers, electric generators, and the state economy at large.

Table 1.1 summarizes the estimated NO_x allowances allocated to each state, along with the NO_x and estimated electricity reductions associated with a hypothetical 5% Set-Aside.

Table 1.1 State-by-State Allowances and EE/RE Set-Aside Example Allowances and Estimated Potential Electricity Savings as of 1998 (Note that MA, CT and RI were subsequently adjusted)

State	EGU Maximum Summer NO_x Tons (1)	NO_x Tons at 5% Set-Aside	MWh savings at 5% Set-Aside (2)	Peak MW savings at 5% Set-Aside (3)
AL	28,884	1,444	1,925,600	879
CT	2,545	127	169,667	77
DC	207	10	13,800	6
DE	3,489	174	232,600	106
GA	30,061	1,503	2,004,067	915
IL	30,165	1,508	2,011,000	918
IN	46,627	2,331	3,108,467	1,419
KY	36,315	1,816	2,421,000	1,105
MA	14,619	731	974,600	445
MD	14,788	739	985,867	450
MI	26,344	1,317	1,756,267	802
MO	23,171	1,159	1,544,733	705
NC	29,967	1,498	1,997,800	912
NJ	7,898	395	526,533	240
NY	29,391	1,470	1,959,400	895
OH	45,776	2,289	3,051,733	1,393
PA	48,038	2,402	3,202,533	1,462
RI	1,115	56	74,333	34
SC	16,286	814	1,085,733	496
TN	25,386	1,269	1,692,400	773
VA	18,009	900	1,200,600	548
WI	16,751	838	1,116,733	510
TOTALS	**522,271**	**26,114**	**34,818,067**	**15,899**

(1) Set-Aside based on revised state-by-state maximum summer NO_x emission levels as presented in Appendix C of EPA Final Rule 40 CFR Parts 51, 72, 75, and 96 issued on October 20,1998.
(2) MWh equivalent is based on EPA default value of 0.0015 lbs of NO_x/kWh; 1,000 kWh per MWh.
(3) MW equivalent is based on a 60% load factor for the five ozone-season months.

1.2 SUMMARY OF STATE SET-ASIDE PROGRAMS

As of 2005, seven states have developed EE/RE Set-Aside Programs as part of their NOx SIP Call efforts[3]. These states are Indiana, Maryland, Massachusetts, Missouri (implemented after the referenced 2005 report), New Jersey, New York, and Ohio. These states have established EE/RE Set-Aside Programs using 1% to 5% of their NO_x trading program budget.

Programs in Massachusetts, Missouri, New Jersey, New York, and Ohio address evaluation, measurement, and verification (EM&V) requirements with specific procedures, which are summarized below:

- Massachusetts stipulates that M&V of energy saved or generated by each project shall adhere to the International Performance Measurements and Verification Protocol (IPMVP) or the U.S. EPA's Conservation Verification Protocol (CVP). Also required are M&V provisions of NEPOOL's Operating Procedure 18 "Metering and Telemetering" or other provisions acceptable to the state agency.
- Missouri, in lieu of specific M&V procedures, proposes to rely on a requirement that all applications be submitted with certification by a professional engineer attesting that information and calculations submitted in the application are complete and accurate. The state

[3] U.S. EPA, 2005

agency also has the right to require verification of data and calculations presented in the application as a condition for awarding the allowances and may include site visits by the agency or its agents.

- New Jersey has a specific guidance document for energy efficiency projects (see "Measurement Protocol for Commercial, Industrial and Residential Facilities," inc by ref. at NJAC 7:27-31.21).
- New York requires that applicants follow protocols as specified by the state, and is currently developing additional guidance material that will clarify their M&V procedures.
- Ohio states in its guidance that sponsors must use established M&V procedures. The guidance refers to M&V procedures developed by DOE and EPA as examples.

Web sites for these programs, where available, are listed in the Appendix.

1.3 SUMMARY OF TWO PREVIOUS EE/RE SET-ASIDE GUIDANCE DOCUMENTS

EPA has organized the Set-Aside Program guidance into three documents, which are available on the EPA website: http://epa.gov/cleanenergy/

The first Set-Aside guidance document, *Creating an Energy Efficiency and Renewable Energy Set-Aside in the* NO_x *Budget Trading Program: Establishing a Set-Aside*, focuses on the elements that states typically consider in determining whether to establish a Set-Aside Program. It discusses the types of projects eligible for set-aside allowances, and how to determine an appropriately-sized set-aside pool. The critical elements for crediting EE/RE allowances in a state's SIP are addressed.

The second Set-Aside guidance document is, *Creating an Energy Efficiency and Renewable Energy Set-Aside in the* NO_x *Budget Trading Program: Designing the Administrative and Quantitative Elements*. It focuses on the key design elements necessary for quantifying and allocating allowances under a Set-Aside Program. While states can determine these elements after their initial SIP submission, it is important that they be decided upon before the Set-Aside Program begins.

In the first two guidance documents, EPA emphasizes that most elements can be determined by the individual states. One of these is eligibility of various project types, which typically differs from state to state. State rules and instructions also vary for project timing, aggregation, documentation, EM&V, allowance calculation, and length of award; as well as for procedures when the set-aside pool is under or over subscribed; and in the type of guidance available to those who apply for set-aside allowances.

1.3.1 Overview of First Guidance Document

The first guidance document details factors to consider in determining the size of the set-aside, including determining what types of projects will be eligible, and length of time a project must be in place to be eligible for an award. The design issues that the first guidance document addresses include:

1. What types of projects are eligible for awards, and who would receive allowances?
2. Can the pool size be used so that most allowance awards go new projects?
3. How should the pool be sized to include actions implemented before 2003?
4. How does pool size depend on the number of control periods the award will be given for (length of award)?

5. How can states adjust their set-aside pools to handle over and under subscription?

The following table summarizes the recommended approach for the design elements that the EPA provides in the first guidance document:

Table 1.2 First Guidance Design Recommendations

Program Design Element	EPA's Recommendation
Size of Set-Aside	5 -15 percent
Eligibility of Applicants and Projects	Not more than one applicant for each project should receive allowances-- allowances should be awarded to end user
Focusing on "New" Projects	Pool large enough for "new" and "business-as-usual" projects
Credit for Early Actions	Yes
Length of Award	3 years
Over-Subscription	First come, first served
Under-Subscription	Pro-rata reallocation

1.3.2 Overview of Second Guidance Document

In the second guidance document, the EPA addresses the various program elements that states will need to define for administering their Set-Aside Program. In particular, the second document focuses on how to design the set-aside application process; how to allocate set-aside allowances to eligible projects; how to translate energy savings and displacements into emissions reductions; the time frame for processing applications and administering allocations; and the kinds of documentation and reporting that can be used.

The design issues that the second guidance document addresses include:

- How should applicants request allowances from the set-aside, and at what point in the control period should they apply?
- How can states design procedures for reviewing applications, and for notifying applicants that they have been accepted to the program?
- How can the energy savings from eligible projects be translated into emissions reductions?
- After energy savings are calculated, when should allowances be distributed to program participants?
- What type of information should be requested in forms and other submittals, and how should these forms be designed?

The EPA has recommended an approach for each design issue. The following table summarizes the EPA's overall recommendations.

Table 1.3 Second Guidance Design Recommendations

Program Design Element	EPA's Recommendation
Application Process	"Two-step" process
Translating Energy Savings and Displacements into Emissions Reductions	Emissions factor
Accounting for "Business as Usual" (BAU) or Baseline Uncertainty	Compensation factor
Award Process	"Seasonal Lag" option
Timing	Coordination between all processes
Documentation, tracking and reporting	Establishment of appropriate NO_x Account Tracking System (NATS), Periodic and on-going documentation

In practice, state approaches vary for the design elements shown above in Table 1.3:

- The two-step application approach is in place in Indiana and Ohio; and the one step approach is taken in Massachusetts, Missouri, New Jersey, and New York.
- Missouri, New Jersey, New York and Ohio use the EPA's recommended conversion rate of 1.5 lbs/MWh. Indiana and Massachusetts use a variety of calculations for different categories of projects.
- Application deadlines and the timing of allowance distribution vary from state to state.

1.4 ELIGIBLE PROJECTS FOR THE EE/RE SET-ASIDE

Each State decides which types of projects and programs can be included in a Set-Aside Program. In the EPA's first guidance document, *Establishing an Energy Efficiency and Renewable Energy Set-Aside*, EPA provides general recommendations for determining the types of energy efficiency actions and entities that could qualify for Set-Aside Program allowances. In that document, EPA states that while it is up to each state to determine who and what types of projects qualify for allowances, it is important that the Set-Aside Program provides allowances only for reductions or displacements of electricity use. As such, EPA recommends that states follow six major criteria that projects must meet in order to be eligible to be awarded with EE/RE set-aside allowances:

1. Reduces or displaces electricity load from core source, EGUs in the SIP Call region
2. Is not required by Federal government regulation and is not used to generate compliance or permitting allowances
3. Is in operation in the year(s) for which it will receive allowances
4. Reduces or displaces energy during the summer ozone season (May 1-September 30)
5. Is capable of being documented and verified
6. Have savings that equal at least one ton of NO_x allowances, or can be aggregated with other projects into one-ton increments

Examples of the types of projects that would be eligible for the Set-Aside Program are:

- End-use energy efficiency projects, including demand-side management programs
- Highly efficient electricity generation for the predominant use of a single end user, such as combined cycle, combined heat and power, microturbine, and fuel cell systems
- Projects generating electricity through the capture of methane gas from sanitary landfills, water treatment plants, sewage treatment plants, or anaerobic digestion systems operating on animal or plant wastes
- Renewable energy generation projects that utilize resources such as solar energy or wind energy

1. 5 LINKING EMISSIONS REDUCTIONS FROM AN EE/RE SET-ASIDE TO A STATE IMPLEMENTATION PLAN

By following applicable state and federal regulatory procedures, states can gain "credit" for the resulting NO_x reductions in their SIP for ozone. The EPA recognizes that many of the traditional measures for improving air quality have been taken, and that states value new and innovative approaches to reducing emissions. The 2004 document, *Guidance on State Implementation Plan (SIP) Credits for Emission Reductions from Electric-Sector Energy Efficiency or Renewable Energy Measures*,[4] describes how emissions reductions from EE/RE resources can be applied to state SIP provisions regarding: reasonable further progress (RFP), rate of progress (ROP), attainment demonstrations, and maintenance plans. The 2004 Guidance document also outlines procedures for ensuring that reductions are quantifiable, surplus, enforceable, and permanent. It is important to note that only reductions calculated using an emissions rate equivalent to – or lower than – the displaced emissions rate meet the "surplus" criterion. This means that while allowances can be allocated to EE/RE resources using a high (incentive) emissions rate, the rate for determining total emissions reductions eligible for SIP credit is the displaced emission rate.

The 2004 Guidance document is intended to serve as a living document that will be updated based on new information. EPA and state officials retain the discretion where appropriate to adopt approaches to the approval of SIP measures on a case-by-case basis that differ from the guidance. Nevertheless, as many areas of the country continue to experience challenges in meeting air quality standards, it is expected that EE/RE resources will continue to play an important role in state plans for improving air quality.

1.6 ORGANIZATION OF THE GUIDANCE DOCUMENT

This guidance document is divided into eight Chapters and one Appendix:

- Chapter 1, Introduction, discusses document organization and the NO_x SIP Call Program.
- Chapter 2, Evaluation Issues and Notes on Terminology, covers basic emissions accounting standards, the difference between allowances and emission reductions, some other key evaluation issues, and terminology.

[4] U.S. EPA, 2004

- Chapter 3, Determining NO_x Allowances from EE/RE Programs and Projects, describes the steps suggested for determining emissions allowances to be allocated to EE/RE projects. The rest of the Chapters support Chapter 3 with details and background information associated with the various steps.
- Chapter 4, Measurement and Verification Concepts, provides background information on the M&V process for calculating electricity savings from energy efficiency projects or programs in the context of the Set-Aside Program.
- Chapter 5, Calculating Energy Savings from Energy Efficiency Projects and Programs Using Existing Documentation, discusses how to determine electricity savings from efficiency projects or programs for the Set-Aside Program if the application for allowances includes an M&V report on electricity savings.
- Chapter 6, Calculating Energy Savings from Energy Efficiency Projects and Programs Using New Analyses – Establishing a NO_x Set-Aside Specific Evaluation Protocol, covers defining a state-specific process using the M&V Options defined in the IPMVP as well as background on other M&V approaches.
- Chapter 7, Measurement and Verification for Renewable Energy Projects, discusses determining electricity savings from renewable energy projects.
- Chapter 8, Determining Emission Allocation Rates and Potential Emissions Reductions from Electricity Savings, provides information and options for determining pounds per kWh emission rates that can be used to calculate an allowance allocation rate and potential emission reductions from EE/RE projects or programs.

The Appendix provides a list of key resources that provide useful information on EM&V, emission reductions, and EE/RE projects.

Chapter 2 Evaluation Issues and Notes on Terminology

This Chapter provides background on some fundamental issues associated with conducting energy efficiency and renewable energy project evaluations when the objective of the evaluations is to determine emission reductions or allowances. The Chapter starts with a discussion of evaluation standards as they relate to calculating emission reductions. Next is a discussion of the difference between an emission allowance and an emission reduction in a cap and trade program. Following this discussion is a section on other key evaluation issues and a section on terminology.

2.1 BASIC EVALUATION ACCOUNTING STANDARDS

There are several general principles associated with the emissions accounting industry that can apply to the NO_x Set-Aside Program. Compliance with these principles should be the basis for evaluation activities. These principles are summarized in the World Resources Institute and World Business Council For Sustainable Development document*: GHG Protocol for Project Accounting.*[5] The GHG Protocol is the basis for the following discussion of the accounting principles and how they apply to the NO_x Set-Aside Program.

- Relevance – Physical and temporal boundaries are properly defined for the project or program. Of particular importance for the Set-Aside Program are:
    - The project and program are in an area served by the electric generating units (EGUs) in the state
    - The time frame for the electricity saving analyses is the ozone season. Electricity savings calculated from most M&V efforts are reported for a complete year and converted to a value for the 5-month ozone season based on measure-specific characteristics.[6]
- Completeness – The scope of evaluation takes into account the primary and secondary effects and the direct and indirect emissions associated with the project or program. Of particular relevance for the Set-Aside Program are:
    - Increases (or decreases) in on-site fuel or electricity consumption are taken into account[7]
    - The baseline is appropriate for the NO_x SIP Call Program – the baseline defined for the original use of a M&V report might be different than that required for the NO_x Program.[8]

---

[5] The GHG Protocol for Project Accounting, released in December 2005, is a tool for determining the greenhouse gas emission reduction benefits of climate mitigation projects. It was produced using a collaborative process involving businesses, NGOs, governments, academics, and other (WRI and WBCSD, 2005a).

[6] For example, an energy efficiency retrofit of a heating system may not save any electricity during the summer ozone season.

[7] Examples might be fuel consumption for back up generation at a renewable energy plant or increased electric heating requirements after a lighting retrofit reduces the heat gained in an office building from the lighting system.

- Consistency – Consistent definitions, assumptions, tests, and methods are used for defining the baseline and the project energy use and emissions. Examples of consistency include:
    - Using the same measurement techniques for determining the baseline and reporting period electricity consumption of a system
    - Using the same assumptions for weather, indoor environment (temperature set points, illumination levels, etc.) and occupancy in a building for baseline and reporting period energy analyses
- Transparency – Documentation and reporting include all relevant information in a coherent and factual manner that allows reviewers to judge the reliability and accuracy of the data and results. Examples of good, transparent, analyses are:
    - Project descriptions indicate the secondary emissions and direct effects associated with the project or program clearly indicated
    - Critical assumptions are stated and documented
    - Documentation is presented in a format that allows the reviewer to follow a connected path from assumptions, to data collection, to data analysis, and to results
- Accuracy – NO_x reductions are calculated at a level of accuracy such that the savings are neither intentionally over- nor under-estimated, the accuracy of the estimate is indicated, and the level of accuracy is sufficient for maintaining the integrity of the Set-Aside Program.
- Conservatism – When assumptions are required concerning the baseline definition, energy savings, or NO_x emission factors, conservative assumptions are adopted. This is an important consideration for the Set Aside Program in that the tendency is towards conservative estimates. However, for determining the best estimate of actual savings and reductions the estimate should not be prejudiced to optimistic or conservative.

---

[8] The most common example is that the baseline for a performance contract might be existing equipment, whereas for the NO_x Set-Aside Program the appropriate standard might be current energy standards, which would most likely be more efficient than the existing equipment prior to a retrofit. The end result is lower savings when comparing the energy use of new equipment with an energy standard versus comparing the new equipment with the equipment that was actually replaced.

2.2 ALLOWANCE ALLOCATIONS VERSUS EMISSION REDUCTIONS

Cap and trade programs are enforced through the issuance of a limited number (equivalent to the emissions cap) of allowances to core emission sources. Through trading and banking of these allowances, individual sources can vary their emissions, as long as the aggregate emissions for all sources do not exceed the allowances issued. By limiting the total volume of emissions for a particular set of sources, cap and trade programs automatically account for any action that reduces emissions, including energy efficiency and renewable energy (EE/RE).

For example, consider an energy efficiency project that is projected to reduce electricity consumption in a complex of privately owned buildings. If electricity consumption is reduced as anticipated, the related pollution reduction occurs not at the buildings but at a fossil fuel unit (that itself receives emission allowances). The owner of that fossil fuel unit can then sell unneeded allowances to other emitting sources, but the total number of allowances is still at the capped level. This illustrates that when allowance markets operate efficiently, total emissions in a capped system equal the capped level regardless of new EE/RE resources.

When a state establishes a Set-Aside Program, a percentage of the state's allowances is reserved for qualifying EE/RE resources. Allocating allowances to EE/RE projects does not result in emissions above the cap since the RE allowances are "set-aside" or subtracted from the total number of allowed core-source allowances. Thus, even if emissions reductions were "double-counting" by EGUs, project developers, or some other entity, total emissions would not increase beyond the capped level. However, whether EE/RE projects result in actual emissions reductions below the cap, depends on actions taken by the allowance holder.

EE/RE set-aside allowance recipients can sell their allowances at the current trading price or "bank" them in anticipation of receiving a higher price in the future. While this approach offers an incentive for EE/RE project developers, the re-sale of allowances means that pollution reductions are unlikely to occur to levels below the state set cap. Under a cap-and-trade program, the only way to ensure that real emissions reductions below the cap result from EE/RE resources is to remove set-aside program allowances from circulation, i.e. "retiring" them. Retiring allowances allows a state to credit the reductions towards its SIP goals. This linkage represents an opportunity for states that have adopted all traditional emission control strategies to take advantage of new pollution reduction opportunities and move closer towards compliance with federal air quality standards.

Two of the options, but not necessarily the only options, for crediting emissions reductions are:

- Baseline Approach − Incorporating the estimated effect that EE/RE programs have on emissions within the projected emissions inventory baseline provides a corresponding decrease in the emissions cap. With this approach, there is no Set-Aside Program. Essentially, the cap is reduced to account for "parallel" EE/RE programs that are implemented as part of a state's overall approach to energy resource and environmental management.
- Control Measures Approach − Incorporating emission reductions from individual control measures, e.g., EE/RE projects or programs supported by a Set-Aside Program provide a corresponding decrease in the emissions cap but, only if the allowances are retired.

While the title of this document uses the term "reductions", the methods discussed actually relate to how a state calculates the quantity of allowances allocated to EE/RE activities within the cap and trade program. Whether, these allowances contribute to reductions beyond the capped level is a policy decision that requires retiring of EE/RE allowances through voluntary actions by the EE/RE allowance recipients or a re-purchase program operated by the state or another entity.

2.3 KEY EVALUATION ISSUES

When determining the quantity of allowances for allocation to energy efficiency or renewable energy projects, states need to address a number of issues. Some of these are unique to the Set-Aside Program, but most are common to other evaluation analyses. The key issues are discussed below.

Program versus project evaluation

A project is a single activity at one location. Examples include an energy-efficient lighting retrofit in an office building or a photovoltaic system installation at a factory. A program is a group of projects, with similar characteristics that are installed in similar applications, such as a utility program to install energy-efficient lighting in commercial buildings, a developer's program to build a subdivision of homes that have photovoltaic systems, or a state residential energy efficiency code program. As described in this document, the techniques for determining savings from a single project or a group of projects with similar characteristics (a program) are quite similar, with one exception. That exception is that while each project is evaluated individually, programs are evaluated from a sample of projects with the results applied to the entire program "population"[9]. The end result is that program evaluation on a "per–project" or "per-ton" basis tends to be much more cost-effective than project-by-project analyses. As a result, it is more cost-effective to encourage programs or large aggregations of similar projects to participate in the Set-Aside Program.

Additionality

Additionality is the term used in the emission mitigation industry for addressing the key question of how can one know that a project will produce *reductions in emissions that are additional to any that would have occurred in the absence of the certified project activity*. This raises the issue of defining "baseline" or "business-as usual" conditions. As the baseline is a "what-if" value, it cannot be directly measured and must be implied from available information. Energy savings and emission reductions are calculated as the difference between baseline and post-project installation (reporting period) energy use and emissions.

As discussed later in this document, having consistent and simple baseline standards is an important part of a successful Set-Aside Program. In summary, baseline definitions will consist of: (a) existing conditions (e.g., the energy consumption of the inefficient system being replaced), (b) code requirements (e.g. appliance standards), or (c) baseline levels of activity included in a state's SIP (e.g. a pre-existing, mandated statewide renewable energy portfolio).

Defining the Project or Program – Assessment Boundaries and Ownership

[9] The exception is when a large-scale data analysis approach is used. With this approach, statistical analyses are conducted on the energy usage data (typically collected from the meter data reported on utility bills) for all or most of the participants and possibly non-participants in the program. This approach is primarily used with residential programs where relatively homogenous homes and measures are implemented and project-specific analyses are not required or practical.

When evaluating the emission reductions and the allowances to be allocated to EE/RE project, it is important to properly define the project boundaries. Ideally, all primary effects (the intended savings) and secondary effects (unintended positive or negative effects) and all direct emissions (at the project site) and indirect emissions (at other sites) will be taken into account[10].

The Set-Aside Program focuses on indirect emission reductions at EGUs that result from EE/RE projects. Sometimes, though, secondary effects warrant consideration. For example, an on-site lighting retrofit has a primary effect of reducing electricity consumption due to lower wattage light bulbs. The secondary effect might be increased space heating requirements due to the lighting retrofit reducing the space heat gain from lighting. From a programmatic perspective, a residential air conditioner program that promotes installation of more efficient air conditioning could have a secondary effect of increasing the use of air conditioning as the homeowners' cost of operation is reduced. In addition, for projects that increase on-site fuel consumption, such as a biomass-fueled boiler with auxiliary natural gas consumption, direct emission calculations are required.

It is also appropriate to consider ownership and control issues for the projects and programs being evaluated. While not necessarily a technical evaluation issue, it is not unusual for there to be questions associated with whether the facility owner, the contractor, or perhaps a state project sponsor is to receive the allowances.

Uncertainty, Error, Rigor and Risk

The terms uncertainty and error are not interchangeable. *Error* is applicable when the exact "correct" value is known, while *uncertainty* is applicable when no such knowledge is available. Error calculations in savings estimates are possible with most renewable energy projects since the electricity savings are equal to the output of the project (i.e. the baseline is zero). For example, the electricity savings from a photovoltaic system are equal to the output of the system, which can be directly measured.

