*** NOTICE ***

The following material is a working draft. As such, this material has no legal force or effect, meaning it does not have binding effect on the obligations of any party. EPA is releasing this draft material in the interest of disclosure and information sharing. Because this material is in draft, a state could not rely on it as meeting Clean Power Plan (CPP) or any other legal or regulatory requirements. This document remains under development and is subject to further change and finalization at a later time.

EPA is providing the draft of this document, the drafts of the CPP Model Rules, and the drafts of other associated technical support materials for informational purposes only. EPA withdrew the Model Rules and accompanying documents from OMB review before the review was completed. The Administrator has not signed the Model Rules. With respect to the Model Rules, EPA has not completed several of the steps necessary to conclude a rulemaking action under CAA section 307. The agency has not completed the responses to comments and has not completed the docketing process for supporting materials at this time as would be required under CAA section 307(d)(6) for a final rule. The docket will remain open, with the potential for finalizing the Model Rules at a later date. These materials are not being published in the *Federal Register* or the *Code of Federal Regulations* and are not subject to judicial review. *See* CAA section 307(b)(1).

While this is a deliberative document that EPA is not required to release, for the reasons discussed in the Cover Memorandum accompanying the Draft Model Trading Rule Preamble and Regulatory Text, the agency is providing the public with its work to date on these topics. This is in keeping with the agency's general ability to share deliberative material with the public at its discretion in appropriate circumstances.

Draft EM&V Guidance for Demand-Side Energy Efficiency

Table of Contents

This is a draft document and does not reflect any final or official agency statement to implement, interpret, or prescribe law or policy. It does not affect the rights or obligations of any party

Acronyms and Abbreviations

ACEEE – American Council for an Energy-Efficient Economy
AMI – advanced metering infrastructure
ANSI – American National Standards Institute
ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers
C&S – building energy code and equipment energy standard
CEIP – Clean Energy Incentive Program
CHP – combined heat and power
CO_2 – carbon dioxide
CPP – Clean Power Plan
CPB – Common Practice Baseline
CVR – conservation voltage reduction
DOE – (United States) Department of Energy
EE – energy efficiency
EERS – energy efficiency resource standard
EIA – (United States) Energy Information Administration
EGU – electricity generating unit
ERC – emission rate credit
ERC-TCS – ERC Tracking and Compliance System
ESCO – energy services company
EM&V – evaluation, measurement, and verification
EPA – (United States) Environmental Protection Agency
EUL – effective useful life
FCM – forward capacity market
FEMP – (U.S. Department of Energy) Federal Energy Management Program
HVAC – heating, ventilating, and air-conditioning
IOU – investor-owned utilities
IPMVP – International Performance Measurement and Verification Protocol
ISO – independent system operator
ISO-NE – ISO New England
LBNL - Lawrence Berkeley National Laboratory
LEAS - lifetime equivalent annual savings
LED – light emitting diode
M&V – measurement and verification
MW – megawatt
MWh – megawatt-hour
NEEP – Northeast Energy Efficiency Partnerships
NGO – non-governmental organization
NREL – National Renewable Energy Laboratory
O&M – operations and maintenance
PUC – public utilities commission
RCT – randomized control trial
RTF – (Northwest Power and Conservation Council Northwest) Regional Technical Forum
RE – renewable energy
RMR – rate-based model rule
RUL – remaining useful life
SEE Action – State and Local Energy Efficiency Action Network
T&D – transmission and distribution (system)
TRM – technical reference manual
UMP – (United States Department of Energy) Uniform Methods Project

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1. Introduction

The Clean Power Plan (CPP) establishes CO_2 emission performance rates for affected electric generating units (EGUs) as well as equivalent rate-based and mass-based state CO_2 emission goals. Under the CPP, states must submit an approvable plan to the EPA that establishes CO_2 emission standards for affected EGUs in the state. These emission standards must assure achievement of either the CO_2 emission performance rates or the applicable state CO_2 emission goal. A state may submit a plan that applies either rate-based or mass-based emission standards, and a plan may include an emission trading program.

Regardless of the state plan type, demand-side energy efficiency (EE) can reduce power-sector CO_2 emissions and help affected EGUs achieve the applicable emission standards. The EE policies and approaches already adopted by states, municipalities, and companies across the country may provide a head start in helping EGUs comply with the CPP under both rate-based and mass-based state plans.

For states choosing to adopt a plan type that establishes rate-based emission standards for affected EGUs (expressed as an emission rate in pounds of CO_2 per megawatt-hour (MWh) of electricity), demand-side EE may be included in the plan as an "eligible resource" that can be issued "emission rate credits" (ERCs). ERCs may then be used by an affected EGU for the purpose of complying with its rate-based CO_2 emission standard. For rate-based state plans that include demand-side EE as an eligible resource, a key component of the plan is a set of requirements for evaluation, measurement, and verification (EM&V) of EE savings that is consistent with the CPP.[1]

The EPA is providing this *Draft EM&V Guidance for Demand-Side Energy Efficiency* (*Draft Guidance*) as a supplemental technical resource to help states, EE providers, and the private firms that providers hire—e.g., EE evaluators and independent verifiers—successfully implement EM&V that is consistent with the provisions in the Rate-Based Model Rule (RMR).[2] The scope of the *Draft Guidance* is limited to EM&V for demand-side EE. It applies to EE projects and EE measures, including those implemented in an EE program, that are submitted by an EE provider that seeks issuance of ERCs by a state. The *Draft Guidance* is intended to support all types of EE providers, including investor-owned utilities (IOU), public utilities, private companies such as an energy service company (ESCO), and the owners and operators of large commercial or industrial facilities. It applies to EE activities installed or operating across all customer sectors, including low-income segments of the population.[3]

This *Draft Guidance* is not a regulatory document and therefore does not establish any additional or parallel EM&V requirements. Instead, it takes the EM&V provisions of the CPP and RMR as a starting point

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[1] For a description of the EM&V requirements and approach in the CPP, see Section VIII.K.3 at page 64908 of the printed version. For the structural state plan requirements that each EE provider must adhere to, see §60.5830 and §60.5835 of the CPP at page 64952 of the printed version.

[2] This basic information is provided for background only. It should not substitute for a thorough review of the applicable CPP and RMR. In the event of any discrepancy between the CPP and draft RMR with this *Draft Guidance*, the CPP or RMR is controlling.

[3] This includes EE activities targeting low-income customers. While electricity savings is an important outcome for low-income EE, it is generally implemented for other reasons. The primary goal of most low-income EE activities is to lower the burden of energy costs for a disadvantaged population. Additional goals are to achieve co-benefits including but not limited to health, safety, and comfort. In addition, low-income EE activities are typically designed with the intent to deliver bundled services for the targeted segment, beyond just electricity savings. While these considerations may affect the broader determination of cost-effectiveness of low-income programs, the EM&V requirements in the CPP and RMR nevertheless apply to the quantification and verification of low-income EE projects and EE measures included in a rate-based state plan.

and provides non-regulatory technical details to help EE providers understand and implement them. The *Draft Guidance* does not address EM&V for other types of eligible resources, such as renewable energy (RE), combined heat and power (CHP), or other zero- and low-emitting resources that generate electricity. The applicable EM&V approach for these other types of eligible resources is provided in the CPP and RMR.

This *Draft Guidance* also does not apply to states implementing mass (or tonnage) based plans.[4] States with mass-based plans that are implementing demand-side EE policies or strategies as a complementary compliance strategy[5] are likely to have their own EM&V framework and requirements for purposes of ensuring that customer-funded EE investments are cost-effective and achieving intended results. These states are not required to address EM&V in their state plan, nor is there a need to change existing EM&V approaches in any way.

Contents of this *Draft Guidance* include *Key Definitions*, *Discussion*, and *Applicable Guidance* that describes how to implement key EM&V provisions addressed in the RMR. The *Applicable Guidance* sections below aim to address the public comments that the EPA received in response to the *Initial Draft EM&V Guidance* released in August 2015. A key theme in these comments was a request to add clarity and technical details to demonstrate how EE providers can implement the EM&V approach outlined in the CPP and RMR. Changes from the August 2015 version to this update therefore include:

- Clarifying the applicability of certain EM&V provisions
- Refining the associated technical guidance and terminology
- Pointing to external resources that can help EE providers implement key EM&V plan components

One additional change is the removal of policy- and project-specific EM&V information (e.g., covering building energy codes, industrial projects, and equipment standards) which commenters generally viewed as repetitive of the information already provided in the August 2015 *Initial Draft EM&V Guidance* on core EM&V topics. This version of the *Draft Guidance* is similar to the initial version in that both reflect a set of well-known and standardized EM&V best-practices and protocols that are already in wide use.

In providing this *Draft Guidance* at this time, the EPA recognizes that the best-practice approaches, protocols, and procedures that are now used by states, EE providers, and others – and upon which this document is based – will evolve and improve over time as new technologies and methods emerge and the EE marketplace changes. To ensure that this *Draft Guidance* and related EM&V information continues to reflect best practices over time, the EPA may periodically provide updates and/or additional supporting materials.

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[4] This is because MWh of electricity savings (or RE/CHP generation) are not the basis for establishing or issuing the mass-based compliance instrument (i.e., the allowance). Instead, a pre-determined quantity of allowances – equivalent to the state's mass emissions budget – is created and distributed to states at the beginning of the program. Compliance in a mass-based state plan is determined solely by CO_2 emissions measurements at the affected source. In these instances, compliance does not require emission-rate adjustments based on savings from demand-side EE.

[5] Demand-side EE activities can contribute to meeting customer electricity demand by replacing generation that would otherwise occur at affected EGUs. These activities can therefore reduce the total quantify of CO_2 emissions from affected EGUs and lower the number of allowances required for purposes of demonstrating compliance. This makes compliance less expensive, on average.

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1.1. What is EM&V?