However, the electricity saving from energy efficiency projects cannot be measured. The savings are equal to baseline energy consumption less the consumption associated with the new project, with the understanding that baseline consumption is a hypothetical value that cannot be directly measured. Thus, uncertainty is the more relevant term to use for energy efficiency savings calculations. While this uncertainty can be disconcerting for some, the concept of the cap and trade program is that irrespective of the uncertainties associated with any allowance, the cap on allowances prevents emissions from increasing beyond a certain level.

For almost all evaluations, complete and robust data will not be available to assess the statistical uncertainty in every parameter or in the overall savings estimates. For example, it is typical that a single data point will be available for key parameters (e.g. power consumption or building occupancy). While some parameters can be inferred from a sample of measurements, in most situations uncertainty estimates require expert judgment.

Rigor is a term used to encompass the issues of uncertainty and error for M&V activities and is defined as the level of expected reliability of energy, and thus emission, reductions in terms of both accuracy and precision. *Accuracy* refers to the degree to which the determined savings are near the true value and not biased, e.g., off in one direction or another. *Precision* refers to the closeness of agreement among repeated measurements of the savings. Rigor can be defined to be within certain accuracy levels and precision limits.

[10] See Section 2.4 on Terminology for more information.

Successful evaluations find the proper balance between rigor and cost – too much of either can result in an unsuccessful Set-Aside Program.[11] What is an acceptable level of rigor is often a subjective judgment based on the value of the NO_x allowances, the risk to the Set-Aside Program associated with over- or underestimated savings, and a balance between encouraging EE/RE actions and high levels of accuracy and precision. Each State can decide what level of risk it considers acceptable and thus its requirements for rigor.

Using Electricity Savings Documentation Not Prepared for the Set-Aside Program

With this document, EPA has established a two-pronged approach to providing guidance on M&V. The first approach, as described in Chapter 4, involves quality assurance guidelines for reviewing M&V documentation not specifically prepared for the Set-Aside Program, but submitted with an application for set-aside allowances. The second approach, as covered in Chapter 5, offers guidance on what could be included in a project or program M&V plan specifically prepared for the Set-Aside Program. Both approaches rely on standards common to all M&V activities: relevance, completeness, transparency, consistency, accuracy, and conservativeness. However, some form of energy savings documentation will often be prepared as part of a project or program implementation. If this documentation is usable, it can be more cost-effective for the state to evaluate this documentation than to require a new M&V effort.

Persistence

Each state can determine the number of ozone seasons for which each EE/RE application can be valid. *Persistence* is a term for how long the energy savings (and emission allowances) continue to be valid. If the projects or programs are allowed to accrue allowances over multiple season , the state will have an interest in validating the persistence of savings. The methods typically used are annual reviews of savings reports and inspections to ensure that the projects or programs are still operating properly. Including a persistence report and/or inspection procedure is an important aspect of each state's guidance documents.

Evaluation Costs and Value of Information

When designing and implementing a Set-Aside Program, the challenges associated with evaluation will be reduced to balancing the cost, effort and rigor of various approaches with the value of the information generated by the efforts. Most of the value of information is tied to the value of NO_x allowances and overall Set-Aside Program integrity. The costs for high levels of confidence in the EE/RE NO_x allowance calculations must be compared to the risks (and costs) associated with the value of allowances being allocated to EE/RE projects and programs. In this sense, evaluation processes are about risk management. Low-risk projects require less evaluation rigor; high-risk projects require more evaluation rigor. How much risk is acceptable is tied to the size of the set-aside, the value of the allowances, other benefits of promoting EE/RE activities, and the resources available to state agencies and EE/RE promoters involved in implementing the Set-Aside Program.

Understanding the implications of various M&V requirements on the transaction costs associated with applying for and documenting allowances is an important part of designing a state Set-Aside Program. It is important to note that given the value of NO_x allowances and the small number of credits that can be generated from typical efficiency and renewables programs, the amount of effort that is appropriate

---

[11] A good resource for uncertainty calculations are ASHRAE's Guideline 14 on Measurement of Demand and Energy Savings (ASHRAE, 2002) and the WRI/WBCSD document Measurement and Estimation Uncertainty for GHG Emissions (WRI and WBCSD, 2005b). See the Appendix for location of these documents.

to spend on evaluation may be limited. The experience of other states and the M&V resource documents described in Chapter 4 and referenced in the Appendix can provide guidance on this issue.

Other Project Types

This guidance document addresses electricity savings from renewable energy projects and demand side efficiency projects. Some states may wish to include other project types such as combined heat and power (CHP), supply side efficiency projects, or thermal energy (e.g. natural gas) efficiency projects. These can be valid project types and may be addressed in future EPA Guidance documents.

2.4 TERMINOLOGY

The EE/RE Set-Aside Program combines insights from two fields, environmental and energy management, each of which has its own terminology and acronyms. In this document, the following terms are and definitions are provided.

Two of the key terms are *measurement and verification (M&V)* and *evaluation*. These terms are sometimes used interchangeably within the energy efficiency industry but have distinct meanings within the emissions control field. For the purposes of this document, these definitions are used:

Evaluation: The process of determining potential emission reductions from a project or program including consideration of energy savings, emission factors, and any gross savings to net savings adjustments required.

Measurement and verification (M&V): A subset of evaluation that is associated with the documentation of energy savings or generation using one or more methods that can involve measurements, engineering calculations, statistical analyses, and/or computer simulation modeling.

Other important terms are:

Allowances: Allowances represent the amount of a pollutant that a source is permitted to emit during a specified time in the future under the NOx Budget Trading Program. Under the set-aside provision, allowances are allocated to EE/RE projects and programs, and are tracked in a NO_x Account Tracking System. Allowances are often confused with *credits* earned in the context of project-based or offset programs, in which sources trade with other facilities to attain compliance with a conventional regulatory requirement. Cap and trade program basics are discussed at the following EPA Web site: http://www.epa.gov/airmarkets/cap-trade/index.html

Baseline: Conditions, including electricity consumption and related NO_x emissions that would have occurred without implementation of the subject project or program. Baseline conditions are sometimes referred to as "business-as-usual" (BAU). Energy and emission reductions are calculated as the difference between the baseline and the project or program energy use and emissions. Options for determining baselines include (a) "project specific" and (b) "multi-project" or "performance standards" baselines. The "project specific" definition uses the subject site's existing or pre-project circumstances to define the baseline; this could involve using site-specific historical energy use or emissions data. "Multi-purpose" definitions utilize either conventional practices as the basis for a baseline or energy codes and regulations to define the baseline energy use (e.g. equipment efficiency standards).

Core Sources: Primary NO_x emitting sources granted allowances by the EPA under a state NO_x budget. For the purposes of the energy efficiency and renewable energy set-aside, allowances will only be credited for electricity reducing measures that lower demand from EGUs larger than 25 MW.

Direct and Indirect Emissions: Direct emissions are changes in emissions at the site (controlled by the project sponsor or owner) where the project takes place. For EE/RE projects this includes consideration of any increases or decreases in fuel use on-site (e.g., cogeneration fuel consumption) due to the subject project or program. Indirect emissions are changes in emissions that occur at the emissions source (e.g., the power plant or EGU). Indirect emissions are the primary source of allowances under the EE/RE Set-Aside Program.

Measure: An energy efficiency measure is a specific activity that can be a part of or an entire energy efficiency project. Examples of measures are lighting retrofits, motor replacement, and controls retrofit. These might be completed at a single facility, and in combination are considered a "project".

Net and Gross Savings: Calculation of savings at the site level (location of the renewable or energy efficiency project – sometimes called facility level savings for energy efficiency projects) results in a "gross savings" estimate. Gross savings are calculated as the difference between baseline and post-installation energy use. Net savings are the savings that actually occur at the EGU, and are typically calculated at the program level. There are a number of factors that states may take into consideration when converting gross savings into net savings. For example, common factors for consideration with energy efficiency programs are increased savings due to transmission and distribution losses between the project site and the EGUs, reduced savings due to lack of additionality, i.e. "free riders", and increased savings due to "spillover" effects (actions of non-program participants).

Persistence Review: Process for determining how long the energy savings and emission allowances continue to be valid once a project is installed.

Primary and Secondary Effects: Primary effects are those that the project or program are intended to achieve. This may include reductions in energy use per unit of output (energy efficiency) or increases in renewable energy generation. Secondary effects are other, unintended, impacts of the project or program such as life cycle impacts (e.g., increasing energy use as it becomes more efficient and less costly), activity shifting (e.g., when generation resources move to another location), and market leakage (e.g., emission changes due to changes in supply or demand of commercial markets). These secondary effects can be positive or negative.

Project: A single measure or group of energy efficiency and renewable energy measures at one location. This could include energy-efficient lighting and motors retrofits in an office building, or a photovoltaic system installation at a factory.

Program: A group of projects, with similar characteristics and installed in similar applications. Examples could include a utility program to install energy-efficient lighting in commercial buildings, a developer's program to build a subdivision of homes that have photovoltaic systems, or a state residential energy efficiency code program.

Reporting Period: This is the time period (typically one to five years) after a project is installed and during which allowances are applied for and perhaps approved. This is also called the post-installation period or performance period.

Rigor: The expected reliability, accuracy and precision, with which energy savings or emission allowances are calculated. A higher level of rigor indicates more confidence that the results of the evaluation are both accurate and precise, i.e., reliable. *Accuracy* is an indication of how close a value is to the true value of the quantity in question. *Precision* is an indication of the closeness of agreement among repeated measurements of the same physical quantity. The terms accuracy and precision can be used in reference to the reliability of a model, measured data, or meter's measurements.

Chapter 3 Determining NO_x Allowances for EE/RE Projects and Programs

This Chapter provides a description of the recommended process for documenting NO_x allowances from energy efficiency and renewable energy projects or programs. The first two sections compare efficiency versus renewable projects, and project versus program evaluations, respectively. The third section provides an overview and discussion of the steps with subsequent sections providing more detail on each step.

3.1 RENEWABLE VERSUS ENERGY EFFICIENCY MEASUREMENT AND VERIFICATION

This document covers calculating electricity savings associated with both energy efficiency and renewable energy activities. The difference between the analysis of the two types of activities is that with energy efficiency projects there will be a level of uncertainty associated with the energy savings calculations that may be difficult to calculate whereas with renewable energy projects there will be a level of error that is relatively easy to calculate. This is because documenting the energy savings from renewable energy projects involves a direct measurement of output. In contrast, documenting the energy savings from energy efficiency projects involves development of a baseline scenario that estimates what would have happened in the absence of the efficiency project or program. As a result of this added complexity, the majority of this document addresses M&V of energy efficiency activities.

3.2 PROGRAM VERSUS PROJECT EVALUATION

Each state's Set-Aside Program will be assigning allowances to either (a) very large individual projects, (b) aggregations[12] of individual projects or (c) programs. Examples of individual projects are a lighting retrofit in an office building, a motor retrofit at an industrial facility, or a wind turbine installation. Examples of programs would be a new energy efficiency building code sponsored by a state, a home compact florescent lighting rebate program sponsored by a utility, or an initiative by a private company to install photovoltaics on the roofs of all their grocery stores.

Either a program or a project evaluation approach can be employed for the NO_x Set-Aside Program. However, a programmatic approach to evaluation will be more cost-effective on a per kWh, or per NO_x ton, saved basis because the savings associated with a sample of projects is applied to a large number of projects. This may be an important consideration when designing a state's Set-Aside Program and determining whether only programs, or both programs and projects can participate.

The project based evaluation approach involves determining savings and allowances associated with a specific project. For aggregated projects, the savings from each project are added together to determine the total allowances to be allocated to the projects. This approach is used when only a few projects are under consideration, when each project is unique enough that sampling approaches are not valid, or when the savings that accrue to each project must be determined individually (for example, if each project site owner intends to retain their own emission allowances).

[12] A state could assign allowances to individual projects, however EPA will not place allowances in less than one ton increments. A NO_x ton would require on the order of 1.3 million ozone season kWh savings, or about a dozen typical 50 kW projects, assuming an emissions factor of 0.0015 lbs of NO_x per kWh.

Using the program approach, a sample of individual projects is evaluated and the savings of the sample projects are extrapolated to the total population of projects in the program. This is commonly used in large programs where similar energy efficiency or renewable energy projects are installed in similar applications, e.g., rebates for high efficiency air conditioners in single-family residences. In this example, a sample of homes might be selected and the electricity bills before and after the installation of the high efficiency air conditioners would be compared. The savings from this sample would then be applied to all the homes that participated in the program.

3.3 EVALUATION PROCESS FLOW CHART

This guidance document, like other M&V and evaluation manuals for EE/RE activities, describes an overall approach. It does not offer a recipe for measuring and verifying individual projects. This is because (a) there are many project types, (b) the sources of uncertainty vary by project types, and (c) deciding how accurate is accurate enough varies for different applications. However, what this guidance document does provide is background and discussion of issues as well as recommendations for what could be included in M&V reports and reviews of submitted M&V reports, general information on how to calculate electricity savings, presentation of some options on how to calculate NO_x savings from electricity savings, and notation of specific resources that contain sample M&V approaches for common technologies. The goal of providing this guidance is that with this information state representatives can design their own Set-Aside Program's evaluation requirements.

The evaluation process is presented in Figure 3.1. As a reminder, the calculation of electricity savings is termed *measurement and verification*, or M&V. Evaluation is the overall process of determining the emission allowances from the electricity savings.

The process consists of these steps:

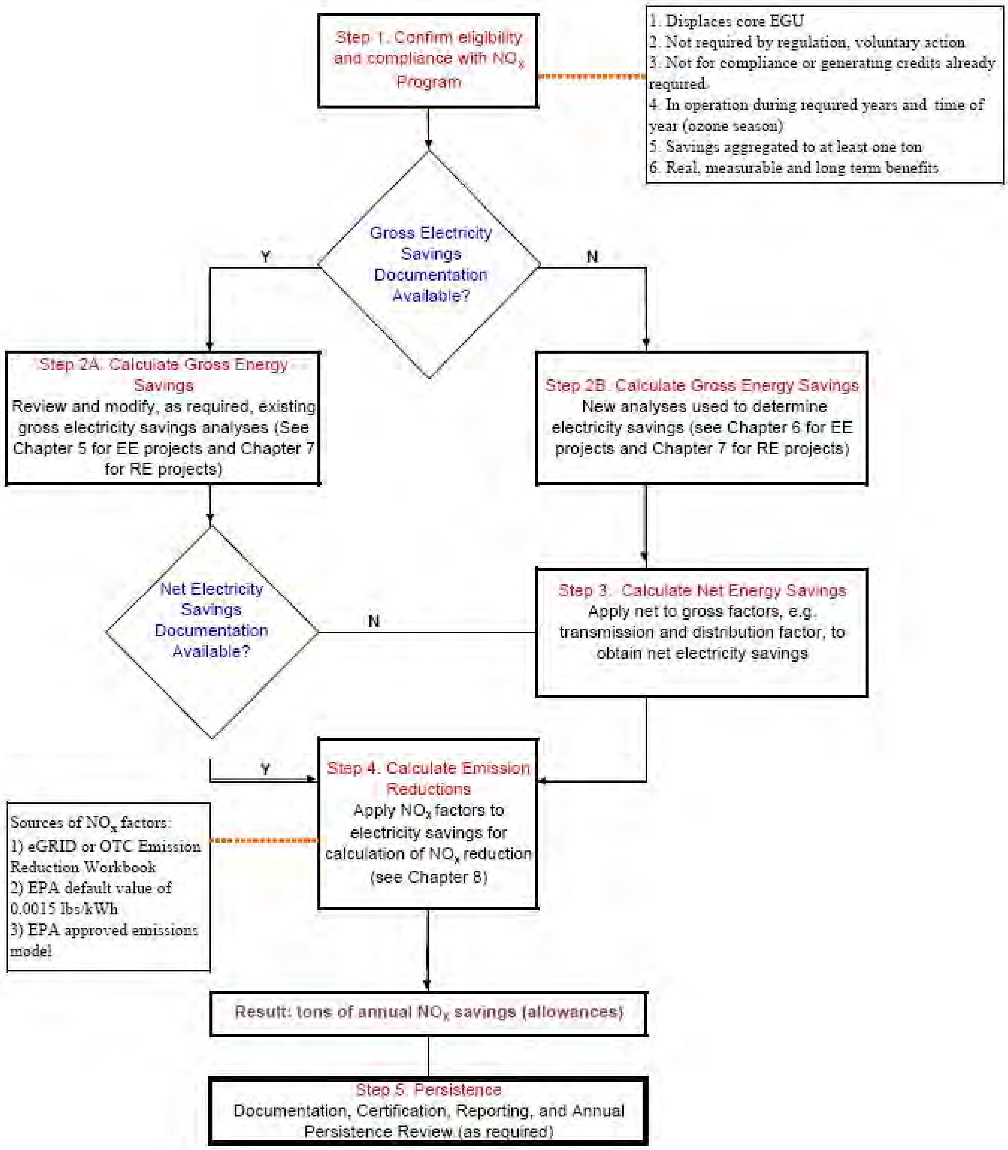
- Step 1 - Confirming that the EE/RE project or program meets the basic requirements of the NO_x Set-Aside Program. Confirming that the projects or programs meet the basic requirements is completed through a checklist process.
- Step 2 - Calculating gross electricity (kWh) savings or generation. Calculating electricity savings is done through either (Step 2A) evaluating M&V activities that have been completed as part of an EE/RE project or program implementation or (Step 2B) completing new M&V activities specifically for determining NO_x emission reductions. If existing M&V documentation is used, then the state will want to have a process for independently validating the reported electricity savings and possibly adjusting the reported values. For such reviews, the state could provide Quality Assurance Guidelines (QAG) for checking submitted documentation. Chapter 5 provides information on a Set-Aside Program QAG.

  Irrespective of whether Step 2A or 2b is followed, a critical consideration is defining the baseline conditions. The baseline conditions assumed for the savings calculation must be consistent with the EPA NO_x Sip Call Program baseline requirements.
- Step 3 - Determining net electricity savings at the generation source(s). In some instances, particularly for programs, it is appropriate for the gross savings calculated in Step 2 to be further adjusted. These gross to net adjustments might include free riders, spillover, secondary effects, and a transmission or distribution loss factor.
- Step 4 - Converting electricity savings to NO_x values. Calculating the NO_x emission allowances associated with the electricity savings is done through either the use of a fixed

value of NO_x emissions per kWh or an electricity grid model. Several grid models are available through the EPA and can be used for the Set-Aside Program.

- Step 5 - Completing a persistence analysis to ensure that the savings continue through the term of the allowances allocation. Persistence is typically evaluated through inspections or a review of electricity consumption (energy efficiency projects) or production (renewable energy projects) records.

Figure 3-1: Evaluation Process for NO_x Set-Aside Program



3.4 SAMPLE CALCULATIONS

The following two examples demonstrate the calculation of allowances from an energy efficiency program and a renewable energy project. When reviewing these examples it is important to recognize that allowance prices can affect the decision to apply for allowances and the level of evaluation effort that is cost-effective. Information on current emission allowance prices are available through brokerage firms listed at http://www.epa.gov/airmarkets/trading/buying.html.

3.4.1 Sample Energy Efficiency Project

A chain of grocery stores implements a program to replace its existing lighting with more energy-efficient lighting. Over 100 stores replace 30,000 fixtures that consume 92 Watts each with the same number of fixtures that consume 61 Watts. The estimated hours of operation for the lights are 3,800 per year, 1,600 of which are during the ozone season. The resulting savings estimate is 1,488,000 kWh during the ozone season, which translates into 1.1 tons of NO_x (rounded to a single one-ton allocation). assuming the EPA NO_x default value of 0.0015 lbs of NO_x per kWh.

Step 1: Compliance with NOx SIP Call Program Requirements

EPA recommends that projects meet the following criteria:

- The electricity saved at the stores displaces EGU provided electricity in the state
- The project was not required by regulation, it was a voluntary project
- The project was not undertaken by an EGU or other party for NO_x SIP Call compliance nor is it generating allowances already required
- The project is in operation during the ozone season
- The total savings are at least one ton of NO_x

If the project meets the, it passes this step.

Step 2: M&V to determine gross electricity savings

This step involves calculating electricity savings from a project either through reviewing, and perhaps modifying, existing M&V documentation or by undertaking a new M&V effort. Assuming, for this project there is no existing M&V documentation, the state requires that the project sponsor conduct the M&V and provide a report. In this case, a typical M&V approach involves conducting an inventory of a sample of the pre-retrofit and post-retrofit lighting fixtures to determine the reduction in power demand[13] and then measuring the operating hours of the same sample to determine actual energy savings during the ozone season.

The savings are equal to the difference between the baseline energy use and the post-retrofit energy use during the ozone season. For this project the baseline energy usage is the sum of the baseline kWh consumption of the replaced fixtures and the post-retrofit energy usage is the kWh for the new fixtures.

---

[13] Demand is electricity consumption per unit of time.

The following simplified equation can be used to determine estimates of energy savings for lighting efficiency projects:

kWh $savings_t$ = [(kW/$Fixture_{baseline}$ x $Quantity_{baseline}$) - (kW/$Fixture_{post}$ x $Quantity_{post}$)] x Operating Hours

Where:

- kWh $Savings_t$ = kilowatt-hour savings realized during post-installation time period t
- kW/$Fixture_{baseline}$ = lighting baseline demand per fixture
- kW/$Fixture_{post}$ = lighting demand per fixture during post-installation (reporting) period
- $Quantity_{baseline}$ = quantity of affected fixtures before the lighting retrofit
- $Quantity_{post}$ = quantity of affected fixtures after the lighting retrofit
- Hours of Operation = total number of post-installation operating hours during the ozone season (assumes number is the same before and after the lighting retrofit)
- Note that 1,000 Watt hours equals one kilowatt-hour (kWh)

Thus, the energy savings equal:

[(92 Watts/fixture x 30,000 fixtures) – (61 Watts/fixture x 30,000 fixtures)] x 1,600 hours = 1,488,000,000 Watt hours or 1,488,000 kWh per ozone season.

Wattage values can be determined by fixture measurements with a power meter or from manufacturer data. Operating hours can be obtained from measurements of hours that the fixtures are operating. This is typically done for a sample of the fixtures using a type of meter that records, over a period of time, the on and off status of light fixtures[14].

Step 3: Net Electricity Savings Calculation

In some instances, it is appropriate for the savings calculated to be modified to account for a variety of factors. For a lighting project, these could include uncertainty in the savings calculation (e.g. uncertainty in operating hour measurements) and/or addition of savings for transmission and distribution losses between the grocery stores and the power plant, which is the source of the displaced NO_x emissions. Another common adjustment might be for the *interactive savings* associated with the lighting retrofit. For this case, it might be savings associated with reductions in the cooling required in the grocery stores due to less lighting and thus less heat from the lights. However, for simplicity, no adjustments are assumed for this example.

Step 4: Calculate Emission Reduction

For this example, we assume that the state wishes to use the EPA's default value of 0.0015 lbs of NO_x per kWh, which results in 1.1 annual tons of NO_x savings for the lighting retrofit program during the NO_x season.

The calculation is 1,488,000 kWh saved during NO_x season times 0.0015 lbs of NO_x per kWh, which equals 2,232 lbs, or 1.1 tons. Since allowances are allocated in integer units, the project could receive a single, one-ton, allowance.

[14] These devices are installed inside a light fixture and are generally known as "light-loggers."