Evaluation, measurement, and verification (EM&V) is defined in the CPP as the set of procedures, methods, and analytic approaches used to quantify the MWh of electricity savings from demand-side EE, and the MWh of electricity generation from renewable energy (RE) or other eligible measures. For demand-side EE, EM&V compares measured electricity usage with an EE project or EE measure in place with the best estimate of the likely energy use in the absence of the project or measure (the "counterfactual" scenario or baseline). MWh of electricity savings are quantified relative to this counterfactual baseline.

Other key components of a robust EM&V approach for a demand-side EE project or EE measure include but are not limited to determining the effective useful life (EUL) of the project or measure, selecting an appropriate EM&V method, verifying that the EE project or EE measure is installed and operating properly, applying an appropriate best-practice protocol or guideline, and accounting for interactive effects and independent variables that affect electricity use. *Applicable Guidance* on how to apply each of these components in the context of a rate-based state plan for ERC issuance is provided below.[6]

1.2. Experience with EM&V for Demand-Side EE

From the time that demand-side EE emerged as an important energy strategy in the 1970s, efforts to quantify and verify the resulting MWh savings have been critical to its success, credibility, and expansion. The earliest such efforts involved quantifying savings from individual EE projects and EE measures. This was followed by an evolution and improvement in practices for a broad range of EE programs and strategies across sectors. Today, these EM&V practices are used by utilities, energy service companies (ESCOs), and other EE providers. They are backed up by well-established protocols and guidelines, and overseen by Public Utility Commissions (PUCs) and other governing agencies. The EM&V industry now comprises many large firms and hundreds of individual practitioners, and is supported by training and education programs, as well as published reports and publicly available data and technical resources.

The EM&V approaches and best practices in wide use today—and upon which the quantification and verification provisions of the CPP and RMR are based—are primarily derived from PUC requirements for customer-funded EE programs typically implemented by utilities, as well as the DOE's Federal Energy Management Program's (FEMP) requirements for ESCO projects. These oversight mechanisms have generated the majority of the methods, protocols, and definitions for quantifying electricity savings that the EE industry uses today. However, the level of oversight and review, and the specifics of how EM&V is applied necessarily varies in response to the policy context and specific objectives for which EE is deployed.[7]

With this evolution in EM&V, many states and utilities now routinely rely on EE as a resource in meeting energy (MWh) and capacity (MW) goals and to ensure reliable electricity service. All 50 states currently administer some type of EE program, while 25 states have mandated statewide EE standards or goals such as energy efficiency resource standards (EERS) and mandates for "all cost-effective EE." Many jurisdictions also support private sector EE projects (such as those implemented via ESCO energy performance contracts), as well as building energy codes and equipment standards for equipment not covered by

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[6] Figure 2-1 below provides a conceptual illustration of how EE savings can be quantified with respect to a Common Practice Baseline (CPB), as provided for in the RMR.

[7] While this document reflects current best practices for EM&V, it is applied within a specific policy context (i.e., the Clean Power Plan, the authority for which comes from the Clean Air Act) and therefore should not be misinterpreted as directly transferable or applicable to other contexts.

federal efficiency requirements.[8] In addition, two Independent System Operators (ISOs)—ISO New England (ISO-NE) and PJM Interconnection—have established forward capacity markets (FCMs) that compensate suppliers of EE and other demand-side resources on par with electric generation to meet regional capacity needs and ensure system reliability. The oversight and quality control of EE in each of these contexts differs somewhat, but in each case relies on EM&V procedures that are robust, transparent, and well documented.

Despite improvements in EM&V over time, challenges remain. One such challenge is that quantification practices are more robust for some EE program and policy types than for others. Additionally, there is limited experience applying EM&V in the context emission trading programs, where each MWh of saved electricity may become a commodity that can be bought and sold. As a result, the final CPP and RMR include a number of safeguards and quality-control features that are intended to ensure the accuracy of quantified EE savings.

1.3. Issuance of ERCs for Demand-Side EE in a Rate-based Emission Trading Program

This section briefly describes the two-step ERC issuance process established in the CPP. It is intended as background information for stakeholders not familiar with this process[9]. As noted above, in the event of any discrepancy between this *Draft Guidance* and the CPP or RMR, the CPP or RMR is controlling.[10]

Two-Step ERC Issuance Process. Under the CPP, a potential EE provider that implements EE projects or EE measures in a rate-based state plan can apply for ERCs pursuant to a two-step process. The RMR specifies the process for the issuance of ERCs to eligible resources.

- **Step One:** In the first step, a potential ERC provider submits an eligibility application for a qualifying EE activity to the state. The state or its agent then reviews the application to determine whether the potential ERC provider meets eligibility requirements for the issuance of ERCs. Section V.E.2.b(1) of the RMR identifies the required contents of the eligibility application, the need for application review by an independent verifier, and the timeline for state review of an eligibility application.

- **Step Two:** After the ERC provider has implemented the eligible EE activity approved in step one, it may undertake step two in order to be issued ERCs. In this second step, the ERC provider must periodically submit an M&V report[11] to the state documenting the MWh of electricity generation or energy savings resulting from the eligible resource. These results are quantified according to the EM&V plan approved as part of the eligibility application in step one and verified by an accredited

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[8] See: https://www.epa.gov/cleanpowerplan/fact-sheet-clean-power-plan-clean-energy-now-and-future. Going forward, there continues to be significant potential for additional demand-side EE in every state. The Lawrence Berkeley National Laboratory (LBNL) projects a continued trend towards increased penetration of EE over the next 5, 10, and 15 years. See: https://emp.lbl.gov/sites/all/files/lbnl-5803e.pdf.

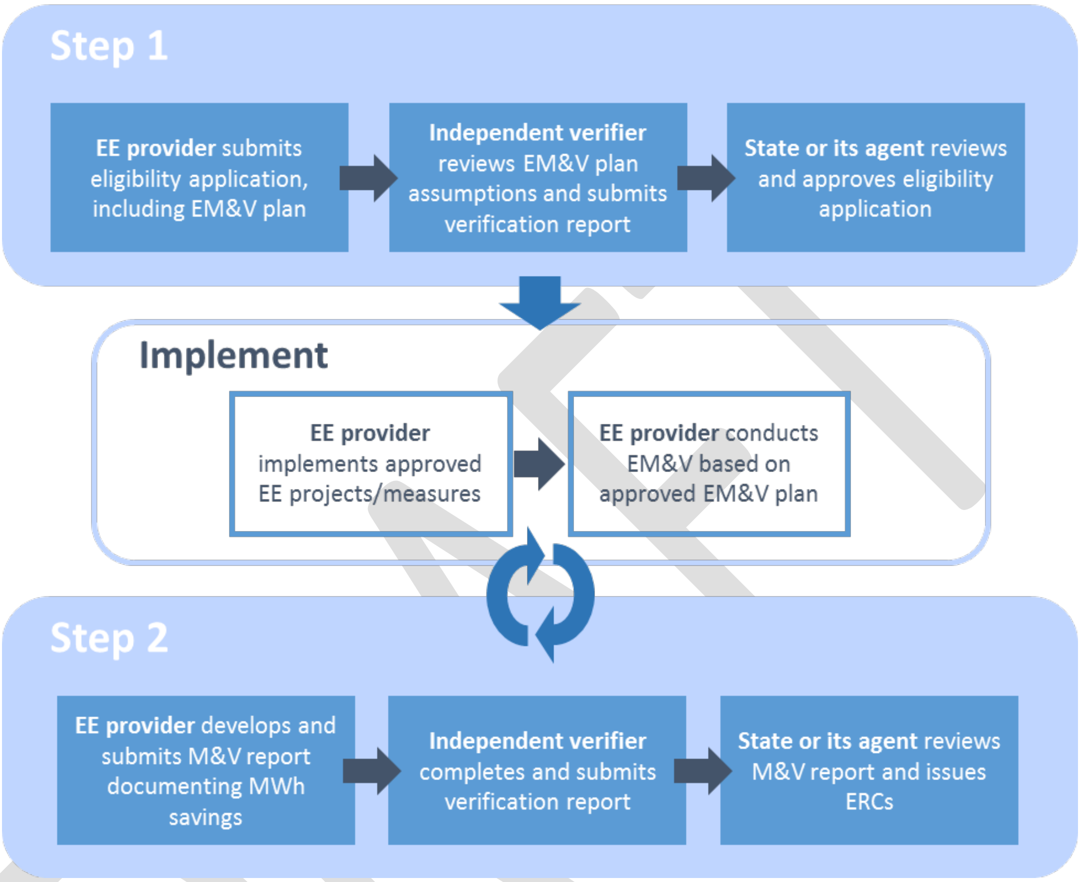
[9] This *Draft Guidance* uses the term “EE provider” to refer to the representative for the EE eligible resource, which is the responsible party that makes all submittals related to ERC issuance. This representative may be, but is not required to be, the implementer of the EE projects or EE measures addressed in an EM&V plan.

[10] See 40 CFR 60.5805(a), as well as Section V.E.2.b of the RMR.

[11] Monitoring and verification (M&V) reports identify the time period covered by the M&V report, describe relevant quantification methods, protocols, guidelines, and guidance specified in the EM&V plan were applied during the reporting period to generate the quantified MWh of electricity savings, and must document the MWh savings from the EE projects or EE measures.

independent verifier. The independent verifier[12] must submit its verification assessment in a report that accompanies the M&V report submitted to the state. The state then reviews the M&V report and determines the number of ERCs (if any) that should be issued. The state or its agent then reviews the M&V report and determines the number of ERCs to issue. Sections V.E.2.b(2)-(4) of the RMR describe the requirements for this second step.

Figure 1-1. Illustration of ERC Issuance Process



Compliance in a Rate-Based State Plan. Affected power plants covered by a rate-based emission standard demonstrate compliance by either meeting the applicable standard at the power plant, or by adjusting the CO_2 emission rate calculation by adding ERCs to the denominator of the power plant's reported CO_2 emission rate. In this way, ERCs represent additional generation (the denominator, *in MWh*) with zero associated CO_2 emissions (the numerator, *in lbs*). Once EE providers have earned ERCs for quantified and verified MWh of electricity savings, they may sell them to an affected fossil-fueled power plant.[13] The power plant adds the ERCs to its total net electricity output and thereby adjusts its reported CO_2 emission

[12] Verification reports are included as part of an eligibility application and an M&V report. Verification report content differs depending upon whether the report is a part of an eligibility application or M&V report. All verification reports must include a verification statement that sets forth the findings of the verifier, based on its assessment of the eligibility application or M&V report. The required contents of a verification report for an eligibility application must describe the review conducted by the accredited independent verifier and provide the accredited independent verifier's assessment as described in Section V.E.2.b(3) of the RMR.

[13] Alternatively, EE providers may sell or otherwise transfer their ERCs to another market participant (e.g., a broker or trader).

rate for purposes of achieving the applicable rate-based emission standard. This is represented by the following equation:[14]

$$CO_2\text{emission rate} = \frac{\sum M_{CO2}}{\sum MWh_{op} + \sum MWh_{ERC}}$$

Where:

CO_2 emission rate	=	An affected EGU's calculated CO_2 emission rate that will be used to determine compliance with the applicable CO_2 emission standard.
M_{CO2}	=	Measured CO_2 mass in units of pounds (lbs) summed over the compliance period for an affected EGU.
MWh_{op}	=	Total net electricity output over the compliance period for an affected EGU in units of MWh.
MWh_{ERC}	=	ERC replacement generation for an affected EGU denominated in units of MWh.

1.4. EM&V in the CPP and RMR

The EM&V approach established in the CPP and RMR is based on best practices from across the country for quantifying and verifying savings. The EPA released several documents characterizing and distilling these practices for application in the CPP and has solicited the public's help in shaping and refining the final versions of these documents. In June 2014, the EPA proposed carbon pollution emission guidelines for certain existing EGUs, as well as a "State Plans Considerations" technical support document (TSD)[15] that outlined a general approach to establishing an EM&V approach. The EPA received public comment on the TSD and used this information to establish the EM&V provisions of its Proposed Federal Plan for the Clean Power Plan and the accompanying *Initial Draft EM&V Guidance*, both of which were released in August 2015. The EPA subsequently took public comment on these documents, which has been used to refine the EM&V approach in the RMR and in this *Draft Guidance*.

The figure below illustrates the contents and relationship between the CPP emission guidelines, the RMR, and this *Draft Guidance*.

Figure 1-2. Summary of EM&V in the CPP, RMR, and Draft Guidance

Clean Power Plan (CPP)	Rate-Based Model Rule (RMR)	Guidance Document (Draft Guidance)
August 2015	*December 2016*	*December 2016*
Requirements for EM&V that states and tribes must meet to comply with the CPP for a rate-based state plan	Provisions that can be used to meet the EM&V requirements in the CPP for a rate-based state plan	Supplemental technical guidance on how to implement the provisions in the RMR for a rate-based state plan

EM&V in the Clean Power Plan (for rate-based state plans). The CPP establishes several key EM&V requirements to ensure that demand-side EE activities implemented in a rate-based emission standard

[14] For details, see Section V.G of the RMR.

[15] Note: See discussion beginning on p. 34 of the State Plan Considerations TSD for the Clean Power Plan Proposed Rule. EPA. 2014. *State Plan Considerations Technical Support Document.* Available at: https://www.epa.gov/sites/production/files/2014-06/documents/20140602tsd-state-plan-considerations.pdf.

plan are quantifiable, verifiable, and robust. In the preamble to the CPP, the EPA noted that the level of EM&V rigor necessary for ensuring the integrity of a rate-based emission trading program may differ from that necessary to ensure effective expenditure of electricity ratepayer dollars through a utility- or state-administered energy efficiency program. The preamble to the CPP also identifies several principles that the EPA used as the basis for establishing minimum quantification and verification requirements for purposes of ERC issuance in a rate-based state plan. These principles include:

- Ensure the integrity of the CO_2 emission reductions in the CPP.
- Leverage existing best practices for purposes of ERC issuance, recognizing the context in which EM&V is applied as part of a rate-based emission trading program.
- Avoid excessive interference with current EM&V conducted at the state and utility level that is robust, transparent, and working well.
- Maintain flexibility to accommodate industry change, technology improvement, and innovation in EM&V approaches and protocols over time.
- Strike a reasonable balance between EM&V rigor and accuracy and the level of effort and cost involved in EM&V.

Consistent with the above principles, the CPP emission guidelines require that EM&V plans for an EE activity must include the following components:

- A demonstration of how savings will be quantified and verified by applying industry best-practice protocols and guidelines
- A baseline that represents what would have happened in the absence of the EE intervention
- The effects of changes in independent factors affecting energy consumption and savings[16]
- The length of time the EE action is anticipated to continue to remain in place and operable, effectively providing savings[17]

EM&V in the Rate-Based Model Rule. One way that a state can be assured of implementing the basic state plan provisions for EM&V is by adopting the associated RMR provisions. Consistent with the CPP, the RMR specifies provisions for:

- Conducting EM&V, including specific approaches for all aspects of quantifying and verifying savings from eligible EE activities
- The components and approach to developing applicable documents, including EM&V plans, M&V reports, and independent verifier reports

All EM&V provisions for demand-side EE are provided in Section V.C.4.e of the RMR.

[16] I.e., factors not directly related to the EE action, such as weather, occupancy, or production levels.

[17] For the overall EM&V approach and rationale in the CPP, see Section VIII.K.3 of the CPP at page 64908 of the printed version. For the structural state plan requirements that each EE provider must adhere to, see §60.5830 and §60.5835 of the CPP at page 64952 of the printed version.

1.5. Contents of this Draft EM&V Guidance

The remainder of this document provides supplemental technical information that describes how to successfully implement the EM&V provisions of the RMR. It is organized into the following topics:

- **Section 2.1 Baselines for Calculating Savings**
- **Section 2.2 Electricity Savings Quantification Methods**, which addresses deemed savings, direct M&V, and comparison group methods in detail
- **Section 2.3 Effective Useful Life**
- **Section 2.4 Verification of EE Project or EE Measure Installation**
- **Section 2.4 Additional Aspects of Savings Quantification,** which covers independent variables affecting electricity consumption and savings, interactive effects, transmission and distribution (T&D) savings and adders, accuracy of savings, and avoiding double counting
- **Section 2.6 Timeframes for Reporting Savings and ERC Issuance**
- **Section 2.7 Best Practice EE EM&V Protocols and Guidelines**

The *Draft Guidance* does not address each individual EM&V provision in the RMR. For certain provisions, the RMR is assumed to be sufficiently detailed such that no further information is required. This document only addresses the EM&V topics for which the EPA has determined that additional technical information may be useful for ERC issuance purposes.

In addition, this *Draft Guidance* includes a **glossary of key terms** used in this document. It is intended to be consistent with best-practice protocols and guidelines already in wide use, and can be supplemented with the more complete glossary provided in the SEE Action Energy Efficiency Impact Evaluation Guide.[18]

[18] State and Local Energy Efficiency (SEE) Action Network. 2012.

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2. Draft EM&V Guidance Applicable to Demand-Side EE in Rate-Based State Plans

The *Discussion*, *Applicable Guidance*, and *Key Terms* provided in each of the sections below are intended to help states, EE providers, and the private firms that providers hire (e.g., EE evaluators and independent verifiers) successfully implement an EM&V approach that is consistent with the EM&V provisions in the RMR. As previously described, the information provided here leverages and is generally consistent with EM&V best practices, protocols, and procedures already being used by the majority of states across the country.

For the EM&V topics addressed below, the following information is provided:

- **Discussion** that includes a high-level overview, offers relevant background information, and describes applicability to the CPP emissions guidelines.
- **Applicable Guidance** that is intended to help states, EE providers, and the firms they hire implement the EM&V provisions in the RMR.
- **Key Terms** that are included in text boxes in each section and are also compiled in the *Glossary of Terms* at the end of this document.

> **Key Terms for EE Activities**
>
> **EE measure**: a single technology, energy-use practice or behavior that, once installed or operational, results in a reduction in the electricity use (in MWh) required to provide the same or greater level of service at an end-use facility, premise, or equipment connected to the delivery side of electricity grid; EE measures may be implemented as part of an EE program or an EE project.
>
> **EE project:** a combination of measures, technologies, energy-use practices or behaviors that, once installed or operational, results in a reduction in the electricity use (in MWh) required to provide the same or greater level of service; EE projects may be implemented as part of an EE program.
>
> **EE program:** organized activities sponsored and funded by a particular entity to promote the adoption of one or more EE projects or EE measures that, once installed or operational, results in a reduction in the electricity use (in MWh) required to provide the same or greater level of service in multiple end-uses, facilities, or premises.
>
> **EE activity:** an EE measure, EE project, or EE program.

The remainder of this *Draft Guidance* describes how the following seven topics may be applied consistent with the RMR provisions:

1. Baselines for Calculating Savings
2. Electricity Savings Quantification Methods
3. Effective Useful Life
4. Verification of EE Project or EE Measure Installation
5. Additional Aspects of Savings Quantification
6. Timeframes for Reporting Savings and ERC Issuance
7. Best Practice EE EM&V Protocols and Guidelines

The corresponding RMR provisions are provided in Section V.C.4.e of that document and are not included below. Therefore the RMR and *Draft Guidance* should be reviewed in parallel.