Step 5: Persistence Review

Depending on how the timing of a state's allocation process and the length of term for allowances, a persistence review of energy savings from the lighting retrofit program may be required. For a typical three-year allowance allocation, one can safely assume that the baseline is unlikely to change over the life of the allowance award. However, other persistence issues can be important and impact energy and emission savings. To address this concern, for example, a project may be credited with five years worth of 1.1 tons of allowances only if annual inspections are conducted. The annual inspections would involve confirming that the lighting fixtures are still in place and metering of operating hours to ensure that lights are still operated as previously stated. Fewer hours would result in fewer kWh saved.

3.4.2 Sample Renewable Energy Project

A private developer installs a wind turbine farm. Metering reports indicate that the wind farm generated 3,500 MWh[15] of electricity during the ozone season. Using the EPA's eGRID electricity database, the state conducts a displaced emissions analysis and determines that pollution is offset from surrounding electric generating units at the rate of 0.002 lbs of NO_x per kWh. If the state adopts this allocation rate, equivalent to the "displaced emissions rate," then three annual tons of NO_x allowances can be allocated for the developer's wind turbine program.

Step 1: Compliance with NO_x SIP Call Program Requirements

Using EPA's recommended criteria, this project passes this step:

- The electricity generated displaces electricity from an EGU in the state
- The project was not required by regulation, it was a voluntary project
- The project was not undertaken by a EGU or other party for NO_x SIP Call compliance nor is it generating allowances already required
- The project is in operation during the ozone season
- The total savings are at least one ton of NO_x

Step 2: M&V to determine gross electricity savings

Because the turbines do not use fuel, there are no on-site emissions from the project and therefore the generated output is the savings. Electrical output is directly measured as it flows from individual or groups of turbines into the electrical grid. In this case, the wind farm developer has submitted a report indicating how much electricity entered the grid during the ozone season. An audit by an independent consultant indicated that the metering reports for several of the individual wind turbines were incomplete and, in addition, spot testing of some electricity meters indicated accuracy problems as high as 5%. Therefore, the consultant suggested discounting the reported savings by 5%. The net savings eligible for allowances are therefore calculated as 3,325 MWh or 3,325,000 kWh.

Baseline issues are usually not relevant for renewable energy projects. This is because of the barriers to investment in renewable projects indicate that they are not "common practice". However, it is possible that some projects would be installed to comply with a state Renewable Portfolio Standard. In this situation, a state would have to decide if the projects are "additional" or being used to comply with a regulatory requirement.

[15] One MWh equals 1,000 kWh.

Step 3: Net Electricity Savings Calculation

In some instances, it may be appropriate for the savings calculated to be modified to account for a variety of factors, such as secondary effects. However, no modifications are assumed for this example.

Step 4: Calculate Emission Reduction

For this example, we assume that the state wishes to use the EPA's eGRID database of power plan emissions to conduct a displaced emissions analysis. The analysis determines that 0.002 lbs of NO_x per kWh is offset from surrounding power plants. Therefore, the NO_x savings (in tons) are equal to 3,325,000 kWh saved times 0.002 lbs of NO_x per kWh equals 6,650 lbs of NO_x savings, or 3.325 tons. If the state elects to allocate allowances at a rate equivalent to the displaced emissions rate, the project could receive three allowances.

Step 5: Persistence Review

Depending on how the state decides to enforce timing of allowances and the length of term for such allowances, there may be a need to review the persistence of energy output from the wind turbine farm. A persistence review for wind turbines might include (a) an annual inspection to ensure the turbines are still in place and (b) operating log submittal requirements that indicate electricity generation during the ozone period. The state would likely require these submittals to be reviewed by an independent auditor.

3.5 DISCUSSION OF INDIVIDUAL STEPS IN EVALUATION PROCESS

The evaluation process defined in Section 3.3 has the following steps:

- Step 1: Confirming eligibility and compliance with NO_x Program
- Step 2: Calculating gross electricity savings at site level
- Step 3: Accounting for baseline adjustments and other effects (e.g. transmission and distribution losses) and calculating net electricity savings at source level
- Step 4: Calculating NO_x allowances from electricity savings
- Step 5: Documentation, certification, reporting, and annual persistence review (as needed)

The following sections discuss each of these steps and the documentation, verification and certification activities.

3.5.1 Confirming Compliance with NO_x Program Requirements

Each state has flexibility in establishing criteria about which EE/RE resources it deems eligible to participate in the NO_x Set-Aside Program. However, EPA recommends that states provide allowance awards only for projects or programs that meet the following criteria:

- Reduce or displace the electricity load from the electric generating units (EGU) that are affected under the NO_x SIP Call
- Lead to energy savings during the summer ozone season

- Include activities that are not already required by federal regulation and are not used to generate compliance or permitting allowances otherwise in the SIP[16]
- Operate in the ozone season for which an applicant will receive allowances
- Be capable of being measured and verified
- Convert to at least a one-ton increment (alone or by aggregating eligible projects)

In addition, EPA recommends that projects not benefit a core source entity by freeing up allowances that the source has already been allocated (for example, by retiring an EGU). It is important that states allow core source entities to qualify for allowances under the Set-Aside Program only if the action entails:

- Installation of a new combined heat and power (CHP) system project (provided allowances have not already been distributed to the project from the new source Set-Aside)
- Renewable energy projects -- including wind, solar, biomass, and landfill methane – that are additional to a renewable portfolio standard (RPS).
- A DSM action either within or outside the source's facility

To help ensure that a given project or program meets a state's required criteria for NO_x allowances, a state can include a checklist. The process could require applicants to self-report compliance and then sign the checklist. Each state could verify the self-reported information through audits and/or inspections.

The end-product of this step is confirmation that the projects or programs under consideration meet the basic requirements of the Set-Aside Program.

3.5.2 Calculating Gross Energy Savings

It is important to follow a consistent set of standards and methods when measuring and verifying the energy impacts of EE/RE projects or programs. Utilizing consistent M&V procedures will help ensure that claimed electricity reductions and their associated emissions reductions are real. Chapters 4 through 7 focus on this subject of calculating electricity savings, i.e. the process of M&V.

The fact that energy efficiency and renewable energy actions vary widely means that varying degrees of accuracy and rigor for M&V may be required. The challenge is to balance transaction costs, accuracy, and repeatability with the value of the allowances and EE/RE action receiving the allowances in the Set-Aside Program.

In general, energy savings from implementing EE/RE actions are the difference between the energy consumption after the action has taken place and the consumption before the action was undertaken.

---

[16] A project should not be required by Federal government regulation. If so required, then no further incentive is necessary to achieve its implementation, and rewarding such actions would be a form of double-counting. Although this criterion applies to actions that are implemented as the result of a federal regulation, there are a few exception: (1) projects that are the result of Executive Orders; Systems Benefits Charge (SBC) programs; (3) Renewable Portfolio Standards; and (4) projects implemented in response to Model Energy Codes. See the first Set-Aside guidance document, *Guidance on Establishing an Energy Efficiency and Renewable Energy Set-Aside in the NO_x budget Trading Program, Volume 1* (U.S. EPA, 1999) for more details on EPA policies and recommendations.

Therefore, the ability to isolate savings for a given project will depend on a realistic definition of what energy consumption would have been had the action not been undertaken. Thus, defining project boundaries and a baseline is a critical step in calculating savings. Baseline adjustments are discussed in Section 4.4 and 5.4.

For renewable energy, defining a baseline tends to be straightforward, as the baseline is typically zero; i.e. the electrical output of the renewable project equals the "savings." However, for energy efficiency projects, M&V depends to a great extent on several key factors: accurate estimate of pre-installation energy use; understanding of the characteristics of the efficiency action and the electricity load being reduced; and consideration of the associated measurement costs and sources of uncertainty. M&V also requires separating the "real" energy reductions from those caused by extraneous factors like operational changes, as well as consideration of the persistence of energy savings.

Fundamentally, the electricity savings determination effort will utilize one or more of the following M&V techniques:

- Inspections: Documenting the existence, characteristics, and operation of baseline or reporting period equipment and systems as well as factors that effect energy use
- Engineering methods: The use of standard formulas and assumptions to calculate the energy use of the baseline and reporting period energy systems
- Statistical analyses: Comparing "before" and "after" electric meter data while taking into consideration changes such as weather, facility occupancy, factory operating hours, etc. (this often involves multivariate statistical models)
- Computer simulation of system performance: The use of computer models for predicting the energy use of systems e.g. F-Chart[17] for solar energy systems and DOE-2[18] for buildings (these models can be calibrated with actual performance data).
- Metering: Directly measuring baseline and reporting period energy use, as well as monitoring of non-energy factors such as weather conditions
- Integrative methods: Combining some or all of the above approaches. For example metering and engineering methods could be utilized for calibrating computer simulations of baseline and reporting period models that receive efficiency retrofits

For calculating electricity savings under the Set-Aside Program, only savings during the ozone season (the five months of May through September) count towards NO_x reductions. Many conventional M&V assessment evaluate savings on an annual (12 month) basis. However, a calculation that simply takes 5/12 of the annual savings is only valid for the simplest of projects. For example, a photovoltaic system or air conditioning retrofit will typically generate more savings during the summer while a heating system retrofit will generate more savings during the winter.

The end-product of this step is an estimate of gross site electricity savings associated with the project or program. This will be in units of kWh (during the ozone season) for the first program year.

3.5.3 Calculating Net Energy Savings

Calculation of energy (electricity) savings at the project site or facility results in what is termed a "gross savings estimate." This is the value of savings directly calculated as the difference between

[17] F-Chart, 2005
[18] U.S. DOE, 2007

baseline and reporting period energy use, at the site of the individual project(s). Net savings are the electricity sources savings that occur at the EGU. The difference between the two is that net savings meet the definitions of the savings for the Set-Aside Program, whereas gross savings may not.

There are a number of factors that may need to be taken into consideration in order to convert gross savings into net savings. The most common factors for consideration are free riders, spillover, secondary effects, and a transmission or distribution loss-factor. Secondary effects and transmission or distribution losses are addressed on either a project-by-project basis or at the program level. In contrast, free rider and spillover net savings corrections are typically made at the program versus the project level.

Another possible consideration is on-site fuel use and any resulting NO_x emissions, that might be associated with the subject project's use of fuel. In most cases, there will not be on-site emissions. However, if projects such as natural gas fueled cogeneration systems participate in the program, there will be significant on-site emissions that need to be calculated. In such situations, the on-site NO_x emissions can be deducted from the emissions savings.

Section 4.4.4 briefly covers net to gross considerations.

The end-product of this step is an estimate of the net source electricity savings associated with the project or program. This will be typically reported in units of kWh (during the ozone season) for the first year of the program.

3.5.4 Allocating NO_x Allowances to EE/RE Projects and Programs

Emissions reduction allowances can be allocated once the project has been shown to displace electricity from core EGUs and net source electricity savings have been estimated. Actual emission reductions depend on which power plants the electricity is displaced from and the emissions rate from those plants. Which power plant(s) would have provided the displaced electricity can vary from day to day and even hour to hour. In addition, the emissions profile of the power plant can vary based on its operating mode and fuel source.

For the Set-Aside Program, the allocation rate is a single value for the ozone season. The form of the allocation rate is in pounds of NO_x per kWh (lbs/kWh). There are several sources and methods for determining this lbs/kWh factor:

- The EPA's default factor as indicated in the NO_x Sip Call is 0.0015 lbs/kWh
- A system average emissions rate either calculated or obtained from an emissions database such as eGRID or the OTC Emission Reduction Workbook, both of which are available online (see Appendix for resources)
- An avoided marginal emissions rate determined using an electrical grid simulation model that estimates emissions factors

This subject is further discussed in Chapter 8.

The end-product of this step is a net estimate of the NO_x savings associated with the project or program. This will be reported in units of tons of NO_x (during the ozone season) for the first year of the program.

3.5.5 Documentation, Certification, Tracking, Reporting and Persistence Evaluation

Documentation, Certification, Tracking and Reporting

Documentation, certification, tracking, and reporting mechanisms include the development of appropriate NATS accounts, and any additional administrative forms and reports, as determined by each state. The procedures for reporting allowances under the Set-Aside Program are the same as those established by the EPA under the NO_x Budget Trading Program. The state must open a general account in the NATS to hold the allowances for the entire Set-Aside Program. Applicants for allowances must also establish a general NATS account. The allowances will be directly transferred from the state into the project sponsor's account. EPA recommends that the state designate a state energy official, air official, or public utility commission official to be an Authorized Account Representative (AAR) to manage the Set-Aside allowances.

It is recommended that the necessary Set-Aside Program documentation be included in the initial application submitted by a program or project sponsor for an allowance award. However, it is likely that additional information will be exchanged between the state and the project sponsor after the initial application is submitted but before the project sponsor is awarded allowances. This may include review of savings calculations conducted by the state, or its agent, and any follow-up submittals by the applicant in response to the reviews.

It is important that states provide feedback to the project sponsor when a proposal has been reviewed and deemed acceptable. If the project is not deemed acceptable, it is important that the state provide recommendations for the modifications necessary to make the project eligible for allowances. A project sponsor could then provide documentation alerting the state about the project's expected implementation date, as well as periodic updates on the project's progress. EPA has provided example forms (contained in the second guidance document of this series) that states may use or adapt for their Set-Aside Programs. Other sample applications and forms can also be found in the Program M&V manuals listed in the Appendix.

Persistence

Each state is responsible for determining when in the annual program cycle to distribute Set-Aside Program allowances to qualified applicants, and for which allowance years they are eligible. For example, a state can utilize the energy savings from one ozone control period to determine the allowance allocations for that allowance year, or can use the savings to determine allocations for the *following* year. The EPA recommends that states allocate allowances for the following ozone season, termed the *seasonal lag option*. Under the seasonal lag option, a project would have to be implemented and in operation for a full ozone season before the state allocates an allowance award. After documenting the evaluation of the first ozone season's electricity and NO_x reduction, the project sponsor would then be allocated allowances to be available for trading at the beginning of the second ozone control period.

EPA also recommends that states provide allowances for three years. For this limited period, persistence may not be an important issue. However, it is important that states be aware of three general persistence issues when awarding allowances:

- Physical life of the measures – what is the length of time the new light fixture will operate?
- Operating life of the measures – will the new motor be properly maintained, will the factory continue to operate and use the new motor?

- Changes in the baseline over time – will the new control system installed be commonplace in the future or required by code or regulation and thus not actually resulting in additional future savings?

If a state decides to conduct persistence reviews, there are three approaches for confirming persistence, which can be used individually or in combination:

- Self-reported annual documentation submitted by the sponsor that indicates that the projects and programs are still in place and generating an equivalent or greater quantity of savings
- Inspections by the state or independent consultants to indicate that the projects and programs are still in place and operating appropriately
- Annual evaluations that calculate savings for each year

EPA recommends that the first two options be utilized for allowances allocated for up to three years. It is important that the allowance values only be adjusted if the results of the documentation submitted by the sponsor (or the inspection reports) indicate significant changes are necessary. If the allowances are allocated for more than three years, a more thorough review of savings could be conducted once every two to three years.

The end-product of this step is an updated net estimate of the NO_x *savings associated with the project or program. This will be reported in units of tons of* NO_x *(during the ozone season) for subsequent years of the allocation.*

Chapter 4 Energy Efficiency Measurement and Verification Concepts

For the NO_x Set-Aside Program, gross program electricity savings can be determined with evaluations based on either (a) M&V of individual projects (such as individual projects that make up a program) or (b) statistical or regression analysis of the electric utility consumption data from a large number of facilities participating in an energy efficiency program. This guidance covers the individual project M&V approach, not the statistical analysis of electric utility data for a large number of facilities..

Evaluations also include assessments to adjust gross electricity savings for the purpose of deriving net electricity savings. This net adjustment is estimated either at the program level (typical) or at the project site level (a-typical).

A strict definition of M&V refers to site surveys, metering of energy consumption, monitoring of independent variables, and analysis activities associated with the calculation of gross energy savings from individual sites or projects. M&V is an input into an emissions reduction evaluation which also includes using one or more of the following techniques: inspections, engineering methods, metering, statistical analyses, and computer simulation and modeling of system performance. Often M&V involves integration of several of these techniques. To help states define an appropriate M&V process for their Set-Aside Programs, this chapter provides an introduction to M&V and background information that will help states understand related concepts and issues.

M&V for individual energy efficiency projects can be quite complicated. However, for renewable energy projects that displace electricity – for example photovoltaic systems and wind turbines – the M&V process for determining energy savings tends to be relatively straightforward; in most cases, it simply involves measuring the electricity output of the renewable energy system. However, there are situations where M&V for renewable energy projects can be more complex (see Chapter 7).

Much of this Chapter is derived directly from the IPMVP,[19] the FEMP M&V Guidelines[20] and American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) Guideline 14,[21] which are described below. These documents constitute the core M&V guidance documents used for energy efficiency projects in the United States and many other countries.

4.1 OVERVIEW OF MEASUREMENT AND VERIFICATION APPROACH FOR DETERMINING ENERGY SAVINGS

Energy savings are determined by comparing energy use before and after implementation of an energy savings project. In general, the following equation applies:

Energy Savings = (Baseline Energy Use) – (Reporting Period Energy Use) ± (Adjustments)

- “Baseline Energy Use” is the electricity consumption that occurred during the period before the project was implemented and which is chosen as representative of normal operations. It is sometimes referred to as “business-as-usual” (BAU) energy use and is what would have occurred had there been no project.

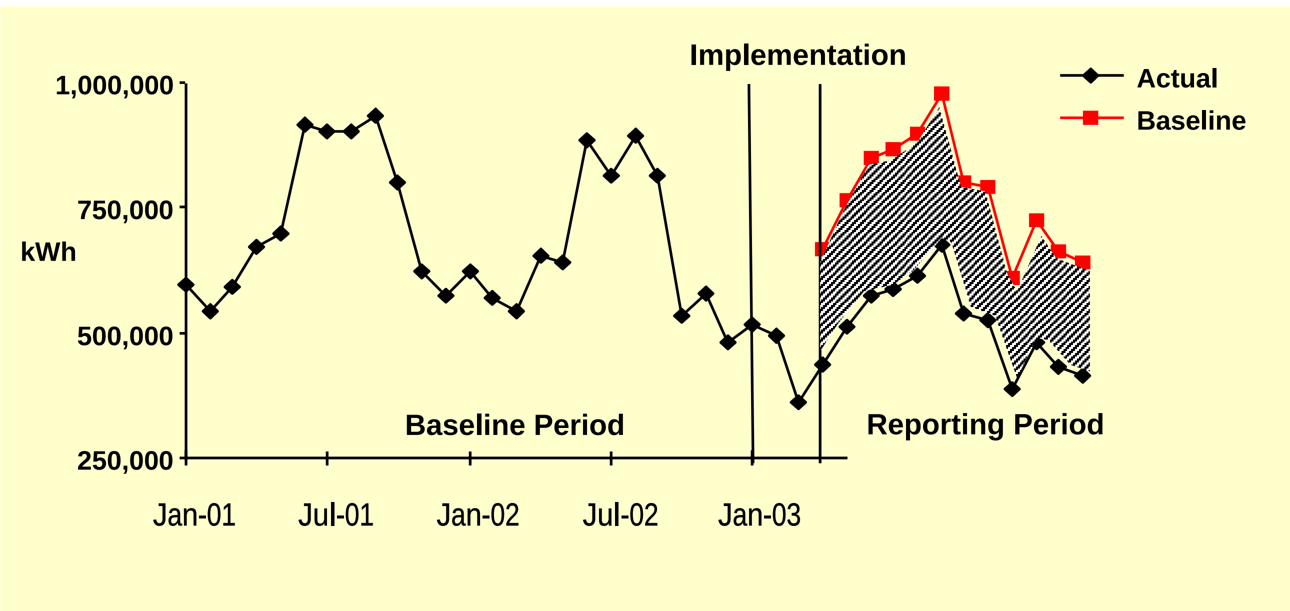
[19] EVO, 2007
[20] U.S. DOE, 2000b
[21] ASHRAE, 2002

- The "Adjustments" term in this general equation is used to re-state the energy use during the baseline and reporting periods under a common set of conditions. This adjustments term distinguishes properly determined savings from a simple comparison of energy usage before and after implementation of a project. The "Adjustments" term in this general equation brings energy use in the two time periods to the same set of conditions. Examples of corrections are weather corrections, if the project involves heating or air-conditioning systems in a building or production levels if the project involves energy efficiency improvements in a factory.

There is no direct way of measuring energy or demand savings, since one cannot measure the absence of energy use. However, the absence of energy use can be estimated by comparing energy use from before and after implementation of a project[22]. However, simple comparison of post-installation energy use with baseline energy use does not differentiate between the energy impacts of the project and the impacts of other factors such as weather or production levels. In order to assess the effect of the project alone, the influence of these complicating factors, must be addressed. For example, a more efficient air conditioner may consume more electricity after its installation if the post-installation weather is warmer than the weather prior to installation.

The basic approach to M&V is shown in Figure 4.1. It involves projecting energy use patterns of the pre-installation (baseline) period into the reporting period. Such a projection requires adjustment of baseline energy use to reporting period conditions of weather, production level, occupancy, and other factors. Therefore, the M&V effort will involve defining (a) the baseline energy use, (b) the reporting period energy use, and (c) any adjustments made to the baseline energy use.

Figure 4-1: Comparison of Energy Use Before and After an Energy Project Is Implemented



---

[22] Energy savings can also be calculated by comparing the reporting period energy use at the project(s) with the reporting period energy use of a "control group". Another approach is to turn a project "on and off" to evaluate a baseline when the project is "off" and the reporting period performance when the project is "on". This approach is also only rarely used.

1. Define data collection and analysis requirements, the M&V Options (see Section 4.3) and techniques that will be used, as well as the rigor and resource requirements, in a M&V Plan.
2. Define and quantify the pre-installation baseline, including (a) the equipment and systems being replaced, (b) baseline energy use and (c) factors that influence baseline energy use. This activity should occur before the project is installed.
3. Define and quantify the post-installation (reporting period) condition, including (a) the equipment and systems being installed, (b) post-installation energy use, and (c) factors that influence post-installation energy use. The baseline and reporting period energy use can be defined through site surveys; spot, short-term, or long-term metering; engineering analyses; computer simulations; and/or analysis of utility billing data.
4. Calculate savings by comparing reporting period and baseline energy use.
5. Conduct annual M&V activities to (a) verify the operation of the installed equipment or system, (b) determine current year savings, and (c) estimate savings for subsequent years.

4.2 M&V RESOURCE DOCUMENTS

Before describing the options and methods for conducting M&V, it is important to note that there are a wide variety of resources that provide useful information on M&V. While M&V is an evolving science, common practices exist and are described in several, frequently cited M&V documents. Much of the work in this guidance document draws on material in these documents.

These documents are important resources for developing M&V rules for each state, but perhaps more importantly they are resources for those who will actually conduct the M&V. The first set of documents listed (Sections 4.2.1 – 4.2.5) are designed for determining savings from individual projects: IPMVP, FEMP M&V Guidelines, ASHRAE Guideline 14, the EPA's Acid Rain Program M&V Guidance and examples of state performance contracting M&V guidelines. The second set of documents (Section 4.2.6) describes programmatic approaches. In addition, the Appendix lists other reference materials and resources.

4.2.1 International Performance Measurement and Verification Protocol (IPMVP)

The IPMVP provides an overview of current best practice techniques for verifying results of energy efficiency and renewable energy projects in commercial and industrial facilities. Internationally, it is the most recognized M&V protocol for demand-side energy activities. The IPMVP was developed with sponsorship of DOE and is currently managed by a non-profit organization[23] that continually maintains and updates the Protocol.

The IPMVP provides a framework and definitions that can help practitioners develop M&V plans for their projects. It includes guidance on best practice for determining savings from efficiency and renewable energy projects. The IPMVP is probably best known for defining four M&V Options for energy efficiency projects. These Options (A, B, C and D) differentiate the most common approaches for M&V and are defined below in Section 4.3.