2.1. Baselines for Calculating Savings

Discussion

Electricity savings from an EE activity is commonly defined as the difference between electricity consumption with the EE activity in place and the consumption that would have occurred in the absence of that activity during the same time period. What would have happened without the EE activity is the baseline case (or "counterfactual"), and electricity consumption under the baseline case is called baseline consumption.

Specifying the baseline case for a particular EE activity is a key challenge with EM&V. If the condition prior to the installation of an EE project or EE measure were always the baseline, this determination would be relatively straightforward. However, most EE activity takes place in a context of ongoing changes in markets, technology, policy, and operations. Specifying a baseline requires consideration of this context. For example, when the EE activity is an improvement to the efficiency of new construction or a new equipment installation that would occur regardless of the efficiency level, the baseline can be defined in terms of the new installations or actions that would otherwise occur. When an EE activity occurs in the context of other EE activities, such as new equipment installation in a market affected by building codes or equipment standards, the other EE activities must be considered in determining the baseline condition for the first EE activity.

Key Terms for Savings

Baseline consumption: the electricity consumption that would have occurred at the baseline efficiency level and operating conditions.

Common Practice Baseline (CPB): the level of energy performance that would occur, in the absence of the EE project or EE measure, at the more energy efficient of either: (1) the highest level of energy efficiency required by the applicable federal, state, or local building energy code or product or equipment standard, if any (i.e., the code or standard that corresponds to the lowest electricity consumption of the buildings or equipment it applies to, all else equal); or (2) the expected technology, operating conditions, or practices that would have existed at the time of implementation or the likely subsequent replacement within the EUL of the EE project or EE measure, in the absence of the EE project or EE measure.

Gross savings: difference between electricity consumption of the affected equipment or facility with versus without the EE project or EE measure in place, without consideration of program influence or attribution. Gross savings is calculated relative to a specified baseline determined without regard to program influence.

Net savings: the difference between energy consumption with the program or intervention in place and that which would have occurred absent the program or intervention, accounting for program influence and attribution.

Operating conditions: the conditions in which the EE project or EE measure or affected structure or equipment is used or operated.

Common Practice Baseline

The EPA for purposes of the RMR requires that EE savings are quantified based on a comparison between energy consumption with an EE project or EE measure in place and the consumption that would otherwise result at the time of the project or measure implementation. This counterfactual scenario is referred to as the Common Practice Baseline (CPB) and defined as follows in the RMR:

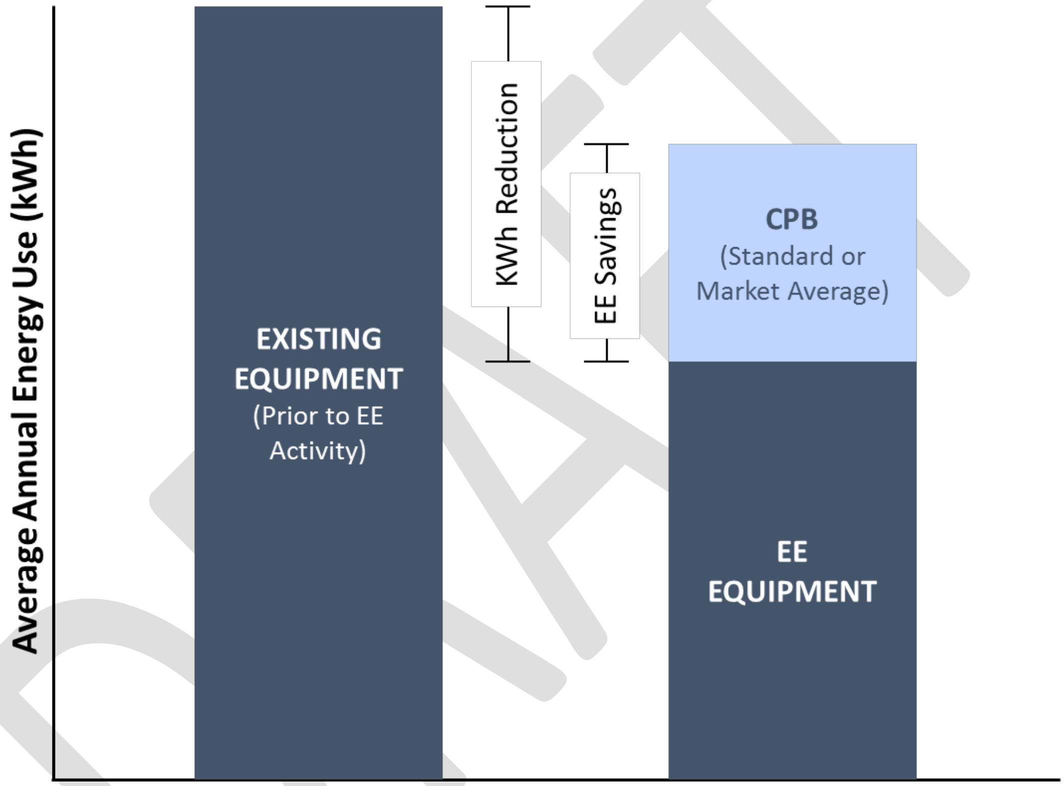
> *<u>Common Practice Baseline</u> means the level of energy performance that would occur, in the absence of the EE project or EE measure, at the more energy efficient of either (1) the highest level of energy efficiency required by the applicable federal, state, or local building energy code or product or equipment standard, if any (i.e., the code or standard that corresponds to the lowest electricity consumption of the buildings or equipment it applies to, all else equal); or (2) the expected technology, operating conditions, or practices that would have existed at the time of implementation or the likely subsequent replacement within the EUL of the EE project or EE measure, in the absence of the EE project or EE measure.*

The CPB is one aspect of ERC quantification designed to ensure that electricity savings are quantified—and ERCs are issued—only for efficiency levels that are (a) beyond what would be typical or expected for the installation and market and (b) beyond existing requirements. While electricity-savings baselines for existing utility EE programs and private-sector EE may differ somewhat by jurisdiction and EE provider, the

CPB definition established in the RMR and discussed in this *Draft Guidance* is consistent with well-established approaches and practices currently in use around the country.

By relying on savings quantified against an applied CPB, the EPA is establishing a uniform basis for quantifying electricity savings from all eligible EE activities, including EE projects and EE measures implemented in the private market (as illustrated in Figure 2-1 for a case in which equipment is replaced on failure). A CPB therefore provides a common, actionable baseline for both public and private investments while still ensuring that EE savings are additional and incremental to what would otherwise occur for similar applications in that market. Since the efficiency level of the market advances naturally, the CPB value for new EE activity must be continually re-evaluated to ensure that new EE projects and EE measures continue to be additional to what is happening naturally in the market.

Figure 2-1. Illustrative Comparison of Total kWh Reduction vs. EE Savings Using CPB for Equipment Replaced on Failure



The *Applicable Guidance* below specifies the CPB that will ordinarily apply, consistent with the RMR definition, for the following different types of EE activities and contexts. While this list does not address each possible type of EE activity, it covers the significant majority that EE providers are currently implementing. It is not intended to exclude any demand-side EE activities.

- **Higher efficiency replacement**: Replacement of existing facility equipment or structural component (such as windows) with high efficiency new equipment or component
- **Higher efficiency equipment in new installations**: Installation of high efficiency equipment or structural components in new construction, major renovation, or other first installation of the equipment type that triggers a building energy code
- **Add-on efficiency**: Equipment or structural changes that can be added to facilities or equipment, such as insulation or controls

- **Operational or maintenance improvement:** Operational improvements such as adjusting set points or run times, or maintenance actions that improve efficiency, without installation of new equipment affected by these improvements or actions[19]
- **Combination EE measures installed as part of the same project:**[20] Combinations of multiple EE measures (e.g., equipment replacement, operational improvement, add-on, new controls, building shell) that jointly affect the same systems
- **New construction or renovation at higher efficiency**: New construction or major renovation that triggers code, to produce a higher efficiency performance building than required by code
- **New state-wide equipment standards**: New state-wide efficiency standards for manufacture or sale of particular types of energy-using equipment, setting a new mandatory minimum efficiency standard for a particular equipment type
- **Whole-building EE improvement**: Comprehensive assessment and improvements to building shell, equipment, or operations
- **Mass market information and encouragement:** Provision of information and encouragement to adopt a wide variety of physical, operational, and behavioral efficiency improvements to large groups of customers
- **Building operations and maintenance training:** Provision of training to building operators on particular types of building operations and maintenance improvements

For higher efficiency replacement or add-on efficiency, the CPB specification also depends on the context of the replacement. Contexts in which higher efficiency replacement activities may be implemented include:

- **Replace on failure:** Replace equipment at the end of its useful life with high-efficiency equipment.
- **Early replacement:** Replace equipment prior to the end of its useful life with high-efficiency equipment.

Contexts in which add-on EE activities may be implemented include:

- Added to existing facility without concurrent equipment replacement (not triggering code)
- Added to existing facility with concurrent equipment replacement (not triggering code)
- Included with new construction/major renovation (triggering code)

Types of Baseline Efficiency and Operating Conditions

The CPB for a particular EE activity will be equivalent to one of the types of baseline efficiency listed in the following text box:

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[19] O&M activity may include installation of control devices, and may also be implemented in conjunction with installation of new equipment affected by the O&M activity, but the installation of new affected equipment is not included as part of the O&M activity itself. Combined implementation of O&M activity together with new affected equipment would require attention to interactive effects.

[20] When measures are installed in combination, it may be simpler to calculate savings for the combination rather than attempting to calculated savings for each measure individually and then adjust for interactive effects.

Key Terms for Baseline Efficiency and Specifying a CPB

- **Existing efficiency**: the efficiency level of equipment, systems, or construction in place prior to the EE activity.
- **Standards efficiency**: the efficiency level for the most stringent[21] applicable federal, state, or local equipment standard or building code (if any) in place prior to the EE activity.
- **Market efficiency**: the average[22] efficiency level of applicable new equipment in the market in place prior to the EE activity.
- **Market/standards efficiency**: the higher of standard efficiency and market efficiency in place prior to the EE activity. Use market efficiency if there is no applicable federal, state, or local code or standard or if market efficiency is above standard efficiency.
- **Dual baseline**: a baseline corresponding to existing efficiency up to the remaining useful life (RUL) of the existing equipment, systems, or construction, and market/standards efficiency for the remainder of the effective useful life (EUL) of the EE activity.[23]
- **Underlying equipment efficiency**: for an add-on or operational EE activity, the efficiency of the equipment that the add-on or operational change applies to (without the add-on or operational change). In cases of early replacement, add on efficiency would be calculated using a dual baseline for underlying equipment efficiency.

To determine the level of baseline consumption[24] that is consistent with this CPB, it is also necessary to identify the operating conditions—consistent with the list below—for the facility or equipment affected by the EE activity. Operating conditions are a function of factors such as facility occupancy levels, operating hours, production levels, or weather, and are frequently quantified in terms of the independent variables discussed in Section 2.5.1.

Key Terms for Operating Conditions for Determining Baseline Consumption

- **Operating conditions:** the conditions in which the EE project or EE measure or affected facility or equipment is used or operated.
- **Post-installation operating conditions**: the average operating conditions in the period after the EE activity is implemented, over the EUL of the activity.
- **Post-installation operating conditions without the add-on or operational improvement:** the average operating conditions in the period after the EE activity is implemented, over the EUL of the activity, but without the add-on or operational improvement.[25]
- **Post-completion operating conditions**: for new construction and major renovation that trigger a code

[21] For building code, "most stringent" means that buildings built to this standard generally use the least energy, all else being equal.

[22] This refers to the average over units of equipment and conditions relevant to the EE application weighted by the prevalence of different units in the market. For example, for the market average efficiency level of applicable units available in the market, a sales-weighted average should be used.

[23] If the RUL of the existing equipment, systems, or construction is greater than the EUL of the EE activity, the dual baseline corresponds to the existing efficiency for the entire EUL. For more information see the *Applicable Guidance* in Section 2.3 below.

[24] Baseline consumption is the electricity consumption that would have occurred at the baseline efficiency level and operating conditions.

[25] In the case of an add-on measure such as building insulation or an operational improvement such as new controls systems, the baseline consumption corresponds to how the facility is operated on average in the post-installation period, but without the add-on or improvement.

requirement, the average operating conditions after the construction is completed and at normal ongoing operations, averaged over the EUL of the activity.

- **No operational change**: for EE activities including O&M improvements, the operating conditions that would have existed in the post-intervention period without those O&M improvements.

To determine which type of baseline efficiency from the list above corresponds with the appropriate CPB for a particular situation, EE providers can consider the following questions:

- Are there applicable codes or standards?
- What equipment, systems, or construction would be expected to be installed or constructed without the EE activity?
- If there are applicable codes or standards, are they more stringent than the equipment, systems, or construction that would be expected be installed or constructed without the EE activity?

The text box below explores these questions for three common situations.

Specifying CPBs for Common Situations

The questions below can help determine which type of baseline efficiency is the appropriate CPB in the following common situations:

1. ***If no change would have been made within the life of the EE activity (without the activity itself):***

   Are there applicable codes or standards?
   While there may be related codes or standards, they typically apply to new installations or replacements or building codes that trigger new construction standards.

   What equipment, systems, or construction would be expected to have existed without the EE activity?
   The previously existing equipment or facilities.

   Therefore, the baseline efficiency for the CPB is the efficiency of the previously existing equipment or facilities.

2. ***If the equipment or facilities would have been changed at the same time even without the EE activity, as in replacement on failure or for non-replacement new equipment or facilities:***

   Are there applicable codes or standards?
   Often yes.

   What equipment, systems, or construction would be expected to have existed without the EE activity?
   The market average new equipment or facilities.

   Therefore, the type of baseline efficiency for the CPB is the more stringent of a) any applicable codes or standards and b) the market average efficiency of new equipment or facilities.

3. ***For early replacement:***

   Are there applicable codes or standards?
   Often yes.

   What equipment, systems, or construction would be expected to have existed without the EE activity?
   The existing equipment or facilities through the remaining useful life (RUL), and the market average of new equipment or facilities thereafter.

   Therefore, the baseline efficiency for the CPB is the efficiency of existing equipment or facilities through the remaining useful life of the equipment or facilities, and the more stringent of any applicable codes or standards and the market average of new equipment or facilities thereafter. This is called a dual baseline.

The *Applicable Guidance* below specifies for the indicated types of EE activity how the CPB is determined and savings calculated consistent with the RMR definition above. For some of these EE activities, the type of baseline efficiency that corresponds with the appropriate CPB is based upon the prevailing code or standards efficiency. This will be the case whenever market average efficiency is lower than the applicable code or standard. For other EE activities and contexts, the CPB specification is based on the market average efficiency. This will be the case for EE measures or markets where compliance with the prevailing codes or standards is high, so that the market average efficiency is above the standards efficiency. Recognizing that accurate determination of market average efficiency may be challenging in certain instances, the *Applicable Guidance* provides acceptable conservative alternatives to explicit calculation of market average efficiency. In still other situations, what would be typical or expected absent the EE activity is no change, so that the CPB corresponds to the existing equipment or practices.

Applicable Guidance

Specifying CPBs

The CPB for a particular situation is specified by identifying the appropriate baseline efficiency from the list provided in the text box above. The following *Applicable Guidance* may be useful:

- Determine the CPB based on the type of EE activity and relevant context.
- Review the market averages and equipment-standards assumptions used to determine the CPB on a regular basis, for example in conjunction with technical reference manual (TRM) updates.
- If savings for a facility are quantified using whole-premises consumption methods (such as IPMVP Option C) or comparison group methods, describe how the analysis and normalization are designed to determine savings relative to the appropriate CPB. In these cases, it is not necessary to determine explicit CPB values for individual pieces of equipment. For example, if the CPBs for a combination of measures are all based on existing equipment and the independent variables other than weather are the same in the pre- and post-installation periods, normalizing pre-installation consumption to the long-run average weather conditions provides savings relative to an appropriate CPB at the whole-facility level.
- To specify the operating conditions for calculating savings as described in 2.5.1:
    - Include all independent variables that materially affect electricity consumption in the operating conditions.
    - If the EE activity does not change the operating conditions, quantify savings relative to the CPB at the post-implementation operating conditions.
    - If the EE activity affects the operating conditions (e.g., as it would for EE activities that involve an O&M improvement), calculate savings relative to the CPB at the operating conditions that would be in place without the EE activity.

For each of the EE activities in Table 2-1 below, the CPB is specified in terms of the baseline efficiency level. The baseline operating conditions at which electricity savings should be calculated are also indicated, with the definitions of efficiency levels and operating conditions provided in the *Key Terms for Baseline Efficiency and Specifying a CPB* and *Key Terms for Specify Operating Conditions for Baseline Consumption* text boxes above. Section 2.5.1 discusses specification of operating conditions via independent variables.

For the EE activity types and contexts listed, the EPA considers the CPB specifications in Table 2-1 to be consistent with the RMR definition of a CPB in most cases. While the table does not address each possible type of EE activity and context, it covers the significant majority that EE providers are currently implementing. It is not intended to exclude any demand-side EE activities. Additional information may be provided in the future as the EE marketplace evolves.

Table 2-1.Typical CPB Specifications for Particular EE Activity Types and Contexts[26]

EE Activity Type	Description	Context	CPB Specification	Operating Conditions for Determining Baseline Consumption[27]
Higher efficiency replacement	Replacement of existing facility equipment or structural components with high efficiency new equipment	Early replacement	Dual baseline	Post-installation
		Replace on failure	Market / standards efficiency	Post-installation
Higher efficiency equipment in new installations	Installation of high efficiency equipment in new construction, major renovation, or other first installation of the equipment type that triggers a building energy code	Any	Market / standards efficiency	Post-installation
Add-on efficiency	Equipment or structural changes that can be added to existing facilities or equipment, such as insulation or controls	Added to existing facility without concurrent equipment replacement (not triggering code)	Underlying equipment efficiency	Post-installation without the add-on
		Added to existing facility with concurrent equipment replacement (not triggering code)	New equipment or facility efficiency without the add-on efficiency	Post-installation without the add-on
		Included with new construction or major renovation (triggering code)	New equipment or facility efficiency without the add-on efficiency	Post-installation without the add-on
Operational or maintenance improvement	Changes in operating practices such as set points or run times	Any	Underlying equipment efficiency	Post-implementation without the operational or maintenance improvement

[26] The RMR definition of a CPB takes precedence over the typical CPB specifications provided in this table. CPBs for any given EE activity may be dependent on the characteristics of each EE activity, facility and electricity-user characteristics, and/or operating conditions.

[27] The operating conditions for the baseline consumption are not necessarily the conditions that were in place prior to the EE activity, but are the conditions that would have been in place in the post-installation period in the absence of the EE activity. If the EE activity does not affect the operating conditions, the post-installation operating conditions are the operating conditions for the baseline consumption.