---

[23] Efficiency Valuation Organization (EVO). The IPMVP and related M&V resources can be found at http://www.evo-world.org.

As of the date of this document, there are three current volumes:[24]

- Concepts and Options for Determining Energy Savings (Volume I)
- Concepts and Options for Improved Indoor Environmental Quality (Volume II)
- Applications:
  - Concepts and Practices for Determining Energy Savings in Renewable Energy Technologies Applications (Volume IIIa)
  - Concepts and Options for Determining Energy Savings in New Construction (Volume IIIb)

A new version of the IPMVP "Concepts and Options for Determining Energy and Water Savings" is due to be published during the first half of 2007.

One particular caution when using the IPMVP is that it is not a compliance document. Simply requiring parties to comply with the IPMVP is insufficient for defining how the actual M&V will be conducted or for the level of rigor and uncertainty expected of the analyses. The IPMVP can, and often is, referenced in M&V planning, but it may be appropriate for additional requirements to be specified to define the M&V requirements of a state's Set-Aside Program. There are several state-specific M&V Guidance documents (listed in Sections 4.2.2 – 4.2.6) that provide more detailed requirements tailored to their respective programs.

4.2.2 Federal Energy Management Program (FEMP) M&V Guidelines [25]

The purpose of this document is to provide guidelines and methods for measuring and verifying the savings associated with federal agency performance contracts. It contains procedures and guidelines for quantifying the savings resulting from energy efficiency equipment, water conservation, improved operation and maintenance, renewable energy, and cogeneration projects. The Guidelines are divided into 8 sections:

- Section I provides an introduction to the FEMP Program and an overview of M&V, as well as a summary and index of the measure-specific M&V methods included in the document.
- Section II provides an overview of procedures for incorporating M&V into a project, details associated with M&V plan preparation, and a "quick-start" guideline, including summary tables and checklists.
- Sections III to VI contain descriptions of measure-specific M&V methods for energy projects; these four sections discuss M&V methods that are based on M&V Options A, B, C, and D, respectively.
- Section VII contains descriptions of measure-specific M&V methods for water conservation measures.

---

[24] These are the latest editions of the IPMVP. They supersede the two previous editions of the document, including the first version, which was titled the North-American Energy Measurement & Verification Protocol (NEMVP).

[25] The current version of the FEMP M&V Guidelines is Version 2.2 (U.S. DOE, 2000b). A supplement to FEMP M&V Guidelines – "Detailed Guidelines for FEMP M&V Option A" was published in 2002 (U.S. DOE, 2002). These FEMP M&V Guidelines, and a number of other M&V resource documents, including some on the use of stipulations for determining savings, M&V checklists and M&V resource lists, can be found at the Lawrence Berkeley National Laboratory website http://ateam.lbl.gov/mv/.

- Section VIII presents M&V method descriptions for other types of measures including new construction, operation and maintenance, cogeneration, and renewable energy.

Compared to the IPMVP, the FEMP Guidelines provides similar background information but more detail on measure specific M&V techniques. For example, there are quick summaries of techniques for determining the savings from lighting retrofits, motor retrofits, and chiller retrofits. The IPMVP, however, provides more current definitions of the various M&V Options.

4.2.3 ASHRAE Guideline 14-2002 Measurement of Energy and Demand Savings [26]

This guideline was developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). ASHRAE is the professional engineering society that has been the most involved in writing guidelines and standards associated with energy efficiency. Compared to the FEMP M&V Guidelines and the IPMVP, Guideline 14 is a more detailed technical document that addresses the analyses, statistics and physical measurement of energy use for determining energy savings.

Guideline 14 provides guidance on how to use measured pre- and post-installation data for quantifying energy and demand savings. Unlike most guidelines and protocols, it provides specific compliance path for two of the three M&V options presented. In addition, to the technical background and a M&V compliance path, the Guideline provides key information on project specific uncertainty analyses, regression analyses, measurement systems and equipment, and case studies.

In the area of building energy performance measurement, ASHRAE also has a number of other Standards and Research Project documents that provide useful details on evaluating building performance. These include:

- Standard 105 – Standard Methods of Measuring and Expressing Building Energy Performance
- 827-RP – Methodology Development to Measure In-Situ Chiller, Fan and Pump Performance
- RP-1050 – Development of a Toolkit for Calculating Linear, Change-Point Linear and Multiple-Linear Inverse Building Energy Analysis Models (weather normalizations)

These, and other documents, are available at: www.ashrae.org.

4.2.4 Acid Rain Program: “Conservation and Verification Protocols” (CVP)

In 1990, as part of Title IV of the Clean Air Act Amendments, Congress set a national emissions cap on SO_2, to be maintained through the issuance of emission allowances under the EPA’s Acid Rain Program. As part of the cap-and-trade program, Congress created the Conservation and Renewable Energy Reserve to award SO_2 allowances as incentives for EE/RE measures.

The verification process was left to the states, but the EPA developed a voluntary guidance called the “Conservation and Verification Protocols” (CVP). The CVP is an alternative or default option to help states ensure that reported electricity reductions have taken place, and to help determine when reductions have occurred. It was developed before the IPMVP, but generally falls within IPMVP’s Option B. There are two savings verification paths detailed in the CVP: one for monitored energy use

---

[26] The Guideline (ASHRAE, 2002) can be purchased at http://www.ashrae.org. As of the publication of this document a new version of Guideline 14 is under development.

and one for estimating stipulated energy savings from a limited number of conservation measures for which expected energy savings are well understood.

It is generally believed that the M&V requirements in the CVP set the bar so high (especially with regard to subsequent year allowances) that utilities either preferred to use their state's less rigorous quantification methodologies or opted not to participate in the process at all. The program's requirements and its lack of flexibility restricted the program's potential success.

4.2.5 State and Utility Program M&V Guidelines

There are several utility and state sponsored programs in the U.S. that offer incentive payments for verified energy savings. Each of these incentive programs has guidelines specifying their individual requirements for M&V. The following list of programs is not comprehensive, but includes programs that have M&V guidelines that are easily accessible.

California Utility SPC Program[27]

The San Diego Gas & Electric Company, Pacific Gas and Electric Company (PG&E), and Southern California Edison Company offer a statewide energy-efficiency program under the direction of the California Public Utilities Commission (CPUC). The Large Non-Residential Standard Performance Contract (LNSPC) Program is a performance-based program that offers incentive payments to project sponsors who develop projects delivering verified energy savings at Host Customer facilities. Energy savings are measured and verified annually by the project sponsor over a two-year period following the approval and installation of the energy-efficiency equipment.

NYSERDA[28]

The New York State Energy Research and Development Authority (NYSERDA) offers the Energy $martSM Enhanced Commercial/Industrial Performance program. This program offers fixed-price incentives to energy service companies (ESCOs) that install cost electric energy efficiency measures. Project-specific incentives are paid based on measured data from the performance period.

State of Hawaii Performance Contacting Guide[29]

The state of Hawaii has published A *Guide to Performance Contracting* that includes M&V Guidelines. These guidelines are modified from DOE's Rebuild America Program.

State of Texas Programs

Texas has statewide programs sponsored by the Public Utilities Commission of Texas. Examples are the TXU Electric Delivery programs. TXUED's Energy Efficiency Markets (TEEM)[30] currently has several energy efficiency programs, including: the mall Air-Conditioner Program and the Commercial and Industrial Standard Offer Program (SOP). The Texas Loan Star Program, which includes savings M&V, is used as a funding mechanism for Texas State Agency energy projects.[31] [32]

---

[27] California, 2000
[28] NYSERDA, 2003
[29] Hawaii, 1998
[30] Oncor, 2003
[31] Texas SECO, 2007

4.2.6 Program Based M&V Guidance Documents

There are established procedures associated with determining the savings from programs that are made up of a large number of similar projects. These procedures are usually associated with utility-sponsored energy efficiency programs where a regulatory body evaluates how much energy was actually saved from a utility program. In these situations, a sample of projects may be investigated and the savings extrapolated to the entire population of participants. The overall approach is called *program impact evaluation.*

Two web-accessible databases provide information on program impact evaluations:

- CALifornia Measurement Advisory Council (CALMAC): http://www.calmac.org;
- Consortium for Energy Efficiency's Market Assessment and Program Evaluation (MAPE) Clearinghouse: http://www.cee1.org/eval/clearinghouse.php3.

Each of the websites has a database with hundreds of independent energy efficiency program evaluation reports and guidelines used to prepare the reports. One notable resource for program impact evaluation guidance is the State Of California Public Utilities Commission's April 2006 *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.* This document can be found at the CALMAC website.

4.3 MEASUREMENT AND VERIFICATION OPTIONS

The 2002 (and the soon to be published 2007) IPMVP defines four M&V options: Options A, B, C, and D. The options are generic M&V approaches for energy projects. Having four options provides a range of approaches to determine energy savings with varying levels of rigor and cost. A particular option is chosen based on the project-specific features of each project. These features include:

- Complexity of the energy efficiency project
- Uncertainty of the project savings
- Potential for changes in key factors between the baseline and post-installation reporting period
- Value of project savings

The Options differ in their approach to the level and duration of baseline and reporting period measurements. Each option has advantages and disadvantages based on project-specific factors and the needs of participants. M&V evaluations with Options A and B are made at the project or system level. Option C evaluations are made at the whole building or whole-facility level. Option D evaluations, which involve computer simulation modeling, are typically made at the whole-building level. Option A involves using stipulated and measured values of the key factors needed to determine energy savings. Compared to Option A, Option B involves using more spot, short-term, and continuous measurements. Options C usually relies on hourly or monthly utility energy bill data. Option D may include spot, short-term, or continuous measurements to calibrate computer models.

The four generic M&V options are summarized in Table 4.1, which is replicated directly from the IPMVP. The following subsections describe the Options in more detail using information from the

---

[32] A number of calculation tools are also available from the Texas A&M System Energy Systems Laboratory website: http://esl.eslwin.tamu.edu/resources/software.html.

soon to be published version of the IPMVP. Chapter 6 contains information on selecting an appropriate M&V Option.

Table 4.1 IPMVP M&V Options (from to be published IPMVP 2007)

M&V Option	How Savings Are Calculated	Cost (not from IPMVP)	Typical Applications
A. Retrofit Isolation: Key Parameter Measurement Savings are determined by field measurement of the key performance parameter(s) which define the energy use of the efficiency measures' affected system(s) and/or the success of the project. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter, and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimates can based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required. The plausible savings error arising from estimation rather than measurement is evaluated.	Engineering calculation of baseline and reporting period energy from: short-term or continuous measurements of key operating parameter(s); and estimated values. Routine and non-routine adjustments as required.	Dependent on number of measurement points. Approximately 1% to 5% of project construction cost of items subject to M&V.	A lighting retrofit where power draw is the key performance parameter that is measured periodically. Estimate operating hours of the lights based on building schedules, occupant behavior, and/or prior studies.
B. Retrofit Isolation: All Parameter Measurement Savings are determined by field measurement of the energy use of the affected system. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period.	Short-term or continuous measurements of baseline and reporting-period energy, and/or engineering computations using measurements of proxies of energy use. Routine and non- routine adjustments as required.	Dependent on number and type of systems measured and the term of analysis/ metering. Typically 3% to 10% of project construction cost of items subject to M&V.	Application of a variable-speed drive and controls to a motor to adjust pump flow. Measure electric power with a meter installed on the electrical supply to the motor, which reads the power every minute. In the baseline period this meter is in place for a week to verify constant loading. The meter is in place throughout the reporting period to track variations in power use.
C. Whole Facility Savings are determined by measuring energy use at the whole facility or sub-facility level. Continuous measurements of the entire facility's energy use are taken throughout the reporting period.	Analysis of whole facility baseline and reporting period (utility) meter data. Routine adjustments as required, using techniques such as simple comparison or regression analysis. Non-routine adjustments as required.	Dependent on number and complexity of parameters in analysis and number of meters. Typically 1% to 5% of project construction cost of items subject to M&V.	Multifaceted energy management program affecting many systems in a facility. Measure energy use with the gas and electric utility meters for a twelve month baseline period and throughout the reporting period.

M&V Option	How Savings Are Calculated	Cost (not from IPMVP)	Typical Applications
D. Calibrated Simulation Savings are determined through simulation of the energy use of the whole facility, or of a sub-facility. Simulation routines are demonstrated to adequately model actual energy performance measured in the facility.	Energy use simulation, calibrated with hourly or monthly utility billing data. (Energy end use metering may be used to help refine input data.)	Dependent on number and complexity of systems evaluated. Typically 3% to 10% of project construction cost of items subject to M&V.	Multifaceted, new construction, energy management program affecting many systems in a facility - where no meter existed in the baseline period. Energy use measurements, after installation of gas and electric meters, are used to calibrate a simulation. Baseline energy use, determined using the calibrated simulation, is compared to a simulation of reporting period energy use.

4.3.1 M&V Option A - Retrofit Isolation: Key Parameter Measurement

Option A involves project or system level M&V assessments where the savings associated with a particular project can be isolated. With this Option, key performance parameters or operational parameters can be spot or short-term measured during the baseline and post-installation periods. However, not all factors are measured under Option A; rather some parameters are stipulated rather than measured. This level of verification may suffice for certain types of projects in which a single parameter represents a significant portion of the savings uncertainty.

Using Option A, energy and demand savings are calculated using “engineering methods”. These methods involve developing estimates of energy and demand savings based on:

- Assumptions concerning operating characteristics of the equipment or facilities in which the equipment is installed, which are informed by measurements (from spot to continuous). Examples are power draws (wattage) of light fixture or fan motors and efficiencies of air-conditioners (kWh/ton) and heaters (Btu out/Btu in).
- Assumptions for how often the equipment is operated or what load it serves. Examples are operating hours of lights or fixed speed fans and air conditioning loads (tons) or heater loads (Btu).

The most straightforward application of engineering methods involves using savings algorithms that summarize how energy use is expected to change due to installation of the energy efficiency measure. Savings are then estimated by changing the model parameters that are affected by program participation. With Option A, at least one of the key model parameters must be measured. The parameters not measured are stipulated based on assumptions or analysis of historical or manufacturer's data. Using a stipulated factor is appropriate only if supporting data demonstrate that its value is not subject to fluctuation over the term of analysis.

This Option, and Option B, are best applied to programs that involve equipment retrofits or replacing failed equipment with efficient models. All end-use technologies can be verified using Option A or B;

however, the accuracy of this option is considered inversely proportional to the complexity of the measure. Thus, the savings from a simple lighting retrofit (less complex) may be more accurately determined with Option A or B than the savings from a chiller retrofit (more complex).

Also true with Options A and B is that measurement of all end-use equipment or systems may not be required if statistically valid sampling is used. For example, both the operating hours for a selected group of lighting fixtures and the power draw from a subset of representative constant-load motors may be metered.

Savings determinations under Option A can be less costly than under other Options, since the cost of deriving a stipulation is usually less than the cost of making measurements. However, since some stipulation is allowed under this Option, care is needed to review the engineering design and installation to ensure that the stipulations are realistic and achievable, i.e., the equipment truly has the potential to perform as assumed. At defined intervals during the reporting period, the installation can be re-inspected to verify continued existence of the equipment and its proper operation and maintenance. Such re-inspections will ensure continuation of the potential to generate predicted savings and validate stipulations.

4.3.2 M&V Option B - Retrofit Isolation: All Parameter Measurement

Option B, as with Option A, involves project or system-level M&V assessments with performance and operational parameters measured at the component or system level. Also, Option B involves procedures for verifying the potential to generate savings that are the same as Option A. In addition, savings calculations, as with Option A, involve the use of engineering methods. *However, unlike Option A, stipulations of major factors are not allowed under Option B.*

Thus, as compared to Option A, additional and often longer-term measurements are required. These include measurements of both equipment operating characteristics, measured with Option A, and the Commonly measured parameters include operating hours for lighting and HVAC equipment, wattage for lighting and HVAC equipment, and line flows and pressure for various compressed air applications.

Option B relies on the direct measurement of end uses affected by the project. Spot or short-term measurements may be sufficient to characterize the baseline condition. Short-term or continuous measurements of one or more parameters takes place after project installation for determining reporting period energy use.

All end-use technologies can be verified with Option B, but the degree of difficulty and costs associated with verification increases as measurement complexity increases. The task of measuring or determining energy savings using Option B can be more difficult and costly than that of Option A. The results, however, are typically more reliable. In addition, the use of longer-term measurements can help with identifying under-performing efficiency projects – which in turn can lead to improvements in their performance.

4.3.3 M&V Option C - Whole Facility

Option C involves use of whole building meters or sub-meters to assess the energy performance of a total building or facility. These meters are typically the ones used for utility billing, although other meters, if properly calibrated, can also be used. Option C is the most common form of M&V for building energy efficiency retrofits. With this option, the energy consumption from the baseline period are compared with energy consumption bills of the reporting period. Option C involves procedures for verifying the potential to generate savings that are the same as Option A.

The evaluation of whole-building or facility level metered data are completed using techniques ranging from simple bill comparisons to multivariate regression analysis. In general, however, simple bill comparison methods are *strongly discouraged* for estimating energy savings because they do not account for independent variables, such as weather. However, Option C regression methods can be very powerful tools for determining savings.

For the regression analyses to be accurate, a robust regression analysis can be used to detect energy savings outside of normal variations in energy use over time. Critical variables may include weather, occupancy schedules, throughput, control set points and operating schedules. Most applications of Option C require at least 9 to 12 months of continuous baseline (pre- installation) meter data and at least 9 to 12 months of continuous data reporting period (post-installation) meter data. Whereas a typical building may experience fluctuations in energy use of up to ten percent during the course of a year, effective normalization for weather and operational characteristics will reveal less fluctuation so that true energy savings may be identified.

All end-use technologies can be verified with Option C. However, this option is intended for projects where savings are expected to be large enough to be discernible from the random or unexplained energy variations normally found at the level of the whole facility meter. The larger the savings, or the smaller the unexplained variations in the baseline consumption, the easier it will be to identify savings. In addition, the longer the period of savings analysis after project installation, the less significant is the impact of short-term unexplained variations.

Another tool that can be used to analyze facility utility billing meter data is EPA’s Portfolio Manager, which employs a methodology that is consistent with IPMVP Option C. While both options encourage monitoring at the whole building level, one minor difference is that IPMVP determines savings at the meter or sub-meter level so that performance changes can be assessed for individual parts of the facility. Portfolio Manager, on the other hand, aggregates all meters in a building so that performance changes can be assessed at the broader facility level. Additionally, because the Portfolio Manager approach combines multiple meters, it must account for differences among fuel types. This is done by converting utility meter data into source energy (or, “primary energy”) consumption. If a building contains only one meter and one fuel type, the two methods of analysis are identical. This would be the case, for example, with a supermarket powered by electricity.

Any commercial building can enter and track utility billing data in Portfolio Manager. For many types of commercial buildings, Portfolio Manager also provides an energy performance rating based on a statistically rigorous multivariate regression analysis that controls for the key independent variables driving energy use. The underlying data is the nationally representative sample of buildings contained in the Energy Information Administration’s Commercial Buildings Energy Consumption Survey (CBECS). To date, about 30,000 buildings have used Portfolio Manager to track, measure, and monitor energy use at the whole building level.

4.3.4 M&V Option D - Calibrated Simulation

Option D involves calibrated computer simulation models of systems, system components, or whole facility energy consumption to determine project energy savings. Linking simulation inputs and results to baseline or reporting period data calibrates the results to actual billing or metered data. Typically, reporting period energy use data are compared with the baseline computer simulation energy use prediction (using reporting period independent variable values) to determine energy savings.

Manufacturer's data, spot measurements, or short-term measurements may be collected to characterize baseline and reporting period conditions and operating schedules. The collected data serve to link the simulation inputs to actual operating conditions. The model calibration is accomplished by comparing simulation results with end-use or whole-building data. Whole-building models usually require at least 9 to 12 months of pre-installation data for baseline model calibration. However, these models are sometimes calibrated with only reporting period data so that they can be used with new construction projects –ones for which no baseline data exist.

Any end-use technology can be verified with Option D if the size of the drop in consumption is larger than the associated simulation modeling error. This option may be used in cases where there is a high degree of interaction among installed energy systems, or where the measurement of individual component savings is difficult. And, as mentioned above, Option D is commonly used with new construction energy efficiency programs, since there are no baseline data.

Savings determined with Option D are based on one or more complex estimates of energy use. Therefore, the accuracy of the savings is completely dependent on how well the simulation models are calibrated and how well they reflect actual performance. Since building simulation models may involve elaborate spreadsheets or vendor estimating programs, accurate modeling and calibration are the major challenges associated with Option D.

4.4 SELECTED M&V ISSUES

4.4.1 Defining a Baseline

Electricity savings are calculated as the difference between adjusted baseline energy use and post-project installation (reporting period) energy use. This is not a difficult calculation for most renewable projects, since the baseline is usually "zero" and net savings (or production) equals the electrical output of the renewable system. However, with energy efficiency projects, determining adjusted baseline energy use is often the most difficult aspect of M&V. This is because once the project is installed there is no longer a baseline to measure or document.

Additionality is the term used in the emission mitigation industry for the key question of whether one can know that a project will produce "reductions in emissions that are additional to any that would have occurred in the absence of the certified project activity." This raises the issue of defining "baseline" or "business-as usual" conditions. As baseline determination is inherently a "what-if" question, it cannot be directly measured and must be implied from available information.

The baseline definitions consists of (a) site-specific issues and (b) broader, policy-orientated considerations. Site-specific issues include the characteristics of equipment and/or systems in place prior to an energy-efficient activity and how and when the equipment/systems were operated. In terms of the characteristics of replaced equipment or systems, it is also important to know when in the life-cycle of the existing equipment or systems the new equipment/systems were installed. The options are (a) "early-replacement" of equipment/systems that had not reached the end of their useful life, (b) installation of new, energy-efficient equipment/systems to replace failed equipment/systems, or (c) new construction.

The broader baseline policy issues for the Set-Aside Program involve ensuring that the emission reductions are "additional" to any that would otherwise occur due, for example, to federal, state, and/or local energy standards. Examples of "standards" include:

- A state energy code, triggered by new construction or major renovations, that specifies the maximum amount of energy use per square foot for buildings.
- A federal appliance standard, such as a minimum air conditioning efficiency.

Thus, for an early replacement, energy-efficient lighting retrofit, the baseline selection decision involves the type of lighting equipment replaced, the power consumption (watts/fixture) of the replaced equipment, and the number of hours the lights would have operated. For an energy-efficient lighting major renovation project, the baseline decisions may include the considerations listed for a retrofit, with the addition of building code, equipment standards, and standard practice issues.

Having consistent and simple baseline standards is an important part of a successful Set-Aside Program. Given the above considerations, baseline definitions can consist of:

1. The minimum efficiency standard. This can apply to both equipment and systems, or a whole facility, as defined by a law, code or by standard industry practice. This is often used for new construction, major renovations, or equipment/systems that replaces failed equipment/systems.
2. The consumption rate of the existing equipment or systems. The baseline is based on measurements or historic data, an inventory of pre-retrofit equipment, or a control-group's energy equipment. This is typically used where no standard exists and/or when the project is an "early replacement" activity – that is, prior to equipment failure.[33]

Option 2 typically provides higher energy savings and, therefore, is preferred by most project and program sponsors. EPA suggests that Option 1 be used for new construction projects and that Option 2 be used for other project types.