EE Activity Type	Description	Context	CPB Specification	Operating Conditions for Determining Baseline Consumption[27]
Combination EE measures installed as part of the same project[28]	Combinations of multiple EE measures and types (e.g., equipment replacement, operational improvement, add-on, new controls, building shell) that jointly affect the same systems	Any	Efficiency levels that would exist without the combination of measures, per the separate CPB specifications (with interactive effects addressed per 2.5.2)	Post-installation without the combination of measures
New construction or renovation at higher efficiency	New construction or major renovation that triggers code, using higher efficiency than required by code	Any	Market / standards efficiency	Post-completion
New state-wide equipment standards	New efficiency standards for manufacture or sale of particular types of energy-using equipment	Any	Market / standards efficiency (prior to the new standards)	Average equipment use
Whole-building EE improvement	Comprehensive assessment and improvements to building shell, equipment, or operations	Any	Efficiency levels that would exist without the combination of measures, per the separate CPB specifications (with interactive effects addressed per 2.5.2)	Post-installation without the combination of measures
Mass market information and encouragement	Provision of information and encouragement to adopt a wide variety of physical and operational efficiency improvements, to large groups of customers with no enrollment requirement	Any	Structure and equipment absent the information and encouragement	Operations without the information and encouragement
Building operations and maintenance training	Provision of training to building operators on particular types of building operations and maintenance improvements	Any	Existing facilities without operations and maintenance improvements due to training	Operations without the improvements due to training

The final two rows of Table 2-1 indicate CPBs for two common types of education/training or behavioral activities. These activities involve providing consultation, advice, information resources, and encouragement, but do not directly support the installation of physical EE measures. Such activities can

[28] When measures are installed in combination, it may be simpler to calculate savings for the combination rather than attempting to calculated savings for each measure individually and then adjust for interactive effects.

span a wide range of approaches and result in a wide array of physical and operational changes to facilities. As a result there is no one default CPB specification. In general for such programs the CPB and operating conditions for baseline consumption corresponds to the affected facility and operations as they would exist without the information or behavioral encouragement.

Using Baselines Established for Purposes Other Than Rate-Based ERC Issuance

- If an EE provider applies a baseline other than a CPB for a savings calculation outside of a rate-based state plan, either recalculate savings directly for purposes of rate-based ERC issuance using a CPB or else develop and apply an adjustment factor to produce the savings estimate relative to the CPB. Document how any such adjustment factor was determined. One adjustment approach is as follows:
    - Determine the ratio of EE activity savings relative to the CPB vs. EE activity savings relative to the other baseline.
    - Multiply the savings relative to the other baseline by this ratio.
    - For example, suppose that a large number of 13W lamps are installed with a pre-specified EUL of 5 years. Suppose the total savings was calculated as 120MWh/year relative to a 60W baseline, while the CPB baseline is 45W. The ratio of savings at the CPB versus savings at the original baseline is:

      $$R = (45-13)/(60-13) = 32/47 = 0.68$$

      The annual MWh savings relative to the CPB would be:

      $$Savings_{CPB} = R \times Savings_0 = 0.68 \times 120 \text{ MWh} = 81.6 \text{ MWh}$$

- For an existing EE program with established procedures for calculating gross or net savings, and for which the other specifications of this *Draft Guidance* are met, the CPB may be applied as follows:
    - If the EE program's baseline for calculating gross savings is at least as stringent (represents at least as high efficiency) as the specified CPB in this *Draft Guidance*, the gross savings using the program's existing methods may be reported as quantified savings consistent with the CPP.
    - If the EE program's net savings calculation can be shown to be at least as stringent as the savings quantification based on the specified CPB, the program's net savings may be reported as quantified savings.

2.2. Electricity Savings Quantification Methods

This section presents *Discussion* and *Applicable Guidance* for each of three broad EM&V methods, beginning with *Discussion* and *Applicable Guidance* that applies to all three.

2.2.1. Applying EM&V Methods

Discussion

The RMR requires the use of one or more of three broad EM&V methods to quantify savings, including: 1) **deemed savings,** 2) **direct measurement and verification**, and 3) **comparison group** methods. Each of these methods is defined in best-practice protocols and is commonly applied by EE providers, oversight agencies, and the firms they hire to quantify and verify savings. The decision of which method(s) to apply for each EE activity involves consideration of factors such as objectives of the EE activity being evaluated, the scale of the activity, and evaluation budget and resources.

Key Terms for EM&V Methods

Deemed savings EM&V methods: an electricity savings quantification approach that applies estimates of average annual electricity savings for a single unit of an installed demand-side EE measure that has been developed from data sources (such as prior metering studies) and analytical methods widely considered acceptable for the measure; and is applicable to the situation and conditions in which the measure is implemented. Deemed savings methods can include:

- *Deemed savings values* – pre-specified estimates of average annual electricity savings for an EE project or EE measure.
- *Deemed formulas* – pre-specified formulas for calculating savings, using some deemed parameters and some inputs that are specific to each project or measure.
- *Deemed parameter values* – pre-specified values of parameters that are used to calculate savings using a deemed formula.

Direct measurement and verification: an electricity savings quantification approach that uses onsite observations, engineering calculations, statistical analyses, and/or computer simulation modeling using measurements to determine savings from an individual EE project or EE measure. In the context of an EE program or portfolio of related EE projects, project- or measure-level measurement and verification is applied to a fraction of the total population of EE measures or projects and then scaled using statistical sampling and estimation to represent electricity savings from the total population. The International Performance Measurement and Verification Protocol (IPMVP), listed in Section 2.7, defines ***two retrofit isolation*** and ***two whole-facility*** *M&V options* used in the EE industry:

- *Retrofit isolation* – assessing savings from each EE measure individually (IPMVP Options A & B).
- *Whole facility* – analyzing savings from each EE measure in a project/facility collectively (IPMVP Options C & D).

Because the quantification process ordinarily involves direct observation of installed equipment or of its effects on whole-facility consumption, the process is referred to as direct measurement and verification, and a separate implementation verification step is not needed for the EE measures subject to this process.

Comparison group EM&V methods: an electricity savings quantification approach, based on the differences in electricity consumption patterns between a population of premises with EE projects or EE measures in place and a comparison group of premises without the EE projects or EE measures. Comparison group approaches include randomized control trials (RCTs) and quasi-experimental methods using nonparticipants and may involve simple differences or regression methods.

Applicable Guidance

- Determine which of the EM&V methods to apply for quantifying savings for each EE activity by referring to the *Applicable Guidance* in Sections 2.2.2 through 2.2.4.
- Apply the best-practice protocols and guidelines identified in those subsections and in Section 2.7 (Use of EE EM&V Protocols and Guidelines). Examples include but are not limited to:
    - International Performance Measurement and Verification Protocol (IPMVP, an international M&V protocol)[29]
    - Federal Energy Management Program (FEMP) M&V Guidelines[30]
    - American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) protocols and guidelines[31]
    - California Energy Efficiency Evaluation Protocols[32]

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[29] Evo-World. 2016. Available at: http://evo-world.org/en/.

[30] U.S. DOE Federal Energy Management Program. 2008. Available at: http://portal.hud.gov/hudportal/documents/huddoc?id=doc_10604.pdf.

[31] ASHRAE. 2016. *Resources & Publications*. Available at: https://www.ashrae.org/resources--publications.

- California Evaluation Framework[33]
- U.S. DOE, The Uniform Methods Project (UMP): Methods for Determining Energy Efficiency[34]

- If EM&V plans (as described in Section 1.3 above) specify the use of protocols or guidelines, provide a list of applicable minimum provisions from these documents as well as a description of the applicable sections and methods that they describe. Simply referencing a specific protocol or guideline is not sufficient. For example, the IPMVP provides for four quantification options with flexibility regarding a number of savings calculation assumptions. The details of how a particular protocol or guideline will be applied are critical.

- If using a combination method that consists of more than one of the three EM&V methods described here, clearly describe the basis and rationale for combining the methods. Examples of combination methods include:
  - Use of comparison group methods to determine savings relative to existing equipment, with engineering analysis using deemed parameters to adjust the result to savings relative to a standards/market CPB, as referenced in Section 2.2.4
  - Use of deemed savings to determining initial savings, with limited simulation analysis (M&V method, IPMVP Option D) to estimate adjustments for interactive effects

2.2.2. Deemed Savings Methods

Discussion

The deemed savings EM&V method uses pre-specified unit savings values or pre-specified formulas with some pre-specified parameter values as the basis for quantifying savings.

Because deemed savings values are agreed upon in advance, such values can help alleviate some of the guesswork in program planning and design. To ensure that the deemed savings method provides accurate savings estimates it is important to have a credible basis for the values applied and to ensure that criteria defined in applicable protocols and guidelines are followed. A best

Ex Post v. _Ex Ante_ Savings

The RMR requires that savings from EE activities are quantified after they occur. In applying the deemed savings method, it is important to distinguish between *ex post* savings determined after implementation and *ex ante* savings projected prior to implementation:

- *Ex ante* savings values are projected for a particular program, project, or measure, and may be developed by a variety of means, including custom engineering analysis or site-specific observations. They are not necessarily based on established unit deemed savings values or parameters.
- *Ex ante* savings are based on projected quantities of installed measures.
- Savings quantified on an *ex post* basis by the deemed savings method must be based on verified quantities of installed measures, with the verified mix of measure types and

[32] California Public Utility Commission. 2006. *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.* Available at: http://www.calmac.org/publications/EvaluatorsProtocols%5FFinal%5FAdoptedviaRuling%5F06%2D19%2D2006%2Epdf.

[33] California Public Utility Commission. 2004. *California Evaluation Framework.* Available at: http://www.calmac.org/publications/California%5FEvaluation%5FFramework%5FJune%5F2004%2Epdf.

[34] NREL. 2013-2015. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. Prepared by Cadmus Group. Available at: http://energy.gov/sites/prod/files/2013/07/f2/53827_complete.pdf.

practice from utility EE programs is to document deemed savings values or deemed formulas in a transparent and freely available manner in a spreadsheet, an online searchable database, or similar resource. The term commonly used for such resources is a technical reference manual (TRM).[35] As of this document's publication approximately 20 TRMs are in use across the United States at the state and regional level. The methodologies for deriving deemed values can vary across jurisdictions, and some TRMs include information based on prior-year EM&V. Other TRMs include values based on computer simulations or engineering algorithms.