4.4.2 Baseline Adjustments

As indicated above, the "adjustments" term in the general savings equation is used to re-state energy use of the baseline and reporting periods under a common set of conditions. Adjustments can be either "routine" or "non-routine". Routine adjustments are those that are predictable, variable, and measurable. Non-routine adjustments are those that tend to be one time events and are perhaps unpredictable. A non-routine adjustment would be required, for example, when a factory where the project takes place changes its product line. Significant routine adjustments are addressed in a M&V plan whereas non-routine adjustments, due to their nature, tend not to be addressed in the planning process, but as they occur.

Some examples of routine adjustments for energy efficiency projects are:

- Weather adjustments for projects involving space heating or air conditioning in buildings
- Operating hours adjustments for indoor lighting retrofits
- Building occupancy adjustments for projects involving indoor air ventilation systems

[33] A nuance for early replacement projects with respect to using either existing conditions or code requirements for a baseline is if the replaced equipment/systems had a remaining lifetime shorter that the allowance time period. In this situation, the first year(s) of the allowance might have an existing condition baseline and the later years a code requirements baseline. However, given the expected short lifetime of allowances, this nuance should not be significant.

- Production changes for projects involving industrial production processes

The characteristics that govern energy consumption, and thus the adjustments, are called independent variables. The appropriate independent variables to consider for defining baseline energy use can be determined by "common sense", regression analysis, or other forms of mathematical modeling. Independent variables found to have a significant effect on the baseline period energy use can be included as adjustments to calculation of savings and monitored at the same time as the reporting period energy consumption data.

Perhaps the most common independent variable that needs to be considered is weather. Weather can be measured in many different ways, but often just outdoor dry bulb temperature is evaluated. Tools for addressing weather's impact on energy savings are included in the project and program M&V guideline documents listed in the Appendix.

4.4.3 Net to Gross Adjustments

M&V at the project level generally involves calculating "gross" energy savings. However, when calculating emission savings, states will want to know the net impact of the EE/RE project or program, or the "net" savings. Adjustments, as discussed above, tend to be addressed at the project level, whereas net to gross issues tend to be addressed at the program level.

The difference between gross and net savings is the savings that would have occurred without the influence of the program and the implementation of the subject projects. Three common factors for calculating net savings are:

- "Free rider" and "spillover" effects
- Secondary effects
- Electrical transmission and distribution (T&D) losses

4.4.3.1 Free Riders and Spillover

Free riders and spillover are factors often taken into consideration for DSM programs conducted by utilities and public agencies. Free riders are participants that would have implemented an EE or RE project without the benefits of the sponsoring program. Spillover projects are activities that participants or non-participants in a program implement, but not because of the direct influence of the program (for example, they do not receive financial incentives). The methods for determining free riders and spillover include using reference values from similar program types, participant self-reports and interviews, comparison of participants with non-participants, and econometric modeling. For the purposes of a Set-Aside Program, EPA recommends that states conduct minimal or no evaluation of free rider and spillover issues. This is because of the nature of the cap and trade program, the value and risk of the allowances, and the types of projects being implemented under the Set-Aside Program.

4.4.3.2 Secondary Effects

Secondary effects are unintended consequences of a project activity. The main type of secondary effects for efficiency projects are referred to as "interactive effects" – and these can be substantial. Interactive effects are the impacts that an energy efficiency measure has on energy use within a facility and which are indirectly associated with the measure. For example, reducing lighting loads through an energy efficient lighting retrofit can also reduce air conditioning and/or increase heating requirements. This occurs because less heat is generated by energy efficient lighting.

A broader type of secondary effect occurs when energy efficiency programs have effects beyond a single facility and begin to impact energy supply and distributions systems. In this situation, the term "leakage" is used. Types of leakage includes *one-time* effects such as air emissions resulting from construction activities, or *upstream and downstream* effects such as emissions associated with a supply chain that supports the operation of a renewable energy project. These types of secondary effect tends to be negligible for efficiency and renewable projects, and is not suggested for inclusion in evaluation analyses for the NO_X SIP Call Set Aside Program.

4.4.3.3 T&D Losses

Once savings at the site level are calculated then the source level savings can be determined. In most analyses of EE/RE projects the site and source savings are assumed to be equal. However, inevitably there will be some electrical transmission and distribution (T&D) losses.[34] These can range from negligible for a high voltage customer located close to a power plant to over 10% for smaller customers located far from power plants. In addition, higher T&D losses are inevitable during on-peak hours. Thus, some jurisdictions have calculated on-peak, versus off-peak, T&D loss factors.

If a T&D loss factor is being considered, it is best to adopt one factor (or perhaps two – one for on-peak and one for off-peak) for the entire state and not try to be too fine grained. Two options for quantifying T&D losses are (a) assuming a simple adder for source savings or (b) not including T&D losses directly, but considering them a counterweight to uncertainty in the site savings calculation. The adder could be a value calculated for the specific transmission and distribution network in question. Potential sources of such data are local regulatory authorities, local utilities, and the regional independent system operator (ISO).

EPA's CVP[35] for the Acid Raid Program suggest the following default values for T&D losses, as a proportional adder to on-site energy savings:

- T&D savings for residential and commercial customers – 7%
- T&D savings for industrial customers – 3.5%

---

[34] Transmission is typically considered the high voltage movement of electricity from a power plant to a sub-station, and distribution is the lower voltage movement of electricity from a sub-station to the end users. However, some high-energy use customers receive electricity at transmission voltage levels and thus have lower T&D losses.

[35] U.S. EPA, 1995

Chapter 5 Calculating Energy Efficiency Savings Using Existing Documentation – Quality Assurance Guidelines

When project sponsors apply to receive allowances from the Set-Aside Program, they provide information about the EE/RE project or program. This information will often contain an indication of the emissions savings associated with the project or program including documentation of how the savings were determined. Most likely, this emissions savings documentation (in the form of a M&V or evaluation report) will not have been prepared for the sole purpose of applying for the Set-Aside Program.

Instead, the documentation may have been prepared for other purposes (e.g., regulatory reporting for a utility DSM program, or performance payments for a guaranteed energy savings agreement between a contractor and a customer). Although not necessarily prepared per the M&V requirements of a state's Set-Aside Program, the documentation may be sufficient for the purposes of the Set-Aside Program. Utilizing existing documentation in combination with Quality Assurance Guidelines (QAG) can save significant costs for the sponsor and encourage participation in the program. QAG can help determine whether indicated savings, and the assumptions and rigor used to prepare the documentation, can be used for the Set-Aside Program.

To initiate the approval process, a sponsor submits the necessary application materials with basic information about their project or program using forms similar to those found in the EPA's second guidance document, "*Creating An Energy Efficiency And Renewable Energy Set-Aside In The* NO_x *Budget Trading Program: Designing the Administrative and Quantitative Elements*." Attached to the application is documentation that indicates how the emission savings were determined. This savings documentation consists of an electricity savings M&V report with a kWh savings value and a calculation converting the electricity savings to an ozone season NO_x emission reduction.

This savings documentation is then reviewed, following the Quality Assurance Guidelines, for use in the Set-Aside Program and based on this review, either:

- Used "as is" for determining the NO_x allowances that will be credited to the subject project or program
- Revised by the state or applicant to provide a new value for the NO_x allowances that will be credited to the subject project or program
- Discounted based on specific concerns about the accuracy of the emission reductions values provided
- Increased based on underestimated savings calculations that used more conservative than necessary baseline assumptions
- Rejected

The subject of this Chapter is the review of energy savings M&V documentation submitted to the Set-Aside Program, but not necessarily prepared, specifically for this program. The guidance provided in this section can also be used for reviewing documentation submitted in direct compliance with the M&V requirements of a state Set-Aside Program, as discussed in Chapter 6.

The contents of this chapter are:

- Basic emission accounting standards
- Quality Assurance Guidelines with minimum requirements for any M&V documentation
- Inspections and persistence reviews
- Baseline reviews
- Setting accuracy standards and discounting for uncertainty
- Calculating ozone season savings from annual savings
- Using independent reviewers

5.1 QUALITY ASSURANCE GUIDELINES (QAG)

M&V guidelines and protocols focus on critical elements of M&V. However, there is a wide variation in actual project details such that guidelines and protocols provide more of an overall framework than an explicit set of instructions for completing the actual M&V. Therefore, complying with these guidelines is no guarantee that an M&V report is complete or accurate.

Thus, rather than have applicants adhere to the basic guidelines, a QAG can be used to judge acceptability of the submitted documentation. Adherence to such quality assurance guidelines still allows the M&V methods employed to be shaped by the specific circumstances of the projects or programs, the uncertainty of the savings estimates, and the value of the allowances. A QAG covers key issues associated with different data collection and analysis methods and requires sponsors to describe how certain key issues were addressed rather than requiring them to address each M&V effort in a specific way.

The QAG for the Set-Aside Program are presented in three forms:

- A list of minimum reporting requirements
- A summary table of quality assurance issues for different data collection and analyses methods, and
- Tables of specific issues for each IPMVP Option (A, B, C and D)

These QAG items are derived from related materials in the California Demand-Side Management Advisory Committee (CADMAC) QAG, the FEMP M&V Checklist[36], ASHRAE's[37] Guideline 14-2002 Measurement of Energy and Demand Savings, and LBNL's[38] Guidelines for the Monitoring, Evaluation, Reporting, Verification, and Certification of Energy-Efficiency Projects for Climate Change Mitigation.

5.1.1 Minimum Requirements

Table 5.1 contains a checklist of minimum requirements for an M&V documentation report. EPA

[36] U.S. DOE, 2000a
[37] ASHRAE, 2002
[38] Vine and Sathaye, 1999

recommends that project sponsors evaluate these minimum requirements in order to determine whether an evaluation submitted with a Set-Aside Program application is complete.

Table 5.1 Minimum Requirements for Evaluation or M&V Submittals for NO_x Set-Aside Program

• Program or project site(s) and measure(s) are reasonably defined
• Variables that affect energy and emissions savings are defined (e.g. weather) and assumptions for these variables are presented (e.g. actual or typical weather conditions were used in analyses)
• Time frame of savings analyses are defined in terms of savings during ozone season and number of years for persistence of savings
• Savings claimed are defined as primary, secondary, direct or indirect
• The M&V Option (A, B, C or D from IPMVP) that was used is defined
• Baseline equipment and conditions are defined; baseline adjustments are discussed
• Post-Installation (reporting period) equipment and conditions are defined
• Measurement and analysis activities are described including calculation details
• Critical assumptions and stipulations are defined and documented with supporting information
• Metering approach is defined including the equipment used, schedule of metering, and metering calibration
• Electronic, formatted data, directly from a meter or data logger, would be available, if requested
• Accuracy and precision of estimated savings are reported
• Sample sizes and documentation on how sample sizes were selected are provided (if used)
• Authors of analyses and documentation is indicated with their credentials and signatures on report
• Quality assurance methods are defined

The level of savings uncertainty and the effort required to verify both a project's potential to perform and its actual performance will vary from project to project and program to program. Therefore, one can expect diversity in M&V strategies and level of effort (rigor) between different projects. To facilitate assessing the M&V rigor (accuracy and precision) justified for each project, it is helpful to evaluate the savings claimed and the uncertainty of the savings.

One measure of uncertainty is the complexity of the project. The complexity “ranking” can correspond to the following project characteristics (for energy efficiency projects):

1. Constant load, constant operating hours
2. Constant load, variable operating hours
    a. Variable hours with a fixed pattern
    b. Variable hours without a fixed pattern (e.g., weather-dependent)
3. Variable load, variable operating hours
    a. Variable hours or load with a fixed pattern

b. Variable hours or load without a fixed pattern (e.g., weather-dependent).

A lower position (higher number) in the above list corresponds to more complex projects, which typically require more complex (and more expensive) M&V methods to determine energy savings. Thus, one can use the above list to indicate the complexity of the energy efficiency projects being evaluated. This approach captures the fact that the complexity of isolating savings from fluctuations in load is the most critical determinant of uncertainty. A key implication is that installing utility meters on complicated measures and systems -- like many HVAC installations -- can isolate savings and thereby reduce uncertainty.

In summary, more rigorous (and expensive) M&V approaches are appropriate for high emissions savings measures that are complex. Less rigorous M&V approaches are appropriate for less complex measures with lower savings.

5.1.2 Quality Assurance Issues for Data Collection and Analysis Methods

Table 5.2 lists some general issues for the different IPMVP Options A, B, C, and D. More detailed tables with issues for each Option are in the next section of this Chapter. These tables can be used as checklists for what should be evaluated, i.e. checked for quality and documented in M&V reports. For example, if an applicant submitted a M&V report using Option B analyses, one could use the second column of Table 5.2 as a checklist and supplement it with the more detailed explanation of each checklist item in Table 5.4.

Table 5.2 Quality Assurance Issues for Each IPMVP M&V Option

	Option A: Partially Measured Retrofit Isolation	**Option B: Retrofit Isolation**	**Option C: Whole Facility Analyses**	**Option D: Calibrated Simulation**	**Combinations of Options**
For Individual Projects – Issues that need to be addressed for different M&V Options					
M&V Rigor	X	X	X	X	X
Analytical Assumptions	X	X	X	X	X
Calibration	X	X	X	X	X
Data Type and Sources	X	X	X	X	X
Project Level Sampling	X	X			
Model Specification and Error			X	X	X
Missing Data and Outliers	X	X	X	X	X
Triangulation					X
Reasonableness Analysis	X	X	X	X	X
Independent Variables	X	X	X	X	X
Interactive Effects	X	X		X	X
Measurement Duration	X	X	X	X	X
For Programs - Issues that need to be addressed for different M&V Options					
Program Level Sampling	X	X	X	X	X
Comparison Group			X		X

The following are summary definitions of the categories listed in the Table 5.2:

For individual projects:

- Rigor - Was the accuracy and precision of the savings estimate calculated and reported? Is the rigor (or lack of rigor) reported and documented warranted based on the project savings, complexity and savings uncertainty?
- Analytical Assumptions - What were the key assumptions used in the analysis?
- Calibration - Were the input assumptions and calculated results of the analyses compared and adjusted to actual data? Was instrumentation calibrated?
- Data Type and Sources - Were the sources of data and the methods used in collecting data appropriate?
- Project Level Sampling - What sampling design was used to select the components to be metered? Do the samples meet basic statistical criteria for validity?
- Model Specification and Error - What was the initial and final model specification and how were specific modeling error issues identified and dealt with?
- Missing Data and Outliers - How were outliers and influential observations identified and handled? How were missing data handled?
- Triangulation - If more than one estimate of savings was calculated, how were the results combined to form one estimate?
- Reasonableness Analyses - Were “reality checks” made by comparing M&V analysis results with actual utility bills or basic engineering calculations? Are key assumptions realistic?
- Independent Variables - What were the sources of data for independent variables (e.g. weather) that impact savings calculations?
- Interactive Effects: How were the interactions between different measures (installed at the same location) addressed?[39]
- Measurement Duration - What was the duration and interval of metering, does it cover the full range of operating conditions associated with the project?

For groups of projects in a program:

- Program Level Sampling - What kind of sampling design was used. Did the samples meet basic statistical criteria for validity?
- Comparison Group - Was a comparison group utilized for estimating savings, and if so, how was it selected as representative?

[39] Interactive effects are the effects that an energy efficiency measure has on energy use in a facility, but which are indirectly associated with the measure. For example, reduction in lighting loads, through an energy efficient lighting retrofit, will reduce air conditioning and/or increase heating requirements, since there is less heat generated by the energy efficient lights.

5.1.3 M&V Option Specific Quality Assurance Issues

The following tables raise issues for project sponsors and evaluators to consider and integrate into their plans for adopting one of the four IPMVP Options.

Table 5.3 Quality Assurance Issues for IPMVP Option A: Partially Measured Retrofit Isolation

	Option A Quality Assurance Issues
M&V Rigor	What was the basis for the use of this Option? Is the rigor (or lack of rigor) reported and documented appropriate?
Analytical Assumptions	What were the key assumptions in the analyses and the source of these assumptions?
Calibration	Describe instrumentation calibration methods used.
Data Type and Sources	1. Describe the data that were collected to support the analysis. 2. Describe the source(s) and method(s) of collecting these data. 3. Describe which data were collected from site inspection, building plans, stipulated, etc.
Project Level Sampling	Describe how sampling was used, if at all, to meter only a representative group; for example, if only some lighting circuits were metered for a lighting retrofit. If samples were used for selected measurements, indicate the selection process and the precision and confidence intervals for the collected information.
Missing Data and Outliers	Indicate whether outlier analyses were used and, if outliers were identified, how they were identified, and how they were dealt with. Indicate if any data were missing, why, and what was done to fill in data gaps.
Reasonableness Analysis	Describe how the energy savings results were evaluated to ensure they are reasonable and consistent with other available information.
Independent Variables	What were the independent variable (e.g., weather) data chosen for the analyses and describe how they correspond to the facility and energy efficiency measures?
Interactive Effects	Indicate if interactive effects were taken into account, and if so, how they were determined.
Measurement Duration	What was the duration and interval of metering? How was it determined to cover the full range of operating conditions associated with the project?
Program Level Sampling	If projects were selected to represent the entire population of projects in a program, describe the sampling methods and the precision and confidence intervals achieved.

Table 5.4 Quality Assurance Issues for IPMVP Option B: Retrofit Isolation

	Option B Quality Assurance Issues
M&V Rigor	What was the basis for the use of this Option? Is the rigor (or lack of rigor) reported and documented appropriate?
Analytical Assumptions	What were the key assumptions in the analyses and the source of these assumptions?
Calibration	Describe instrumentation calibration methods used.
Data Type and Sources	1. Describe the data that were collected to support the analysis. 2. Describe the method(s) of collecting and instrumentation used for collecting data. 3. Describe which data were collected from site inspection, building plans, stipulated, etc.
Project Level Sampling	Describe how sampling was used, if at all, to meter only a representative group; for example, if only some lighting circuits were metered for a lighting retrofit. If samples were used for selected measurements, indicate the selection process and the precision and confidence intervals for the collected information.
Missing Data and Outliers	Indicate whether outlier analyses were used and, if outliers were identified, how they were identified, and how they were dealt with. Indicate if any data were missing, why, and what was done to fill in data gaps.
Reasonableness Analysis	Describe how the energy savings results were evaluated to ensure they are reasonable and consistent with other available information.
Independent Variables	What were the independent variables (e.g., weather)? Indicate how data on the variables were collected and validated as accurate and relevant to savings calculation.
Measurement Duration	What was the duration and interval of metering? How was it determined to cover the full range of operating conditions associated with the project.
Program Level Sampling	If projects were selected to represent the entire population of projects in a program, describe the sampling methods and the precision and confidence intervals achieved.

ASHRAE's Guideline 14-2002 for Measurement of Energy and Demand Savings includes several minimum requirements established for retrofit isolation M&V approaches. They are paraphrased here to provide additional guidance on defining specific requirements for use in Option B M&V analyses[40]:

- The baseline data could be collected for a period of time that spans the full range of all independent variables expected to occur under normal facility operations for the ozone season.

---

[40] Descriptions of these criteria and definitions can be found in Guideline 14-2002. Related terminology is defined in standard statistics texts.

- Reasons could be reported for data gaps, elimination or estimation of any actual measured data in the baseline or post-retrofit reporting periods.
- Estimation of missing data could use actual data points that span the typical range of independent variables.
- Where energy use measurement is less than continuous, periodic measurements could be made of demand, and operating periods of relevant equipment could be recorded continuously.
- Where multiple similar systems at one facility are involved, uncertainty and confidence calculations could include the impact of any sampling techniques used.
- The algorithm for savings determination could have a net determination bias error less than 0.005%. [41]
- With each annual savings report, show at least the level of uncertainty and confidence interval in the savings determined during the post-retrofit period.
- The level of uncertainty must be less than 50% of the annual reported savings, at a confidence level of 68%.

[41] Net determination bias is calculated by applying the baseline period's independent variable data to the algorithms for savings determination. This test indicates computational uncertainty introduced by the baseline model.

Table 5.5 Quality Assurance Issues for IPMVP Option C: Whole Facility Analyses

	Option C Quality Assurance Issues
M&V Rigor	What was the basis for the use of this Option? Is the rigor (or lack of rigor) reported and documented appropriate?
Analytical Assumptions	What were the key assumptions in the analyses and the source of these assumptions?
Calibration	Describe facility meter calibration.
Data Type and Sources	1. Describe the data that were collected to support the analysis. 2. Describe the source(s) and method(s) of collecting these data. 3. Describe which data were collected from site inspection, building plans, stipulated, etc.
Model Specification and Error	1. Describe model specifications. 2. If autocorrelation, heteroskedasticity, or collinearity was a problem, describe the diagnosis carried out, the solutions attempted, and their effects. If left untreated, explain why. 3. Indicate experience of person(s) who conducted modeling.
Missing Data and Outliers	Indicate whether outlier analyses were used and, if outliers were identified, how they were identified, and how they were dealt with. Indicate if any data were missing, why, and what was done to fill in data gaps.
Reasonableness Analysis	Describe how the energy savings results were evaluated to ensure they are reasonable and consistent with other available information.
Independent Variables	What were the independent variables (e.g., weather)? Indicate how data on the variables were collected and validated as accurate and relevant to savings calculations.
Measurement Duration	What was the duration and interval of the analysis (e.g., how many months of baseline and reporting period metering data were utilized to develop a model)? How was it determined to cover the full range of operating conditions associated with the project?
Program Level Sampling	1. If a sample was used, describe the sample. 2. Describe the size of the expected sample and achieved sample. 3. Describe the projected and achieved level of precision at a given level of confidence. 4. Describe any tests or comparisons made to examine whether the sample was representative of the whole population. 5. If a stratified sample was used, describe how the strata were defined and how the allocation to strata was determined. 6. If the sample was weighted for analysis, describe the basis.
Comparison Group	If a comparison group was used for comparing “treated” facilities with non-participants, describe the comparison group and the basis for selection.

ASHRAE's Guideline 14-2002 for Measurement of Energy and Demand Savings includes several minimum requirements established for Whole Facility Option C M&V approaches. They are paraphrased here to provide additional guidance on defining specific requirements for use in Option C M&V analyses:

- Baseline data could span the normal, full range of all independent variables under normal facility operations during the ozone season. Given that the ozone season is only five months long, it is suggested that at least two seasons worth of baseline data be used.
- Reasons could be reported for data gaps, data elimination, or estimation of any actual measured data in the baseline or post-retrofit periods. No more than 25% of the measured data could be excluded.
- Where multiple similar facilities are involved (e.g. a "program"), uncertainty and confidence calculations could include the impact of any sampling techniques used.
- The algorithm for savings determination could have a net determination bias error less than 0.005%.
- With each annual savings report, show at least the level of uncertainty and confidence interval in the savings determined during the reporting period.
- The level of uncertainty must be less than 50% of the annual reported savings, at a confidence level of 68%.

Table 5.6 Quality Assurance Issues for IPMVP Option D: Calibrated Simulation

	Option D Quality Assurance Issues
M&V Rigor	What was the basis for the use of this Option? Is the rigor (or lack of rigor) reported and documented appropriate?
Analytical Assumptions	What were the key assumptions in the analyses and the source of these assumptions?
Calibration (metering and model)	1. Describe instrumentation calibration methods used. 2. Describe how the calculations were calibrated to observed data on usage levels. 3. Describe the criteria used to judge whether the model(S) and calculations were appropriately calibrated. 4. Describe input values that were changed to bring the calculations into calibration and give the reasons why a value was changed.
Data Type and Sources	1. Describe the data that were collected to support the analysis. 2. Describe the source(s) and method(s) of collecting these data. 3. Describe which data were collected from site inspection, building plans, stipulated, etc.
Model Specification and Error	1. Describe simulation models used for analyses. 2. Indicate experience of person(s) responsible for modeling. 3. Report the mean of the differences between the simulated and calibration data and other relevant statistical indicators
Calibration	1. Describe data collected, data collection method and calibration. 2. Indicate changes that were made in model as a result of calibration efforts and the basis for those changes.
Data Type and Sources	1. Describe the data that were collected to support the analysis. 2. Describe the source(s) and method(s) of collecting these data. 3. Describe which data were collected from site inspection, building plans, stipulated, etc.
Missing Data and Outliers	Indicate whether outlier analyses were used and, if outliers were identified, how they were identified, and how they were dealt with. Indicate if any data were missing, why, and what was done to fill in data gaps.
Independent Variables	What were the independent variables (e.g., weather)? Indicate how data on the variables were collected and validated as accurate and relevant to savings calculations.
Reasonableness Analysis	Describe how the energy savings results were evaluated to ensure they are reasonable and consistent with other available information.
Interactive Effects	Indicate how interactive effects are addressed by modeling.
Measurement Duration	What was the duration and interval of metering used for collection of calibration data, and how was it determined to cover the full range of operating conditions associated with the project?
Program Level Sampling	If projects were selected to represent the entire population of projects in a program, describe the sampling methods and the precision and confidence intervals achieved.

In ASHRAE's Guideline 14-2002 for Measurement of Energy and Demand Savings several minimum requirements are established for calibrated simulation Option D M&V approaches.[42] ASHRAE's requirements for building calibrated simulation are paraphrased here to provide additional guidance on reviewing Option D M&V efforts:

- The simulation tool used to develop models for buildings could be a computer-based program for the analysis of energy use in buildings. It could be commercially available or in the public domain. The tool could be able to adequately model the facility and energy efficiency measures, performing calculations for each hour of the time period in question (e.g., for a one-year period the model could perform 8,760 hourly calculations). In addition, it could be able to explicitly model at least the following:
  - Thermal mass effects
  - Occupancy and operating schedules that can be separately defined for each day of the week and holidays
  - Individual control set points for thermal zones or heating, ventilation, and air conditioning (HVAC) components
  - Actual weather data
  - User-definable part-load performance curves for mechanical equipment
  - User-definable capacity and efficiency correction curves for mechanical equipment operating at non-rated conditions
- Provide a complete copy of the input data, indicating which data are known and which are assumed. Report the source of all data described as "known" and assess its level of uncertainty.
- Report the name and version of simulation software used. Indicate who completed the analyses. ASHRAE recommends that the skills of the personnel include five years of computer simulation experience.
- Report the source and accuracy of the calibration data. Calibration data could contain at a minimum all measured monthly utility data from 12 bills spanning at least one year.
- The computer model could have an NMBE[43] of no more than 5% and a CV (RMSE)[44] of less than 15% relative to monthly calibration data. If hourly calibration data are used, these requirements could be 10% and 30%, respectively.
- With each savings report, show at least the level of uncertainty and confidence interval for the annual savings determined during the post-retrofit period.
- The level of uncertainty must be less than 50% of the annual reported savings, at a confidence level of 68%.

---

[42] For ASHRAE, calibrated simulation refers to residential or commercial building analyses, versus say a calibrated simulation of an industrial process facility.

[43] NMBE - Net Mean Bias Error

[44] CV(RMSE) – coefficient of variation, root mean square error - indicates the uncertainty inherent in the model.

5.2 INSPECTIONS AND PERSISTENCE REVIEWS

If a state has available resources, a useful validation activity is to inspect projects, or a sample of projects in a program, that are applying for NO_x allowances. Such inspections would ideally include reviews of both pre-installation (i.e., baseline conditions) and reporting period conditions. The objective of such inspections is not the recalculation of savings, but the assurance that the project(s), as installed, have the potential to generate the indicated savings.

The same objective applies to persistence reviews (annual inspections) of the facility to ensure it is still operating properly. Persistence reviews can also include an annual report by the project or program sponsor in which they use new analyses to document the savings from a second year, third year, etc. of operation.

During the inspections, a list of existing (baseline inspection) or new equipment can be cataloged, and performance measurements taken. For example, if constant load motors are being replaced, the electrical draw of the existing and the new motors can be measured to confirm a critical element of the savings calculation. In addition, observing the new equipment in operation and interviewing facility staff can provide additional confidence that the projects are, and will continue, generating savings.

For programs targeting integrated whole-building approaches to energy efficiency, utility bill analysis can be used to statistically evaluate persistence. One useful tool that can be used for this purpose is ENERGY STAR's Portfolio Manager (see p. 4-11 for more information).

5.3 BASELINE REVIEWS

It is important to review what baseline was assumed, how it was selected and how it was applied. For renewable energy projects, the baseline is usually assumed to be zero. For energy efficiency projects baselines, there are two types of baselines to review:

- Existing equipment, systems, and operational conditions. that existed prior to the installation of the project or program, or
- Existing conditions modified to account for state and/or federal energy standards and codes.

If the baseline was assumed to be existing conditions, then the following questions could be asked:

- Are their current state or federal energy standards that apply to the equipment or systems impacted by the project or program?
- How were existing conditions documented?
- What surveys and measurements were conducted?
- What historical data were used for documenting assumptions?

If the baseline was assumed to be existing conditions, modified for energy codes or standards, then the following questions could be asked:

- What current state or federal energy standards were assumed to apply to this project or program?
- How were the standards applied to the existing conditions to develop a new baseline?
- How were existing conditions documented?

- What surveys and measurements were conducted?
- What historical data were used for documenting assumptions?

5.4 MINIMUM ACCURACY STANDARDS AND DISCOUNTING

In order to ensure confidence that the NO_x allowance calculations are conservative and reliable there are two general approaches that states can take to defining expectations for accuracy:

- Set minimum standards for evaluation and M&V accuracy (such as in the ASHRAE Guideline 14 “Prescriptive Path” for Whole Facility Option C method, as described above) and not accept lesser quality M&V reporting. The desired accuracy levels might be defined as compliance with the QAG tables, if the tables are modified to include requirements for specific accuracy and precision levels.
- Develop a graduated scale of discounting based on the accuracy with which various M&V methods capture energy savings and emissions reductions. The discounting rates could vary from zero for evaluation approaches that demonstrate high levels of confidence and precision to significant discounts for determined without complete metering. Discounting would allow participants to weigh the benefits of measurement methods and to select the one that provides the most accurate compromise between the burden of M&V stringency and size of award.

Discounting could be used with caution – it can simply add inaccuracy on top of inaccuracy. For example, setting discounting rates for certain methodologies too high may discourage program participation and thus may restrict a program’s potential success. Alternatively, the potential for gaming is inherent to any discounting strategy; if sponsors know that their savings will be discounted, for example by 20%, then they may “overestimate” savings by 20%. The discount factor depends on the risks inherent in both predicting the savings result and achieving and maintaining the intended equipment or personnel performance level that will produce the predicted savings.

Given these issues around discounting, it may be better to define the limits of acceptable accuracy. For accuracy requirements two sources are ASHRAE Guideline 14 and the New England ISO Forward Capacity Market M&V Protocols that are being issued in the first quarter of 2007[45].

If a discounting approach is to be used, states may consult guidance from the EPA Acid Rain Program (1995 and 1996) for discounting savings from energy efficiency programs implemented by utilities.[46]

- Default option - By relying on default (stipulated) savings, allowable savings are restricted: credit is given for only 50% of first-year savings, and limited to one-half of the measure’s physical lifetime.
- Inspection option - By inspecting (confirming) that measures are both present and operating, allowance is allowed for 75% of first-year savings and is limited to one-half of the measure’s physical lifetime (with biennial inspections), or 90% of first-year savings for physical lifetimes of measures that do not require active operation or maintenance (e.g., building shell insulation, pipe insulation and window improvements).
- Monitoring option - By conducting monitoring over the life of the measure, one obtains allowances for a greater fraction of the savings and for a longer period of time. Biennial verification in subsequent years 1 and 3 (including inspection) is required, and savings for the

---

[45] ISO-NE, 2007
[46] Vine and Sathaye, 1999

remainder of physical lifetimes are the average of the last two measurements. The monitoring option requires a 75% confidence in subsequent-year savings.

In summary, a state may wish to set minimum accuracy standards for NO_x allowance evaluations. In addition, as part of the review process a state may wish to discount the savings and allowances reported by an applicant. The basis for the discount may be somewhat subjective and rely on the professional judgment of the reviewer, with the backing of official state guidance. The discounting may be due to specific concerns about the quality of the analyses, the reported (or unreported) accuracy of the analyses, or concern for secondary effects that are not specifically addressed.

5.5 CALCULATING OZONE SEASON SAVINGS FROM ANNUAL SAVINGS

Ensuring that savings are properly reported for only the ozone season requires special attention when reviewing applications. Typically, M&V activities result in a calculation of annual energy savings. For the Set-Aside Program, however, it is the savings during the five-month ozone season that are of interest.

Unfortunately, only for the simplest energy-efficient projects can a simple ratio (5/12) be used to convert twelve-month savings to five-month savings. Projects for which the 5/12 ratio is potentially applicable are projects with constant savings throughout the year, (i.e., savings are not dependent on weather or operational characteristics). An example of such a project would be a lighting retrofit in an office building that is operated the same number of hours throughout the year.

However, energy consumption and savings typically vary throughout the year depending on whether it is an energy retrofit at a factory that has different production schedules throughout the year, or a retrofit at a school that is not operated during the summer. Many energy efficiency measures' performance also varies with season, particularly those involving heating or cooling systems. Even outdoor lighting retrofits save less energy in the summer (when there are more daylight hours) than in the winter. Therefore, for most projects, a month-by-month analysis and savings report are required to determine what the savings are for the ozone season months of May through September.

5.6 INDEPENDENT REVIEW

Claims for allowances will need to be reviewed and certified by the state prior to their issuance. M&V from EE/RE actions could be carried out by applicants or third parties using guidance provided in this document and other industry sources, as listed in the Appendix. Regardless of who performs the measurement, appropriate documentation and proof of savings, such as utility billing data, data from sub-metering, and sworn claims may be required to prevent fraudulent claims in the Set-Aside system.

Beyond certain minimum requirements, and particularly as it relates to the accuracy of an evaluation effort, there is a degree of professional judgment required to determine what is "good enough." M&V involves balancing accuracy and the time and cost of obtaining incrementally better results. This balancing act requires an understanding of the:

- Value of the information (the electricity and NO_x savings) derived from a M&V effort
- Risk of excessively high or low savings – program integrity versus discouraging participation because of overly conservative estimates
- Accuracy, costs, and practical opportunities and limitations of various M&V approaches

Planning for M&V, or the due-diligence review of a completed M&V effort, requires professional judgment based on experience conducting M&V activities and knowing when incremental efforts to improve accuracy will return a net benefit in savings determination accuracy. M&V certification and oversight of energy savings could be designated to entities within the state with appropriate knowledge and experience with energy use, efficiency and measurement issues, or independent, third-party consultants.

States may consider the use of independent third-party consultants to review applications. Third-party savings verifiers are typically engineering consultants with experience and knowledge of the relevant technologies, as well as with verifying energy efficiency or renewable project performance. Many are participants in industry groups such as the Efficiency Valuation Organization (http://www.evo-world.org), which offers courses in M&V and a Certified M&V Professional (CMVP) program. Utilities often employ these types of consultants for their DSM programs, and may be a source of recommendations. The FEMP also has an M&V evaluation team (http://ateam.lbl.gov/mv/).

Chapter 6 Calculating Energy Efficiency Savings Using New Analyses–Establishing a NO_x Set-Aside Specific M&V Protocol

In this guidance document there are two approaches defined for calculating energy savings. The first approach, as described in Chapter 5, involves using Quality Assurance Guidelines for reviewing M&V documentation that was not specifically prepared for the Set-Aside Program but is submitted with an application for Set-Aside allowances. The second approach, as covered in this Chapter, is guidance on what could be covered in a project or program specific M&V plan specifically prepared for the Set-Aside Program. Both approaches rely on common standards that any M&V activity should achieve: relevance, completeness, transparency, consistency, accuracy, and conservativeness.

The core steps of an evaluation are:

- Gross program electricity savings are determined.
- Gross program electricity savings may be converted to net electricity savings using a range of possible considerations (e.g., free-rider corrections). This calculation is discussed briefly in Section 4.4.3. It is up to each state to decide whether it wants to include net to gross conversions in its M&V requirements.
- Emission factors are applied to net energy savings in order to determine NO_x allowances.

In general, gross electricity savings are determined using one of the following methodologies:

- Project Based Measurement and Verification (M&V) Method. Individual project savings are determined using one or more of the four M&V Options defined in the IPMVP. If a program is being evaluated, then a representative sample of projects in the program is selected and the savings from those selected projects are determined and applied to the entire population of projects, i.e. the program. This project based M&V method is the most common method used for programs involving non-residential facilities, retrofit or new construction, which have a wide variety of factors determining savings and when individual facility savings values are desired. This method is the focus of this Guide.

- Large-Scale Data Analysis Method. This method is only used for large energy efficiency programs. Statistical analyses are conducted on the energy usage data (typically collected from the meter data reported on utility bills) for all or most of the participants and possibly non-participants in the program. This approach is primarily used with residential programs where relatively homogenous homes and measures are implemented and project-specific analyses are not required or practical.

Section 6.1 discusses planning for the Project Based M&V method and Section 6.2 covers sampling basics as related to Project Based M&V. Section 6.3 briefly reviews the large-scale data analysis method.

6.1 REQUIREMENTS FOR A PROJECT M&V PLAN

This section discusses the M&V planning process for individual projects. Program M&V, which addresses a large number of similar projects, is discussed in Section 6.2.

M&V activities fall into the following five areas.

1. Selecting one of the four IPMVP Options for the project. The Options define general approaches to documenting savings.
2. Preparing a project-specific M&V plan that outlines the details of what will be done to document savings.
3. Defining the pre-installation baseline, including (a) equipment and systems, (b) baseline energy use, or (c) factors that influence baseline energy use. The baseline can be defined through a review of regulatory requirements (such as minimum efficiency standards), site surveys, spot, short-term, or long term metering, and/or analysis of utility billing data.
4. Defining the post-installation, reporting period situation, including (a) equipment and systems, (b) post-installation energy use, or (c) factors that influence post installation energy use. Site surveys; spot, short-term, or long-term metering; and/or analysis of billing data can also be used for the reporting period assessment.
5. Conducting annual M&V activities to (a) verify the continued operation of the installed equipment or system, (b) determine current year savings, (c) identify factors that may adversely affect savings in the future, and (d) estimate savings for subsequent years.

As with many things, good M&V is based on both good planning and good implementation.

6.1.1 Selecting an M&V Option

The 2002 IPMVP, as discussed in Chapter 4, defines four M&V Options: Options A, B, C, and D. The Options are generic M&V approaches for energy projects. Having four Options provides a range of approaches to determine energy savings with varying levels of rigor and cost. Table 6.1, using text from the IPMVP, lists the best energy efficiency applications for each of the Options.

Table 6.1 Applications for Each IPMVP Option

Option A **Partially Measured Retrofit Isolation** is best applied where:	**Option B** **Retrofit Isolation** is best applied where:	**Option C** **Whole Facility** is best applied where:	**Option D** **Calibrated Simulation** is best applied where:
• The magnitude of savings is low for the entire project or for the portion of the project to which Option A is applied • The project is simple with respect to having limited independent variables and unknowns • The risk of not achieving savings is low • Interactive effects are to be ignored or are stipulated using estimating methods	• The project involves simple equipment replacements • Energy savings values per individual measure are desired • Interactive effects are to be ignored or are stipulated using estimating methods • Independent variables are not complex	• The project is complex • Predicted savings are large as compared to the recorded energy use • Energy savings values per individual measure aren't needed • Interactive effects[47] are to be included. • Independent variables that affect energy use are not complex or excessively difficult to monitor	• New construction projects are involved[48] • Energy savings values per measure are desired • Option C tools cannot cost effectively evaluate particular measures • Complex baseline adjustments are anticipated • Baseline measurement data does not exist or prohibitively expensive to collect

One of the most important selection criteria for an Option is the cost of implementing the M&V. Some Option-related elements of M&V costs are:

- Option A
  - Number of measurement points
  - Complexity of deriving the stipulation
  - Frequency of post-retrofit inspections
- Option B
  - Number of points and independent variables to be measured

---

[47] Interactive effects are the effects that an energy efficiency measure has on energy use in a facility, but which are indirectly associated with the measure. For example, reductions in lighting loads, through an energy efficient lighting retrofit, will reduce air conditioning and/or increase heating requirements, since there is less heat generated by the energy efficient lights.

[48] IPMVP, 2006

  - Complexity of measurement systems
  - Length of time measurement system must be maintained
  - Frequency of post-retrofit inspections
- Option C
  - Number of meters to be analyzed
  - Number of independent variables used in models
- Option D
  - Number and complexity of systems simulated
  - Number of field measurements required for model input data
  - Effort required for calibration of model
  - Skill of those conducting simulations

While it is very difficult to generalize about M&V costs, a rule of thumb is that M&V costs range from 1% to 10% of project costs. In general, on a per unit of energy saved, costs are inversely proportional to the magnitude of the savings (i.e. large project have lower per savings unit M&V costs) and directly proportional to uncertainty of predicted savings (i.e. projects with greater uncertainty in the predicted savings warrant higher M&V costs).

6.1.2 Project Specific M&V Plan – Energy Efficiency Projects

A project specific M&V plan could describe in a fair amount of detail what will be done to document the savings from a project. It can be a plan for each energy efficiency measure included in the project, for example, when a retrofit isolation approach is used. Or, it can cover the entire project – for example, when whole facility analyses approach is used. The M&V plan will consider the type of energy efficiency measures involved and the desired level of accuracy.

The M&V plan could include a project description, facility equipment inventories, descriptions of the proposed measures, energy savings estimates, a M&V budget, and proposed construction and M&V schedules. A project-specific M&V plan could demonstrate that any metering and analysis will be done in a consistent and logical manner and with a level of accuracy acceptable to all parties.

It is important to realistically anticipate the costs and level of effort associated with completing metering and data analysis activities. Time and budget requirements are often underestimated. Improved time and budget estimates can be achieved by properly defining the critical factors that affect energy consumption prior to completing the M&V plan. Understanding the value of the project's savings is necessary for setting reasonable M&V goals and accuracy requirements.

The following tables summarize what could be contained in the M&V plans. Table 6.2 lists general requirements for an overall plan.

Table 6.2 Energy Efficiency Project M&V Plan Content - General Components

Category	M&V Plan Components
Project Description	Project goals and objectives
	Site characteristics and constraints (e.g. absence of utility meter data at site)
	Measure descriptions that include how savings will be achieved
Project Savings and Costs	Estimated savings by Measure
	Estimated M&V cost by Measure
Scheduling	Equipment installations
	M&V activities
Reporting	Raw data format
	Compiled data format
	Reporting interval
M&V Approach	Accuracy and precision requirements
	Options used
	Person(s) responsible for M&V activities

Table 6.3 lists requirements that could be addressed for each measure (e.g., building lighting retrofit, building air conditioning retrofit, control system upgrade) that is included in the project being evaluated.

Table 6.3 Energy Efficiency Project-Specific M&V Plan Contents - Measure Specific Components

Category	**M&V Plan Components**	**Examples**[49]
Analysis Method	Data requirements	kW, operating hours, temperature
	Basis of stipulated values	Lighting operating hours equal 4000/year based on metered XYZ building
	Savings calculation equations	kWh $savings_t$ = [(kW/$Fixture_{baseline}$ x $Quantity_{baseline}$) - (kW/$Fixture_{post}$ x $Quantity_{post}$)] x Operating Hours
	Regression expressions	Three parameter change-point cooling model
	Computer simulation models	DOE-2 simulation model
Metering and Monitoring	Metering protocols	ASHRAE Guideline 14 pump multiple point test throughout short term monitoring
	Equipment	ABC Watt Hour Meter with 2 watts accuracy
	Equipment calibration protocols	NIST[50] protocols
	Metering points	Flow rate, RMS power
	Sample Size	25 lighting circuits out of 350
	Sampling accuracy	90% confidence/10% precision
	Metering duration and interval	2 weeks/15-minute data
Baseline Determination	Performance factors	Boiler efficiency
	Operating factors	Load, operating hours
	Existing service quality	Indoor temperature set points
	Minimum performance standards	State energy code
Savings Adjustments	Party responsible for developing adjustments	Smith Engineers hired by Sponsor
	Savings adjustment approach	Baseline adjusted for reported period weather and building occupancy levels

When preparing a M&V plan one can use the resources found in energy efficiency project M&V guidelines. References to some of these M&V Guidelines are found in the Appendix. Within these guidelines, there are three types of M&V plans:

- Stipulated or Deemed Savings - for projects with well-known and documented savings (e.g. energy-efficient appliances such as washing machines, computer equipment and

[49] These examples are not for one particular type of project or IPMVP Option, but a variety of project types and Options.
[50] NIST - National Institute of Science and Technology

refrigerators, lighting retrofit projects with well understood operating hours). NYSERDA, Texas TEEM, and the California Standard Offer Program M&V Guidelines contain stipulated values and M&V methods for several typical energy efficiency measures.

- Prescriptive Methods - for projects with significant M&V "experience" and well understood determinants of savings there are M&V procedures and spreadsheets (e.g. lighting and motor retrofits and solar water heating system installations). The FEMP Guidelines contain prescription approaches to several common energy efficiency measures. The ASHRAE Guidelines contains a prescriptive method for Option C, whole facility analysis.
- Generic Approaches - Conceptual approaches applicable to a variety of project types for which deemed values cannot be established and for which prescriptive M&V methods are not available (e.g. comprehensive building retrofits and industrial energy efficiency measures). The FEMP and ASHRAE Guidelines contain several generic approaches.

For the deemed savings approach, it is increasingly common to *stipulate* a parameter or to hold its value constant regardless of what the actual value is during the term of the NO_x allowance[51]. A stipulation in a M&V plan is essentially an agreement between the applicant and the state to accept a stipulated value, or a set of assumptions, for use in determining the baseline or reporting period energy consumption. If certain requirements are met (e.g., satisfactory commissioning results were submitted, annual verification of equipment performance is performed, and maintenance is being done), the savings are considered to be confirmed.

Stipulated values could be based on reliable, traceable, and documented sources of information such as:

- Standard tables, from recognized sources indicating the power consumption (wattage) of certain pieces of equipment that are being replaced or are being installed as part of a project (e.g., lighting fixture wattage tables)
- Manufacturer's specifications
- Building occupancy schedules
- Maintenance logs
- Performance curves published by national organizations

Sources of stipulated values must be documented in the M&V plan. Even when stipulated values are used in place of measurements, verifying equipment performance is still recommended (with the caveat that *direct stipulation of energy savings* is never recommended). Properly used, stipulations can reduce M&V costs and simplify procedures. Improperly used, they can give M&V results an aura of authority. Deciding whether parameters could be stipulated requires understanding how they will affect savings, judging their affect on reliability and uncertainty of results, and balancing the costs, risks, and goals of the project and the Set-Aside Program.