Applicable Guidance

When to Use Deemed Savings Methods

- Apply deemed savings methods for relatively simple, well-defined EE projects or EE measures such as light bulbs or other electrical equipment for which the average operating characteristics that are the basis for the deemed values are well known, or where there is little uncertainty as to average unit savings.

- Do not apply deemed savings EM&V methods for unique and custom applications.[36] This includes EE projects with multiple EE measures with complex interactive effects that cannot be comprehensively and accurately taken into account and documented.

How to Apply Deemed Savings Methods

- Implement deemed savings methods by applying the following steps:
    1. Establish savings quantification formulas by specifying deemed parameter values, parameter applicability, and conditions for applying the formula. Deemed parameters may include per-unit savings values or average values of savings calculation formula inputs such as hours of use or equivalent full-load hours. The simplest form of a deemed savings calculation formula is simply savings per unit times number of units.
    2. Apply the formulas and documented measure counts to calculate pre-verified savings.
    3. Perform installation verification to confirm that units were installed, unit quantities, and appropriate application of deemed values and calculations. Installation verification may consist of reviewing independent third-party reports on measure installation rates based on customer surveys and/or onsite verification that installations were installed according to specification. The verification process may be based on a valid statistical sample that represents the entire population of EE projects or EE measures.
    4. Apply the formulas, parameters, and verified units to determine the total quantified savings.

- Ensure that deemed values are:

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[35] DOE. 2011. *Scoping Study to Evaluate Feasibility of National Databases for EM&V Documents and Measure Savings*. Prepared by Jayaweera, T.; Haeri, H.; Lee, A.; Bergen, S.; Kan, C.; Velonis, A.; Gurin, C.; Visser, M.; Grant, A.; Buckman, A.; The Cadmus Group Inc. Available at: http://energy.gov/sites/prod/files/2013/11/f5/emvscoping_databasefeasibility_appendices.pdf.

[36] For more complex EE projects or EE measures with significant savings variability, consider the use of direct M&V or comparison group methods instead of deemed savings. While direct M&V and comparison group methods may include the use of deemed values for certain parameters used in the calculation of savings, the incorporation of direct measurement or consumption data analysis moves such methods outside of the deemed savings category.

  - Based on EE activity type, applicability conditions, assumptions, calculations, and references that are publicly documented and available
  - Quantified as the most likely averages of electricity savings and other factors that determine such values over the lifetime of the EE measure, such as average occupancy, typical weather, typical operating hours, and EUL
  - Developed and vetted by independent, third parties and developed using analytical methods that are widely considered acceptable for the measure, purpose, and data sources (such as prior metering studies)
  - Appropriately adjusted if borrowed from secondary sources from other geographic areas

- Apply deemed savings methods as follows:
  - Use deemed savings methods to quantify savings from individual EE projects or EE measures. Apply these methods to a fraction of the total population of EE projects or EE measures and then scale using statistical sampling and estimation to represent electricity savings from the total population.
  - Apply deemed values only for the specific EE projects or EE measures for which the values were developed.
  - When a database or TRM with deemed savings values is updated based on new information, apply the revised deemed values and calculation methods only to EE projects or EE measures implemented after the effective date of the update. Do not apply the revised values to EE projects or EE measures for which EM&V has already been completed, unless the purpose is to develop and apply revised values was included in the EM&V Plan.
  - If deemed savings values, parameters, or formulas produces quantified electricity savings relative to a baseline that differs from the CPB in an EM&V plan for a respective EE project or EE measure, document and justify needed adjustments to the applicable deemed savings values, parameters, or formulas to ensure that electricity savings are quantified relative to the appropriate CPB or are otherwise more conservative than the CPB.

- Ensure that savings are adjusted for independent factors that affect energy consumption, as relevant, in accordance with Section 2.5.1.

Documentation

- Indicate the conditions for which each deemed savings value, parameter, or formula is applicable (e.g., climate, building type, end use, and measure implementation mechanism).

- Include information on the assumed baseline technology and conditions used to establish the deemed savings values, to ensure that deemed savings values reflect the appropriate CPB.

- Describe the CPB specification as indicated in Section 2.1 for each deemed savings value.

Resources

When applying deemed savings methods, use one or more best-practice protocols and guidelines. Examples include but are not limited to:

- ACEEE, Status and Opportunities for Improving the Consistency of Technical Reference Manuals[37]

[37] T. Jayaweera, A. Velonis, H. Haeri, C. Goldman, S. Schiller. 2012. *Status and Opportunities for Improving the Consistency of Technical Reference Manuals.* American Council for an Energy-Efficient Economy (ACEEE) Summer

- ACEEE, Behind the Curtain: Characterization of Measure Technologies within Technical Reference Manuals[38]
- ACEEE, Technical Reference Manuals Best Practices from Across the Nation to Inform the Creation of the California Electronic Technical Reference Manual (eTRM)[39]
- Public Utility Commission of Texas, Approach to Texas Technical Reference Manual – Revised for version 3.0 (Final)[40]
- State and Local Energy Efficiency Action Network, Energy Efficiency Program Impact Evaluation Guide[41]
- Northwest Power & Conservation Council Regional Technical Forum[42]
- Lawrence Berkeley National Laboratory and U.S. DOE, Using Deemed Savings and Technical Reference Manuals for Efficiency Programs and Projects Webinar[43]

2.2.3. Direct M&V

Discussion

Applying a direct M&V method involves obtaining measurements from an individual EE project or EE measure installation site as a basis for quantifying savings. For direct M&V-based savings quantification of individual EE projects or EE measures, the selected measurement technique is applied to a specific piece of equipment, for the site as a whole, or both. For direct M&V-based savings quantification of an EE program or group of EE projects or EE measures, direct M&V may be conducted for each project or measure in the group. It may also be conducted, as is more common, for a sample of projects or measures with the sample results then used to determine savings for the full group.

The application of direct M&V methods can establish accurate savings for most EE activities. However, these methods tend to be more expensive than deemed savings or comparison group methods. The cost for direct M&V is driven by factors such as the measurement equipment required, the measurement duration, the number of sample points needed at an individual project or measure site, and the number and complexity of sites to obtain the targeted accuracy. The selection of direct M&V versus other methods therefore involves trade-offs between cost and level of uncertainty in the EE savings values, but may also establish greater certainty in the quantified savings values.

Study on Energy Efficiency in Buildings. Available at: http://aceee.org/files/proceedings/2012/data/papers/0193-000150.pdf.

[38] Z. Tamble, M. Brown, B. Parnell, S. Lynch, R. Buckley, A. Maxwell. 2016. *Behind the Curtain: Characterization of Measure Technologies within Technical Reference Manuals.* ACEEE Summer Study on Energy Efficiency in Buildings. Available at: http://aceee.org/files/proceedings/2016/data/papers/2_1182.pdf.

[39] A. Beitel, T. Melloch, B. Harley, A, Mejia. 2016. Technical Reference Manuals Best Practices from Across the Nation to Inform the Creation of the California Electronic Technical Reference Manual (eTRM). ACEEE Summer Study on Energy Efficiency in Buildings. Available at: http://aceee.org/files/proceedings/2016/data/papers/6_1027.pdf.

[40] Public Utility Commission of Texas. 2013. Approach to Texas Technical Reference Manual – Revised for version 3.0 (Final). Prepared by TetraTech.

[41] State and Local Energy Efficiency Action Network. 2012. Energy Efficiency Program Impact Evaluation Guide. Available at: www.seeaction.energy.gov.

[42] Northwest Power & Conservation Council, Regional Technical Forum. About the RTF. Available at: http://rtf.nwcouncil.org/about.htm.

[43] Lawrence Berkeley National Laboratory and U.S. DOE. 2016. Using Deemed Savings and Technical Reference Manuals for Efficiency Programs and Projects. June 27, 2016 Webinar. Available at: https://emp.lbl.gov/sites/all/files/EMVWebinar_June2016.pdf and https://www.youtube.com/watch?v=PLnBkglQh68&feature=youtu.be.

Several protocols (e.g., the IPMVP[44]) are considered industry standards that define terms, establish procedures, and serve as an overall framework for conducting direct M&V for savings quantification of individual EE projects and EE measures. These best-practice protocols and guidelines define the type of consumption data and analysis used to quantify savings and provide information about which options to use for different types of EE activities. Common options and applications are summarized in Table 2-2 below. See the IPMVP for details.

Table 2-2. Common Direct M&V Options and Applications

Option	Name	Basis for Savings Calculation	Common Applications
A	Partially Isolated Retrofit	End-use measurements of some parameters, with other parameters deemed	Lighting, with hours of use metered and kW savings deemed based on wattage of installed equipment with market/standards baseline or
B	Retrofit Isolation	End-use measurement of electricity consumption or proxy, with no deemed parameters	Systems with variable loadings such as motors
C[45]	Whole-Facility	Metered electricity consumption for a whole facility, before and after EE is installed	Complex or combination measures affecting multiple systems, where combined savings are at least 10 percent of whole-facility consumption and the CPB can be justified as based on existing conditions
D	Calibrated Simulation	Simulated whole-facility electricity consumption with and without the EE in place, where the simulation model is calibrated to metered electricity consumption for the post-installation period	Complex or combination measures affecting multiple systems, where prior existing equipment efficiency is not the CPB

Each of the direct M&V options above quantifies savings as the difference in electricity consumption for an EE activity with the EE in place compared to the baseline case. The quantification uses combinations of engineering formulas and regression models to estimate annual electricity use, and is based on the metered or measured data for the post-installation operating conditions. Routine variations in independent variables such as occupancy, weather, production levels, and other interactive factors are captured in the range of measured or metered data or are accounted for by the formulas and modeling in order to derive annual electricity use under the specified conditions. The analysis used to translate the observed measurements into annual consumption values for the average post-installation condition of the independent variables is considered a “routine” adjustment.