Evaluation of a few key aspects of the project could drive decisions about whether to use stipulations and how to use them effectively in an M&V plan:

- Availability of reliable information
- The project's likelihood of success in achieving savings

[51] U.S. DOE, 2002

- Uncertainty of the stipulated parameter and its contribution to overall project uncertainty
- The cost of measurement

Overall uncertainty in predicted savings, and the degree to which individual parameters contribute to overall uncertainty, could be carefully considered in deciding whether to use stipulations. Savings prediction uncertainty can be assessed by identifying the factors that affect savings and estimating the potential influence of each factor. Factors having the greatest influence could be measured if at all practical. Several “rules of thumb” are:

- The most certain, predictable parameters can be estimated and stipulated without significantly reducing accuracy.
- Stipulating parameters that represent a small degree of uncertainty in the predicted result and a small amount of savings will not produce significant accuracy concerns.
- Parameters could be measured when savings and prediction uncertainty are both large.
- Even if savings are high, but uncertainty of predicted savings is low, full measurement may not be necessary for M&V purposes.
- If savings are small but the uncertainty in the predicted savings is high, stipulation would shift risk to the state and the project may not be appropriate for the Set-Aside Program.

6.2 SAMPLING

A program is a group of projects, with similar characteristics and installed in similar applications. Examples include a utility program to install energy-efficient lighting in commercial buildings, a developer’s program to build a subdivision of homes that have photovoltaic systems, or a state residential energy efficiency code program. The difference between project and program M&V is that each project is evaluated, while programs require a sample of included projects to be selected for evaluation with the results applied to the entire program “population”. Program evaluation, on a per project or ton of NOx basis, tends to be more cost-effective than individual project analyses. Thus, with respect to M&V, it is more cost-effective to encourage programs or large aggregations of similar projects to participate in a state Set-Aside Program.

For each project selected for analysis within a program, the M&V Options A, B, C and D are the approaches that can be used. For Option C, whole facility analyses, a billing analyses may be conducted for a sample of projects selected from the population. Alternatively, the utility bills for the entire population may be analyzed.

When a sample needs to be selected, the following steps are typically employed:

1. The population of participants (and/or non-participants) to be represented by the sample is defined. This is called the sample frame. Examples of frames are commercial businesses in a certain area, industrial businesses with certain levels of energy use, and residences with central air conditioning.
2. If the sample frame is not sufficiently homogenous, then the sample frame is subdivided into subsets or strata of projects with similar characteristics. For example, a sample frame of all industrial customers may be further divided into factories with similar products or operating schedules. Creating subsets of homogonous projects helps reduce the sample sizes required for reliable estimates.

3. The size of the project savings estimate (e.g. kWh/project) for the sample frame or for the sub-sets is estimated using initial engineering savings estimates, some preliminary tests, or information from other similar projects.
4. The variability of the savings estimate is calculated for the sample frame or the subsets. Variability is an indication of what range of values for savings might be found in the sample. The larger the amount of variation, the larger the sample size needs to be in order to reliably estimate savings.
5. The population size, the estimated savings impact, and the estimated variance are used to calculate the sample sizes required to meet certain accuracy requirements for the sample frame as a whole or each sub-set of the frame. Several statistical approaches are available for calculating sample sizes. Basic statistics books and several of the resources listed in the Appendix can be consulted.

A successful sample will be sufficiently representative of the population to enable one to draw reliable inferences about the population as a whole. The reliability (rigor) of a sample refers to the confidence with which one can state that the estimate produced by the sample falls within a specified range of the true value in the population. Any time an estimate of a variable (such as energy savings) is based on measurements from a sample (rather than the entire population), the estimate typically will differ from the true value for the population. This difference will vary from sample to sample, so that one cannot state with certainty the magnitude of any error in the estimate caused by using a sample. However, one can state the likelihood or probability that the estimate falls within some specified range of the true value for the population.

Confidence information is typically given alongside the statistics resulting from sampling. *Confidence interval* is the likely range of the true value. *Confidence level* is the chance that the true value will be inside the confidence interval calculated. Confidence is often reported as paired percentages, such as 80/10, with an 80% confidence level and 10% confidence interval. The following is an example:

> A sample of small office buildings retrofitted with energy-efficient air conditioners indicated savings of 5,000 kWh per building per ozone season, +/- 500 kWh with a confidence level of 95%. In other words, the probability is 95% that the 5,000 kWh per building savings estimate falls within 500 kWh of the true average savings for the entire population. This means that if one drew 100 different independent samples, 95% of them would produce estimates within 500 kWh of the population average. This probability (95%) is referred to as the confidence level. The specified range (500 kWh) is the confidence interval. This confidence interval can be stated in absolute terms (±/- 500 kWh) or percentage terms (for example, ±/- 10%). By increasing the size of the sample used to produce the estimate, one can increase the reliability of the estimate (i.e., increase the confidence level and interval).

The reliability of a sample-based estimate can be computed only after the metered data have been gathered. Before collecting the data, one cannot state the level of reliability that a given sample size will yield. However, one can compute the sample size that is expected to be sufficient to achieve a specified reliability level. This is done by using projections of savings estimates and their variability in the sample size calculations. If the projections are too conservative, the estimate will exceed the reliability requirements. If these projections prove to be overly optimistic, then the reliability of the estimates will fall short of the requirements, requiring additional data collection to achieve the specified reliability level.

Another important aspect of sampling is the actual selection of the sample projects from a program. There are two general approaches for sample selection: probability and non-probability based sampling. With a probability-based sample approach, projects are selected randomly. This may be for the sample frame as a whole or samples selected for each subset of the sample frame. When the sample frame is small, a non-probability based sample is usually selected. This approach involves selecting projects on how representative they are of the population under consideration.

This guidance document is not a manual on sample design. However, some basic concepts have been presented that can help a state official understand the requirements of sample design. As with other aspects of M&V, a proper sampling plan requires a through understanding of the projects, the populations impacted, and the factors that determine the energy savings. In addition, a proper sample requires an experienced practitioner who understands the statistics associated with sample design.

6.3 LARGE-SCALE METER DATA ANALYSIS METHOD

Large-scale data analysis applies a variety of statistical methods to measured facility energy consumption meter data (almost always whole facility utility meter billing data) to estimate gross energy and demand impacts for a large energy efficiency program. Unlike the M&V whole facility analysis option (IPMVP Option C), the large-scale data analysis approach usually (a) involves analysis of a census of project sites, versus a sample and (b) does not involve on-site data collection for model calibration. However, on-site validation of measure installation is still recommended for a sample of projects.

Most analysis of meter data involves the use of comparison groups. In conducting assessments of the impacts of programs, evaluators have traditionally used ‘quasi-experimental design.’ Using this approach, the behavior of the participants is compared to that of a similar group of non-participants (comparison group). The purpose is to estimate “what would have happened in the absence of the program.” The two groups need to be similar on average. The only difference should be the fact that one went through an energy efficiency program and one did not. The observed change in consumption in the comparison can be assumed to resemble the change in consumption that would have been observed in the treated group had it not been through a program.

There are three basic ways that large-scale meter data analysis is employed for energy efficiency programs:

- Time series comparison - compares the program participants’ energy use before and after their projects are installed. With this method the “comparison group” is the participants’ pre consumption. Thus, this method has the advantage of not requiring a comparison group of non-participants. The disadvantages are that it cannot be used with new construction programs and even with well-established regression techniques, this approach cannot fully account for all changes in all the independent variables that might impact energy savings. The basic evaluation equations are:
    - Savings = $Q_{pre\text{-}insatllation} – Q_{post\text{-}installation}$.
    - $Q_{pre\text{-}insatllation}$ = quantity of energy used before the project was implemented, *corrected for independent variables*
    - $Q_{post\text{-}installation}$. = quantity of energy used after the project was implemented
- Use of Comparison Group - compares the program participants’ energy use after projects are installed with energy use of non-participants (i.e., they did not have projects installed). This method is used primarily for new construction programs, where there are no baseline

data. The difficulty with this approach is usually related to the cost of analyzing two groups and finding a comparison group with sufficiently similar characteristics as the group of participants. The basic evaluation equations are:

  - Savings = $Q_{non\text{-}particpants} - Q_{particiupants}$
  - $Q_{participants}$ = quantity of energy used by the participants after their projects are installed
  - $Q_{non\text{-}particpants}$ = quantity of energy used by the control group of non-participants, after the participants installed their projects

- Comparison Group/Time-Series- this approach combines the two above approaches and thus has the advantages of comparing similar if not identical groups to each other while accounting for efficiency savings that would have occurred irrespective of the program. If the participant and comparison group are available, it is a preferred approach. The basic evaluation equations are:
  - Savings = $(Q_{pre\text{-}insatllation} - Q_{post\text{-}installation})_{participants}$. - $(Q_{pre\text{-}insatllation} - Q_{post\text{-}installation})_{non\text{-}participants}$
  - $Q_{pre\text{-}insatllation}$ = quantity of energy used before the project was implemented
  - $Q_{post\text{-}installation}$. = quantity of energy used after the project was implemented

Chapter 7 Measurement and Verification for Renewable Energy Projects

This chapter introduces methods for determining savings from renewable energy projects and discusses some related issues. There are a variety of diverse technologies that convert renewable energy into electricity. Despite individual differences, each renewable technology supplies electricity and reduces the use of conventional sources. In contrast, energy efficiency projects reduce electricity consumption. The implication is that renewable energy project M&V is simpler than energy efficiency M&V. This is because, in most instances, M&V simply involves measuring the electrical output of the subject system to determine the quantity of electricity "saved".

The renewable energy projects covered in this chapter are the installation of devices or systems that displace fossil fuel-based electricity production through the use of renewable energy resources. Examples of renewable technologies include photovoltaics, biomass conversion systems (e.g., landfill gas methane recovery projects), and wind systems.

7.1 M&V APPROACHES AND OPTIONS

There are two general approaches for calculating electricity savings:

1. Direct Measurement. This approach assumes that the electricity produced by the renewable system displaces energy that would have been provided by an electric generating unit (EGU). With this one-for-one replacement approach, one only needs to directly measure the net amount of energy produced by the renewable system. This approach is most common with photovoltaic, wind, and biomass energy production projects (assuming there is no supplementary firing with fossil fuels at the biomass facility).
2. Net-Energy Use Calculation. With this approach, purchased electrical energy used at the project site during the reporting period is compared with a baseline to determine the savings in electricity purchases. When a baseline is adopted, there are four methods for calculating savings as defined in the 2003 IPMVP renewables protocol.[52]
   - Comparison with a Control Group. Electricity consumption of the renewable energy system is compared with the electricity consumption of a control group, with similar characteristics under similar conditions. The control group is used as the baseline.
   - Before and After Comparison. Electricity consumption of the renewable energy system is compared with the electricity consumption measured before the renewable system was installed for the same loads. The pre-installation situation is the baseline.
   - On and Off Comparison. Electricity consumption is compared with the renewable energy system "on" versus electricity consumption with the system "off." The baseline equals the situation with the system "off."
   - Calculated Reference Method. The baseline is determined with engineering calculations, and estimated electricity consumption is compared to metered energy use

[52] IPMVP, 2003

when the renewable energy system is in place. This approach has the weakness of using two different analyses methods (engineering estimates and metered data) to determine a difference, i.e. the savings.

These four methods usually require measurement of electricity consumption or supply over an extended period of time in order to capture the variation due to changing climatic conditions.

The four IPMVP Options (A, B, C and D) can also be used for renewable energy projects. Options A and B involve measurements of system performance and are the most common. Option A involves stipulation of some parameters while Option B requires maximum use of measurements in the energy savings analyses. Option C measures the change in whole facility electricity use, usually with utility metering data, associated with the installation of the renewable system. Option D involves the use of computer simulations, calibrated with actual data, to determine savings from a renewable system installation.

Table 7.1 indicates how each IPMVP Option relates to the "direct" and "net energy use calculation" M&V approaches.

Table 7.1 IPMVP Options and Approaches for Renewable Energy Projects

Approach/ IPMVP Option	**Option A** Partially Measured Retrofit Isolation	**Option B** Retrofit Isolation	**Option C** Whole Facility Analyses	**Option D** Calibrated Simulation
Direct Measurement Approach	X (1)	X (1)		
Net Energy Use Calculation Approach				
Comparison With Control Group Method	X	X	X	
Before and After Comparison Method	X	X	X	
On/Off Comparison Method	X	X		
Calculated Reference Method				X

(1) Preferred approaches

7.2 PROGRAMS VERSUS PROJECTS

As discussed in prior Chapters, a program is a collection of similar projects installed in similar applications. The M&V approaches for a renewable energy program may be different than the approaches used for individual projects, for which the direct measurement of output is the usual approach for determining savings. The mostly likely program scenarios under which direct metering of system output would not be used involve large numbers of renewable projects where direct measurement of each system is impractical. For example, if a developer implements a photovoltaic system in a large subdivision it would probably not be cost-effective to meter the output of each home's system. In applications where a large-scale program of small individual projects is applying for allowances, the use of sampling or the net-energy use calculation method would most likely apply. Techniques such as calibrated computer simulation (IPMVP Option D) or analysis of utility billing data (IPMVP Option C) are most appropriate in this context.

7.3 NET METERING OF ELECTRICAL OUTPUT AND FUEL USE

There are situations where the electrical output of the renewable system is *not* directly indicative of electricity savings – and the NO_x savings. These are when:

- The system consumes electricity in order to produce electricity. The consumption is associated with what is known as *parasitic loads*. For example, a solar thermal electric system consumes electricity to power pumps that circulate fluid through the system. In these situations either the parasitic loads have to be directly measured and subtracted from the measured output of the system, or a "net output" meter that accounts for parasitic loads is used.
- The system consumes a fuel that results in on-site NOx emissions. An example is a landfill gas generation system that uses natural gas as a supplemental fuel. In these situations, either (a) on-site fuel consumption measurements could be taken and emission factors applied to the fuel use, or (b) on-site emission levels can be measured. In both cases any NOx emissions calculated from the electricity production or savings of the renewable system must be reduced by emissions associated with on-site fuel use.

7.4 INFORMATION ON METERING

Electricity measurements associated with generator output, parasitic loads, power delivered to the project site, as well as power delivered to third parties and the utility may be needed. Electrical output and parasitic loads can be measured with many commercially available electricity meters. Often these are the same types of meters used by utilities for billing purposes. All electrical meters (and related equipment) are typically provided, installed, owned, and maintained by the project sponsor or the servicing utility. Metering, interconnection (including safety provisions), reporting and other related issues could be in accordance with current electrical standards and the requirements of the servicing electric utility.

With the direct measurement approach, meters could indicate the project's gross output (in kW and kWh) less parasitic use, e.g., pump motors. More sophisticated metering may also show sales to third parties or the local utility, as well as any battery storage losses. The goal is to measure net generation of useful electricity that is used at the project site, provided to the local distribution utility, or provided to other entities.

With the net energy-use approach, deliveries to and from the facility could be separately recorded and treated as separate transactions. Note that power may flow into (from the servicing distribution utility) or out (to the servicing distribution utility) of the site at different times. This means that the metering device could be capable of recording total inflows and outflows, rather than simply providing a net delivered value. For purposes of power delivered to the site, a single meter that records energy supply is preferred. If a calculated transformer-loss value is used, it must be based on certified factory test data for that particular transformer supplied by the manufacturer and acceptable to the state.

The following are some suggested metering requirements:

- kWh and demand metering at the point of delivery
- Time-of-delivery metering
- Conduit to accommodate a telephone line for remote meter reading
- Load profile recording equipment at the point of delivery, with data logger.

7.5 PROJECT SPECIFIC M&V PLAN – RENEWABLE ENERGY PROJECTS

M&V plans for renewable energy projects will need to be custom developed since individual projects are typically unique. The M&V plan could address the following elements:

- Describe the facility and the project; include information on how the project saves energy and what key variables affect the realization of savings. An accounting-type spreadsheet could be prepared that shows estimated baseline and projected performance period data for electricity and fuel purchases. Each of these values will need to be verified (baseline) or determined before and during the reporting period.
- Indicate who will conduct the M&V activities and prepare analyses and documentation.
- Define the details of how calculations will be made and the assumptions about significant variables or unknowns. The performance of most renewable energy projects varies as a function of environmental conditions, such as wind or solar radiation. The appropriate factors could be documented in the plan.
- Accuracy and precision requirements.
- Describe any stipulations that will be made, and the source of data for the stipulations. Describe any simulation software that may be used. Show how calculations of savings will be used to determine emission reductions.
- Specify what metering and data logging equipment will be used, who will provide the equipment, its accuracy and calibration procedures, and how data from the metering will be validated and reported, including formats. Electronic formatted data directly from a meter or data logger is usually required.
- Specify what additional management oversight logs will be maintained, the nature and frequency of entries, and the interpretation that is to be assigned to the results. Examples include logging equipment failures, equipment down time, and system outputs.
- Indicate how quality assurance will be maintained and repeatability confirmed.
- Indicate which reports will be prepared, what they will contain, and when they will be provided.

Chapter 8 Determining Emissions Allocation Rates and Potential Emissions Reductions From Electricity Savings[53]

8.1 INTRODUCTION

When a state establishes an Energy Efficiency and Renewable Energy (EE/RE) Set-Aside Program, a percentage of the state's total quantity of allowances is reserved for qualifying EE/RE resources. These allowances are then allocated by the state to EE/RE projects on the basis of energy savings (expressed in kWh) and an emissions allocation rate, typically specified in pounds per kWh. This emissions allocation rate is determined by the state, and can be set at any level deemed appropriate by state officials. States may choose a conservative allocation rate or a high allocation rate, i.e. an "incentive rate," if they believe it will encourage additional EE/RE projects. Another option is to adopt an allowance allocation rate based on the estimated rate at which EE/RE projects displace pollution from electric generating units (EGUs). This Chapter presents several methods for calculating this "displaced emissions rate".

In addition to serving as the basis for allocating allowances to EE/RE projects, displaced emissions rates can be used to approximate emissions reductions from conventional electricity sources. The impact on air emissions varies depending on the conventional generation sources displaced as well as the prevailing policy context. *Regardless of the emissions rate selected, the only way to ensure emissions reductions, within a cap and trade program, is to retire allowances.* Retiring allowances effectively removes them from circulation so that they cannot be traded and used to authorize emissions. This is particularly important for states seeking to incorporate emissions reductions from EE/RE resources into their SIP for air quality.

8.2 OPTIONS FOR ESTABLISHING AN EMISSIONS ALLOCATION RATE

As indicated above, states under the NO_x Set-Aside Program can allocate allowances at any emissions rate deemed appropriate. This choice depends on the extent to which states wish to incentivize EE/RE resources, and whether consistency with the displaced emissions rate for EE/RE resources is desired. Sources and methods for a lbs/kWh allocation rate are:

1. The EPA default allocation factor as indicated in the NO_x SIP Call: 0.0015 lbs/kWh [54]
2. A simple "system average" displaced emissions rate obtained from an emissions database such as eGRID
3. Detailed time and geographic zone specific displaced emissions rates calculated with an *Hourly Dispatch Model*

---

[53] Portions of this section are from the reports - *Methods for Estimating Emissions Avoided by Renewable Energy and Energy Efficiency* (Keith and Biewald, 2005) and *Final Report on the Clean Energy/Air Quality Integration Initiative Pilot Project of the U.S. Department of Energy's Mid-Atlantic Regional Office* (Jacobson, et al., 2006). The second report publicizes the results of a pilot project that attempts to use renewable energy and energy efficiency projects to obtain credits nitrogen oxide (NO_x) emission reductions under the Clean Air Act.

[54] This allocation rate is equivalent to the design emission rate of the NO_X SIP Call cap and trade program, 0.15lb NO_x/MMBtu of heat input for a 10,000 Btu/kWh EGU.

4. Displaced emissions rates calculated using a “middle ground” calculation method such as:
    - Estimating Regional or State Average Emission Rates for Marginal EGUs
    - Matching Capacity Curves to Load Curves
    - Using Default “New Plant” Emission Rate

Methods 2 through 4 are discussed in Section 8.4.

8.3 CALCULATING EMISSIONS REDUCTIONS

Calculating emissions reductions from EE/RE involves multiplying the quantity of energy saved from energy efficiency measures – or energy generated from renewable sources – by the mass of pollution displaced for each unit of electricity saved or generated (e.g., lbs/kWh). If allowances are retired, the total ozone season emissions reductions can be estimated using the following equation:

Ozone Season NO_x Savings (tons/ozone season) =

Displaced Emissions Factor (lbs/kWh) x Ozone Season kWh Savings x (1 ton/2000 lbs)

This equation takes the energy savings or renewable energy generation determined through the evaluation, measurement, and verification processes described in prior Chapters and multiplies it by an emissions rate.

To achieve actual emissions reductions under a cap and trade program, allowances allocated to EE/RE resources must be retired. When this occurs, one allowance removed from the system results in one ton of pollution reduction. By setting the emissions allocation rate equivalent to the displaced emissions rate, states can ensure that EE/RE resources receive allowances in proportion to the emissions reductions that would occur in the absence of a cap and trade program – that is the quantity of allowances available for retirement resembles the amount of avoided pollution.

8.4 METHODS FOR CALCULATING DISPLACED EMISSIONS RATES

The methods for determining displaced emissions rates range from fairly straightforward to highly complex. They include both spreadsheet-based calculations and dynamic modeling approaches with varying degrees of transparency, rigor, and cost. States could decide which method best meets their needs, given available resources and data quality requirements.

8.4.1 System Average Emissions Rate

One simple approach for calculating emissions reductions from EE/RE resources is to use regional or system average displaced emission rates. Determining a system average rate involves dividing total annual emissions (typically in pounds, or lbs) from all units in a region or power system by the total energy output (typically in megawatt hours, or MWh) of those units. Sources for average emissions rates include the Ozone Transport Commission’s “OTC Workbook”,[55] the Clean Air-Climate Protection Software (CACPS),[56] and EPA’s eGRID database[57]. Each of these tools contains pre-calculated emissions rates averaged at the utility, state, and regional levels. While easy to apply, a

---

[55] Keith, et al., 2003
[56] ICLEI, 2003
[57] U.S. EPA, 2007

shortcoming of this method is that it does not account for the complexity of regional power systems and the fact that some units (such as base load units) are unlikely to be displaced by EE/RE resources.

8.4.2 Dispatch Models

At the other end of the complexity spectrum, computer-based "hourly dispatch models" capture a high level of detail on the specific electric generating units (EGU) displaced by EE/RE projects or programs. An hourly dispatch model involves simulating hourly power dispatch to explicitly estimate emissions from each unit in a system. In general, the model produces a deterministic, least-cost system dispatch based on a highly detailed representation of generating units – including some representation of transmission constraints, forced outages, and energy transfers among different regions – in the area of interest. If the power system is altered through load reduction or the introduction of an EE/RE project, the model calculates how this would affect dispatch and then calculates resulting emissions and prices. With dispatch models, a year's worth of data are generally modeled on a chronological (hourly) basis, with and without the new resource. This approach is generally considered the most rigorous means of quantifying displaced emissions rates. On the downside, it is labor intensive, expensive, and generally difficult for non-experts to evaluate.

8.4.3 Medium Effort Calculation Approaches

In between system average calculations and dispatch modeling, lie several "middle effort" approaches to estimating displaced emission rates. These methods have been developed by analysts to provide a reasonably accurate estimate of displaced emissions at a lower cost than dispatch modeling. They typically use spreadsheets and publicly available data to identify the marginal generating units supplying power at the time EE/RE resources are reducing consumption or the renewable generators are providing electricity. The two major steps in a spreadsheet-based analysis are determining the relevant set of generating units (accounting for the location of the EE/RE resource, as well as transfers between the geographic region of interest an other power areas) and estimating the displaced emissions from those units. These approaches consider whether a specific project's impact on the electricity grid is on currently operating EGUs (the "operating margin") or on longer-term EGU capacity additions and retirements (the "build margin").

The following "middle-ground" approaches can be used by states to estimate displaced emissions from activities such as efficiency and renewable energy projects:

Estimating Regional or State Average Emission Rates for <u>Marginal</u> EGUs. This approach assumes that total emissions are reduced at an average emission rate for each additional kWh of emissions-free renewable energy or energy reduction. In order to provide more precise estimates of the impact on the marginal EGUs that are most likely to be displaced, regional or state average rates are adopted that exclude the baseload EGUs not "backed off" by EE/RE projects system (baseload units typically include nuclear, hydro-electric, and some coal plants). The downside of this approach is that it does not capture the subset of EGUs actually following load and thus subject to displacement. These units could have significantly different emission rates than the overall regional average. This approach was adopted in a 2006 analysis of New Jersey's Clean Energy Program – see Appendix for resources.

Matching Capacity Curves to Load Curves. Generating units are typically dispatched in a predictable order based on cost and other operational characteristics. This means it is possible in principle to predict which unit types will be "on the margin" at a given load level, and therefore what the marginal emission rate is. Data on regional power plants may be used to develop supply curves representing different seasons and times of day. These curves are then used to match regional electricity loads to characteristic emission rates. Although this method uses readily available public data, it is based on a simplified view of dispatch process that does not account for transmission congestion.

Using Default "New Plant" Emission Rate. This simple approach estimates avoided emissions over the long term by adopting the emission rate of the generating unit most likely to be added to the system, i.e. the "build margin" or "surrogate plant" analysis. It is based on the concept that the new EE/RE resource displaces other potential market entrants. In recent years, estimates have used emission rates from a gas-fired, combined-cycle power plant, as most of the newer plants adopt this technology. However, with gas prices increasing and limited pipeline capacity making new gas plants less feasible, advanced-technology coal plants are looking more attractive. Such changes in market conditions could be tracked and accounted for in this "new plant" approach.

Appendix: References and Useful Information Sources

A.1 EPA AND STATE NO_X SIP CALL RELATED DOCUMENTS

Title/Description	URL Address
EPA NO_x Set-Aside Documents	
U.S. EPA. 1999. Guidance on Establishing an Energy Efficiency and Renewable Energy (EE/RE) Set-Aside in the NO_x Budget Trading Program, Volume 1.	http://www.epa.gov/cleanenergy/pdf/ee-re_set-asides_vol1.pdf
U.S. EPA. 2000. Guidance on Establishing an Energy Efficiency and Renewable Energy (EE/RE) Set-Aside in the NO_x Budget Trading Program, Volume 2.	http://www.epa.gov/cleanenergy/pdf/ee-re_set-asides_vol2.pdf
U.S. EPA. 2004a. Guidance on State Implementation Plan (SIP) Credits for Emission Reductions from Electric-sector Energy Efficiency and Renewable Energy Measures.	http://www.epa.gov/ttn/oarpg/t1/memoranda/ereseerem_gd.pdf
U.S. EPA. 2004b. Incorporating Emerging and Voluntary Measures in a State Implementation Plan (SIP).	http://www.epa.gov/ttn/oarpg/t1/memoranda/evm_ievm_g.pdf
U.S. EPA. 2004c. Integrating Energy Efficiency and Renewable Energy Measures in the Air Quality Planning Process Guidance for State and Local Officials. Fact Sheet.	http://www.epa.gov/cleanenergy/pdf/SIPS-factsht-final_nodraftmark.pdf
U.S. EPA. 2005a. A Toolkit for States: Using Supplemental Environmental Projects (SEPs) to Promote Energy Efficiency (EE) and Renewable Energy (RE).	http://www.epa.gov/cleanenergy/pdf/sep_toolkit.pdf
U.S. EPA. 2005b. State Set-Aside Programs for Energy Efficiency and Renewable Energy Projects Under the NO_x Budget Trading Program: A Review of Programs in Indiana, Maryland, Massachusetts, Missouri, New Jersey, New York, and Ohio. Draft Report.	http://www.epa.gov/cleanenergy/pdf/eere_rpt.pdf
U.S. EPA. 2006. Clean Energy-Environment Guide to Action: Policies, Best Practices, and Action Steps for States.	http://www.epa.gov/cleanenergy/stateandlocal/guidetoaction.htm
Other EPA and State NO_x SIP Call Related Documents	
Hathaway, A., D. Jacobson, and C. High. 2005. Model State Implementation Plan (SIP) Documentation for Wind Energy Purchase in States with Renewable Energy Set-Aside. NREL/SR-500-38075. National Renewable Energy Laboratory.	http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/wpa/sips_model.pdf
High, C. J. and K. M. Hathaway. 2007. Avoided Air Emissions from Energy Efficiency and Renewable Electric Power Generation in the PJM Interconnection Power Market Area. Draft. Resource Systems Group,	

Inc. Supported by funding from the U.S. Department of Energy, Clean Energy/Air Quality Integration Initiative.	
Indiana. 2003. NOx Budget Trading Program Energy Efficiency & Renewable Energy Set-Aside Guidance Manual. Department of Environmental Management and Department of Commerce.	http://www.in.gov/idem/programs/air/sip/guide.pdf
Jacobson, D., et al. 2006. Final Report on the Clean Energy/Air Quality Integration Initiative Pilot Project of the U.S. Department of Energy's Mid-Atlantic Regional Office. Prepared for U.S. DOE, DOE/GO-102006-2354.	http://www.eere.energy.gov/wip/clean_energy_initiative.html
Massachusetts. 2006. BWP AQ26 Public Benefit Set Aside NO_x Allowance. Department of Environmental Protection.	http://www.mass.gov/dep/air/approvals/aq26.pdf
Missouri. Energy Efficiency and Renewable Energy Set-Aside Program Web site. Department of Natural Resources.	http://www.dnr.mo.gov/energy/renewables/set-asideprogram.htm
New York. 1998. NOX Budget State Implementation Plan. Department of Environmental Conservation.	http://www.dec.state.ny.us/website/dar/reports/noxbudget.html
U.S. EPA. 2005. Guidance on Incorporating Bundled Measures in a State Implementation Plan.	http://www.epa.gov/ttn/oarpg/t1/memoranda/10885guideibminsip.pdf

A.2 PROJECT M&V GUIDELINES

Title/Description	URL Address
ASHRAE. 2002. Guideline 14-2002: Measurement of Energy and Demand Savings.	www.ashrae.com
California. 2000. Non-Residential Standard Performance Contract Program Procedures Manual. Section III: Measurement and Verification Guidelines.	http://www.pge.com/docs/pdfs/biz/rebates/spc_contracts/2000_on_peak_incentive/III-m&v.pdf
ENERGY STAR. 2007. Portfolio Manager Overview Web site.	http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager
IPMVP. 2002. Concepts and Options for Determining Energy and Water Savings, Volume I, Revised. DOE/GO-102002-1554.	www.evo-world.org
IPMVP. 2003. Concepts and Practices for Determining Energy Savings in Renewable Energy Technologies Applications, Volume III.	www.evo-world.org
IPMVP. 2006. Concepts and Options for Determining Energy Savings in New Construction, Volume III, Part 1.	www.evo-world.org
NYSERDA. 2003. New York State Energy Research and Development Authority (NYSERDA) Standard Performance Contracting Program Measurement and Verification Guideline.	http://www.nyserda.org/programs/Commercial_Industrial/cipp.asp?i=PON
Oncor. 2003 Measurement and Verification Guidelines.	http://www.oncorgroup.com/electricity/teem/default.asp
U.S. DOE. 2000. FEMP M&V Requirements Checklist. Draft.	http://ateam.lbl.gov/mv/docs/checklist.pdf
U.S. DOE. 2000. Measurement and Verification for Federal Energy Projects, Version 2.2. DOE/GO-102000-0960.	http://ateam.lbl.gov/mv/docs/26265.pdf
U.S. DOE. 2002. Detailed Guidelines for FEMP M&V Option A.	http://ateam.lbl.gov/mv/docs/OptionADetailedGuidelines.pdf
U.S. DOE. 2003. Measurement & Verification Resources and Training Opportunities, Revision 5.	http://ateam.lbl.gov/mv/docs/OptionADetailedGuidelines.pdf
Texas. 2007. Texas A&M System Energy Systems Laboratory Web site.	http://esl.eslwin.tamu.edu/resources/software.html
Texas SECO. 2007. LoanSTAR Technical Guidelines Web site.	http://www.seco.cpa.state.tx.us/ls_guideline.htm

A.3 PROGRAM EVALUATION RESOURCES

Title/Description	URL Address
California Measurement Advisory Council. 2007. CALifornia Measurement Advisory Council (CALMAC) Database Web site.	http://www.calmac.org
California Public Utilities Commission. 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.	http://www.calmac.org/events/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf
Consortium for Energy Efficiency. 2007. Market Assessment and Program Evaluation (MAPE) Clearinghouse.	http://www.cee1.org/eval/clearinghouse.php3
Haberl, J., et al. 2003. Procedures for Calculation of NO_x Emissions Reductions from Implementation of the 2000 IECC/IRC Conservation Code in Texas. Proceedings of the 2003 IBPSA Conference, Eindhoven, Netherlands.	http://www.ibpsa.org/proceedings/BS2003/BS03_0443_450.pdf
Hirst, E. and J. Reed, eds. 1991. Handbook of Evaluation of Utility DSM Programs. ORNL/CON-336.	
Princeton University. 2007. PRInceton Scorekeeping Method (PRISM) Web site.	http://www.princeton.edu/~marean/
U.S. EPA. 1995. Conservation Verification Protocols, Version 2.0. EPA 430/B-95-012.	
Violette, D., M. Ozog, M. Keneipp, and F. Stern. 1991. Impact Evaluation of Demand-Side Management Programs, Volume I and II: A Guide to Current Practice. EPRI CU-7179. Electric Power Research Institute	

A.4 EMISSION REDUCTION CALCULATION RESOURCES

Title/Description	URL Address
Biewald, B. and G. Keith. 2004. Estimating Emission Reductions from Energy Efficiency in the Northeast. Synapse Energy Economics, ACEEE, Asilomar.	http://www.synapse-energy.com/Downloads/SynapsePresentation.2004-08.Emission-Reductions-from-Efficiency-in-Northeast.pdf
ICLEI. 2003. The Cities for Climate Protection Greenhouse Gas Emissions Software.	http://www.cacpsoftware.org/
Keith, G. and B. Biewald. 2005. Methods for Estimating Emissions Avoided by Renewable Energy and Energy Efficiency. Final Draft. Synapse Energy Economics Prepared for U.S. EPA. NREL/TR710-37721.	http://www.synapse-energy.com/Downloads/SynapseReport.2005-07.PQA-EPA.Displaced-Emissions-Renewables-and-Efficiency-EPA.04-55.pdf
Keith, G., D. White, and M. Ramiro. 2003. The OTC Emission Reduction Workbook 2.1: Description and User's Manual. Synapse Energy Economics.	http://www.cec.org/pubs_docs/documents/index.cfm?varlan=english&ID=1240
Marnay, C., D. Fisher, S. Murtishaw, A. Phadke, L. Price, and J. Sathaye. 2002. Estimating Carbon Dioxide Emissions Factors for the California Electric Power Sector. LBNL 49945. Lawrence Berkeley National Laboratory.	http://ies.lbl.gov/iespubs/49945.pdf
Jacobson, D., et al. 2006. Final Report on the Clean Energy/Air Quality Integration Initiative Pilot Project of the U.S. Department of Energy's Mid-Atlantic Regional Office. Prepared for U.S. DOE, DOE/GO-102006-2354.	http://www.eere.energy.gov/wip/clean_energy_initiative.html
U.S. EPA. 2007a. Clean Air Markets Allowance Trading Web site.	http://www.epa.gov/airmarkets/trading/
U.S. EPA. 2007b. Clean Air Markets Cap and Trade Web site.	http://www.epa.gov/airmarkets/capandtrade/
U.S. EPA. 2007c. eGRID Web site.	http://www.epa.gov/cleanenergy/egrid.htm#about

A.5 TRANSMISSION AND DISTRIBUTION LOSS RESOURCE

Title/Description	URL Address
Western Area Power Administration. 1988. Distribution System Loss Evaluation Manual.	http://www.wapa.gov/es/pubs/topic.htm#td

A.6 RESOURCES RELATING TO M&V AND EMISSIONS REDUCTION DOCUMENTATION

Title/Description	URL Address
American Petroleum Institute. 2003a. Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry.	http://www.api.org/ehs/climate/new/upload/2004_COMPENDIUM.pdf
American Petroleum Institute. 2003b. SANGEA™ Energy and Emissions Estimating System 2.0 Web site.	http://ghg.api.org/
Hall, D., et al. 1995. Air Pollution Impacts from Demand Side Management. *Energy* 20: Number 1: 27-33.	
Kline, D. and L. Vimmerstedt. 2003. Alternatives for Evaluating the Emissions Impacts of Energy Efficiency and Renewable Energy (EERE) Measures. Draft. National Renewable Energy Laboratory.	
Lazarus, M., S. Kartha, and S. Bernow. 2001. Project Baselines and Boundaries for Project-Based GHG Emission Reduction Trading: A Report to the Greenhouse Gas Emission Trading Pilot Program. Tellus Institute.	http://www.ghgprotocol.org/DocRoot/GCudX4J3KLBrGLxcE5NT/GERT_Tellus_BB_report.pdf
Ontario Ministry of the Environment. 2005. Emission Reduction Credit creation, recording and transfer rules, rules for renewable energy projects and conservation projects, and rules for the operation of the Ontario Emissions Trading Registry. Ontario Emissions Trading Code.	http://www.ene.gov.on.ca/programs/5295e.pdf
Prototype Carbon Fund. 2000. Baseline Methodologies for PCF Projects, PCF Implementation Note Number 3, Version of April 21, 2000. Prepared for Carbon Offsets Unit, Environment Department, World Bank.	http://carbonfinance.org/Router.cfm?Page=DocLib&CatalogID=5623&zrzs=1
Schiller, S. 2006. Energy Efficiency as a Climate Change Mitigation Strategy. Prepared for ACEEE Summer Study.	http://www.schiller.com/images/schiller_EE_GHG_ACEEE.pdf
Turner, W. C. and S. Doty. 2006. Energy Management Handbook, Sixth Edition. Fairmont Press.	
UNFCCC-CDM. 2005. Simplified Modalities and Procedures for Small-Scale CDM Project Activities. Clean Development Mechanism Methodologies Panel.	http://cdm.unfccc.int/Reference/COPMOP/08a01.pdf#page=43
UNFCCC-CDM. 2006a. Approved methodology ACM0002: Consolidated methodology for grid-connected electricity generation from renewable sources.	http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_BW759ID58ST5YEEV6WUCN5744MN763
UNFCCC-CDM. 2006b. Procedures for the Submission and Consideration of a Proposed New Methodology (Version 11). Clean Development Mechanism Methodologies Panel.	http://cdm.unfccc.int/EB/025/eb25_repan17.pdf

UNFCCC-CDM. 2007. United Nations Framework Convention on Climate Change - Clean Development Mechanism Web site.	http://cdm.unfccc.int
Vine, E. and J. Sathaye. 1999. Guidelines for the Monitoring, Evaluation, Reporting, Verification, and Certification of Energy-Efficiency Projects for Climate Change Mitigation. LBNL-41543. Lawrence Berkeley National Laboratory.	http://ies.lbl.gov/iespubs/41877.pdf
Vine, E., et al. 2003. International Greenhouse Gas Trading Programs: A Discussion of Measurement and Accounting Issues. *Energy Policy* 31: 211–224.	
Violette, D. 1998. Evaluating Greenhouse Gas Mitigation through DSM Projects: Lessons Learned from DSM Evaluation in the United States. Prepared for Carbon Offsets Unit, Environment Department, World Bank.	
Violette, D., C. Mudd, and M. Keneipp. 2000. An Initial View on Methodologies for Emission Baseline- Case Study on Energy Efficiency. Prepared for the International Energy Agency and the Organisation for Economic Co-operation and Development.	http://www.iea.org/textbase/papers/2000/eneff.pdf
WRI and WBCSD. 2003. The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard.	http://www.ghgprotocol.org/DocRoot/7e9ttsv1gVKekh7BFhqo/ghg-protocol-revised.pdf
WRI and WBCSD. 2005 GHG Protocol For Project Accounting Web site.	http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=OTAy&doOpen=1&ClickMenu=No
WRI and WBCSD. 2005b. Measurement and Estimation Uncertainty for GHG Emissions.	http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=OTAx&doOpen=1&ClickMenu=No

A.7 GENERAL ENERGY EFFICIENCY AND RENEWABLE ENERGY RESOURCES

Title/Description	URL Address
American Council for an Energy-Efficient Economy	http://www.aceee.org
Consortium for Energy Efficiency	http://www.cee1.org/
Department of Energy Efficiency and Renewable Energy	http://www.eere.energy.gov/
Best Practices Benchmarking for Energy Efficiency Programs	http://www.eebestpractices.com/
Environmental Protection Agency & Department of Energy	
ENERGY STAR	http://www.energystar.gov/
ENERGY STAR Portfolio Manager	http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager
Clean Energy Programs	http://www.epa.gov/cleanenergy/index.htm
National Laboratories Energy Efficiency and Renewable Energy Programs	
Lawrence Berkeley National Laboratory	http://eetd.lbl.gov/
National Renewable Energy Laboratory	http://www.nrel.gov/
Oak Ridge National Laboratory	http://www.ornl.gov/sci/eere/

A.8 REFERENCES

Title/Description	URL Address
ASHRAE. 2002. Guideline 14-2002: Measurement of Energy and Demand Savings.	
California. 2000. Non-Residential Standard Performance Contract Program Procedures Manual. Section III: Measurement and Verification Guidelines.	http://www.pge.com/docs/pdfs/biz/rebates/spc_contracts/2000_on_peak_incentive/III-m&v.pdf
California Measurement Advisory Council. 2007. CALifornia Measurement Advisory Council (CALMAC) Database Web site.	http://www.calmac.org
California Public Utilities Commission. 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.	http://www.calmac.org/events/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf
California PUC – Database for Energy Efficient Resources (DEER)	http://eega.cpuc.ca.gov/deer/
Consortium for Energy Efficiency. 2007. Market Assessment and Program Evaluation (MAPE) Clearinghouse.	http://www.cee1.org/eval/clearinghouse.php3
EVO. 2007. International Performance Measurement and Verification Protocol Web site.	http://www.evo-world.org/index.php?option=com_content&task=view&id=61&Itemid=80
ENERGY STAR. 2007. Portfolio Manager Overview Web site.	http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager
F-Chart. 2005. F-Chart Software Web site.	http://www.fchart.com/
Hawaii. 1998. Guide to Energy Performance Contracting. Department of Business, Economic Development, and Tourism.	http://www.hawaii.gov/dbedt/info/energy/efficiency/state/performance/epc.pdf
ICLEI. 2003. The Cities for Climate Protection Greenhouse Gas Emissions Software.	http://www.cacpsoftware.org/
Inter-laboratory Working Group. 2000. Scenarios for a Clean Energy	http://www.ornl.gov/sci/ee

Future. Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. ORNL/CON-476 and LBNL-44029.	re/cef/
IPMVP. 2002. Concepts and Options for Determining Energy and Water Savings, Volume I, Revised. DOE/GO-102002-1554.	http://www.nrel.gov/docs/fy02osti/31505.pdf
IPMVP. 2003. Concepts and Practices for Determining Energy Savings in Renewable Energy Technologies Applications, Volume III.	
IPMVP. 2006. Concepts and Options for Determining Energy Savings in New Construction, Volume III, Part 1.	
ISO-NE. 2007. ISO – New England Web site.	http://www.iso-ne.com
Jacobson, D., et al. 2006. Final Report on the Clean Energy/Air Quality Integration Initiative Pilot Project of the U.S. Department of Energy's Mid-Atlantic Regional Office. Prepared for U.S. DOE, DOE/GO-102006-2354.	http://www.eere.energy.gov/wip/clean_energy_initiative.html
Keith, G. and B. Biewald. 2005. Methods for Estimating Emissions Avoided by Renewable Energy and Energy Efficiency, Final Draft. Synapse Energy Economics. Prepared for U.S. EPA. NREL/TR710-37721.	http://www.synapse-energy.com/Downloads/SynapseReport.2005-07.PQA-EPA.Displaced-Emissions-Renewables-and-Efficiency-EPA.04-55.pdf
Keith, G., D. White, and M. Ramiro. 2003. The OTC Emission Reduction Workbook 2.1: Description and User's Manual. Synapse Energy Economics.	http://www.cec.org/pubs_docs/documents/index.cfm?varlan=english&ID=1240
NYSERDA. 2003. New York State Energy Research and Development Authority (NYSERDA) Standard Performance Contracting Program Measurement and Verification Guideline.	http://www.nyserda.org/programs/Commercial_Industrial/cipp.asp?i=PON
Oncor. 2003. Measurement and Verification Guidelines.	http://www.oncorgroup.com/electricity/teem/default.asp
Texas SECO. 2007. LoanSTAR Technical Guidelines Web site.	http://www.seco.cpa.state.tx.us/ls_guideline.htm
U.S. DOE. 2000a. FEMP M&V Requirements Checklist. Draft.	http://ateam.lbl.gov/mv/docs/checklist.pdf
U.S. DOE. 2000b. Measurement and Verification for Federal Energy Projects, Version 2.2. DOE/GO-102000-0960.	http://ateam.lbl.gov/mv/docs/26265.pdf
U.S. DOE. 2002. Detailed Guidelines for FEMP M&V Option A.	http://ateam.lbl.gov/mv/docs/OptionADetailedGuidelines.pdf
U.S. DOE. 2003. Measurement & Verification Resources and Training Opportunities, Revision 5.	http://ateam.lbl.gov/mv/docs/OptionADetailedGuidel

	ines.pdf
U.S. DOE. 2007. DOE-2.1E Software Web site.	http://simulationresearch.lbl.gov/
U.S. EPA. 1995. Conservation Verification Protocols, Version 2.0. EPA 430/B-95-012.	
U.S. EPA. 1999. Guidance on Establishing an Energy Efficiency and Renewable Energy (EE/RE) Set-Aside in the NO_x Budget Trading Program, Volume 1.	http://www.epa.gov/cleanenergy/pdf/ee-re_set-asides_vol1.pdf
U.S. EPA. 2004. Guidance on State Implementation Plan (SIP) Credits for Emission Reductions from Electric-sector Energy Efficiency and Renewable Energy Measures.	http://www.epa.gov/ttn/oarpg/t1/memoranda/ereseerem_gd.pdf
U.S. EPA. 2005. State Set-Aside Programs for Energy Efficiency and Renewable Energy Projects Under the NO_x Budget Trading Program: A Review of Programs in Indiana, Maryland, Massachusetts, Missouri, New Jersey, New York, and Ohio. Draft Report.	http://www.epa.gov/cleanenergy/pdf/eere_rpt.pdf
U.S. EPA. 2007. eGRID Web site.	http://www.epa.gov/cleanenergy/egrid.htm#about
Vine, E. and J. Sathaye. 1999. Guidelines for the Monitoring, Evaluation, Reporting, Verification, and Certification of Energy-Efficiency Projects for Climate Change Mitigation. LBNL-41543. Lawrence Berkeley National Laboratory.	http://ies.lbl.gov/iespubs/41877.pdf
WRI and WBCSD. 2005a. GHG Protocol For Project Accounting Web site.	http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=OTAy&doOpen=1&ClickMenu=No
WRI and WBCSD. 2005b. Measurement and Estimation Uncertainty for GHG Emissions.	http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=OTAx&doOpen=1&ClickMenu=No