Regardless of the direct M&V option used, the M&V process may also involve a custom or “non-routine” adjustment if the conditions for which savings are to be quantified are different from the conditions that were metered in ways that are not accounted for by the basic analysis formula or regression model. For

[44] Evo-World. 2016. Available at: http://evo-world.org/en/.

[45] Analysis of whole-premise metered consumption data (Option C of the IPMVP) may use similar building-level models to those applied for comparison group analysis described in Section 2.2.4. Two differences between the use of these models for site-level direct M&V and the comparison group analysis are:

1. Site-level direct M&V is designed to estimate savings relative to the appropriate baseline for the individual site. The comparison group analysis produces savings for a program or group of similar projects.
2. Site-level direct M&V uses additional information either to confirm that no other changes affected the facility over the analysis period, or else to support customized analysis to make any non-routine adjustments to savings estimates required to address changes. This type of custom, non-routine adjustment is not ordinarily included in comparison group analysis.

example, one-time changes to a building's occupied floorspace, operating shifts, or equipment types might involve non-routine adjustments.

Applicable Guidance

When to Use Direct M&V

- Use direct M&V methods for any type of EE activity where the physical address of installed measures is known.
- Use direct M&V methods used for EE activities for which reliable deemed savings methods and values are not available or not applicable, and for populations of EE projects or EE measures that are not in sufficient number or homogeneity for control group EM&V methods to be applicable or feasible, such as because a control group cannot be identified.
- Use direct M&V methods for EE activities that have highly savings variability or uncertainty due to differences in physical or behavioral characteristics across individual sites and applications. Also use direct M&V methods for large, complex projects or installations.

How to Apply Direct M&V

- To quantify savings from an EE program, either:
  - Conduct direct M&V for each project or measure in the program and scale the results to determine program-level savings.
  - Conduct direct M&V for a randomly selected sample of sites and use statistical sample expansion to determine program-level savings from the sample results.
- If statistical sampling and expansion will be used, ensure there is a large enough sample of EE projects within an EE program, a sufficient number of EE measures within an individual EE project site, and sufficient measurement quality across the EE program to meet statistical accuracy requirements.
- Ensure that direct M&V is conducted by staff who have the appropriate expertise, including:
  - Metering and measurement equipment selection, installation, sensing, and calibration
  - Statistical sampling and estimation methods for data collection related to facility electricity use
  - Engineering analysis for facility electricity use, including baseline specification
  - Field data collection quality control
- When measured or metered data results are combined with deemed parameters, match the observed data to the deemed values to ensure accurate results.
- Ensure that savings quantified by direct M&V methods use the CPB as defined in Section 2.1.[46] Before selecting a direct M&V method for EE activities with a CPB that is not existing conditions,[47]

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[46] Direct M&V is often conducted by equipment installers as a way to confirm that measures are working correctly or to demonstrate to the customer that they are achieving the expected improvements from the new equipment. These applications of direct M&V tend to use the existing equipment as the baseline, which may or may not be the required CPB as defined in the RMR and illustrated above.

[47] In the context of utility EE programs and privately-implemented EE activities, direct M&V methods are commonly used for EE projects and EE measures for which existing condition baselines are appropriate.

ensure that a viable approach exists for modifying existing condition baseline energy use measurements to equate to the correct CPB. In some instances this may not be viable. In other situations adjustments can be made, for example:
  - With a motor replacement project where the CPB is a new standard-compliant motor, IPMVP options A and B measurements of existing motor energy use can be adjusted with the use of a ratio of the efficiencies of a standard-compliant motor and the existing motor efficiency.
  - With a whole house retrofit project, where the CPB is a building energy code, IPMVP Option D could be used with a baseline building energy model calibrated for the existing house and then adjusted to code-compliant levels.

- Ensure that savings are adjusted for independent factors that affect energy consumption, as relevant, in accordance with Section 2.5.1.

- Quantify savings for the long-term, post-installation operating condition. If ongoing measurement is not used, use appropriate engineering and statistical methods to adjust the metered and measured data to the long-term annual average condition, normalizing results for weather, productivity, and other routine and non-routine factors as needed.

- Follow good statistical practices for sampling of sites, EE projects, or EE measures. Also follow good practices for sample design, sample management, and sample expansion to the full EE project or full EE program level.

- If direct M&V is conducted for a sample of EE projects or EE measures, verification may be conducted for that sample or on a separate sample from within the overall population of projects or measures. In the latter case, combine the quantified savings per measure from the direct M&V with the verified quantify of measures (e.g., equipment counts) to determine the total quantified savings.

- Follow rigorous quality assurance, quality control, and training procedures.

- For an EE activity that is an operational improvement, the CPB is based on the efficiency of the underlying equipment without the operational improvement, as described in Section 2.1. If the operational improvement can be cycled on and off at intervals over a full year, the CPB can be calculated from the periods when the improvement is off. This approach can be useful for EM&V of grid-side EE activities,[48] in particular.

- Tools designed to apply an automated analysis of consumption data[49] may be used to quantify savings by the direct M&V method, provided the general considerations described in this section

[48] Examples of grid-side EE activities include voltage and VAR optimization (VVO) and conservation voltage regulation (CVR), which produce electricity savings by reducing voltage at the electrical feeder level.

[49] Examples of such tools and their uses and performance in EM&V and other contexts are described in:

- DNV GL. 2015. *The changing EM&V Paradigm - A Review of Key Trends and New Industry Developments, and Their Implications on Current and Future EM&V Practices*. Prepared for the Northeast Energy Efficiency Partnership Regional Evaluation, Measurement & Verification Forum
- Granderson, J, Touzani, S, Custodio, C, Fernandes, S, Sohn, M, Jump, D. 2015. *Assessment of Automated Measurement and Verification (M&V) Methods*. Lawrence Berkeley National Laboratory, July 2015. LBNL#-187225.

are addressed. In particular, describe the quantification methods transparently and show how the analysis can provide savings relative to the appropriate CPB specification.

Documentation

Include the following as part of direct M&V-related documentation:

- Determination, identification, and isolation of measurement variable(s), including identification of the measurement variable and why was it selected (e.g., a ratio of ex post to ex ante project-level savings, duty factor for a residential air conditioner, on/off schedule for an industrial process).

- Sampling and expansion procedures, including how the sample was selected, how the number of sample points were determined, how the case weights were developed, identification of and reasoning for the coefficient of variation used to design the sample, how the individual measurement results were expanded to the population, and how the statistical error metrics were quantified (e.g., confidence and precision levels).

- Planning documents that describe how direct M&V application will be applied at the level of the EE activity, as appropriate. Planning should address questions such as: What type of direct M&V approach was used (e.g., one or more of the four IPMVP methods, a combination, an alternative method)? How were baselines selected and estimated, including how they conform to the specifications in Section 2.1? How was metering and monitoring conducted, including for how long? How was the data collected? What quality assurance and quality control procedures were used? How were electricity savings estimated?

- Reporting procedures, including how the savings results were compiled to produce overall reported savings estimates relative to the appropriate CPB.

Resources

When applying direct M&V methods, use one or more best-practice protocols and guidelines. Examples include but are not limited to:

- International Performance Measurement and Verification Protocols (IPMVP)[50]
- U.S. DOE, The Uniform Methods Project (UMP): Methods for Determining Energy Efficiency Savings, see Chapter 11 – Sample Design Cross-Cutting Protocols[51]
- California Energy Efficiency Evaluation Protocols (2006), see Measurement and Verification Protocol and Sampling and Uncertainty Protocol[52]
- California Evaluation Framework Study (2004), see Chapter 7: Measurement and Verification and Chapter 13: Sampling[53]

- Ethan A. Rogers, Edward Carley, Sagar Deo, and Frederick Grossberg. 2015. *How Information and Communications Technologies Will Change the Evaluation, Measurement, and Verification of Energy Efficiency Programs*. American Council for an Energy-Efficient Economy, Washington, DC.

[50] Evo-World. 2016. Available at: http://evo-world.org/en/.

[51] NREL. 2013-2015. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. Prepared by Cadmus Group. Available at: http://energy.gov/sites/prod/files/2013/07/f2/53827_complete.pdf.

[52] California Public Utilities Commission. 2006. *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals*. Prepared by: The TecMarket Works Team. Available at: http://www.calmac.org/publications/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf.

- Federal Energy Management Program (FEMP) protocols and guidelines[54]
- American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) protocols and guidelines[55]

2.2.4. Comparison Group

Discussion

As an EE EM&V method, comparison group methods are used to measure the effect of an EE activity on a group of end-use electricity consumers. This approach is most commonly used for evaluation of publicly-funded EE programs, such as customer-funded utility EE programs. The same methods can also be applied to quantify savings for a group of end-use customers that have implemented privately implemented EE activities.

Comparison group methods involve the analysis of whole-premises metered consumption data[56] for a group of customers who participate in an EE activity (the treatment group or program participants) and another group who did not participate (the comparison group). The comparison group indicates (directly or through additional analytics) the consumption or change in consumption the participating group would have had without the intervention. That is, the comparison group and associated analysis provides a baseline performance level or CPB against which savings are measured. When comparison group analysis is correctly applied, the comparison group represents the combined effect of the changes other than the EE activity being measured. To the extent the comparison group adequately reflects these other changes on average, explicit knowledge of and adjustment for these changes is not necessary.

An appropriate comparison group has minimal identifiable theoretic or empirical systematic differences from the treatment group, apart from the effect of the EE activity itself. The ideal basis for establishing a comparison group is by random assignment prior to implementing the EE activity. This technique avoids potential for bias, and also has statistically measurable accuracy. However, random assignment is compatible only with limited types of EE activities, as described below.

When comparison groups are established by methods other than random assignment, two common risks to comparison group validity should be addressed. These are applicability and self-selection. Documenting

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[53] California Public Utilities Commission. 2004. *The California Evaluation Framework*. Prepared by: The TecMarket Works Team. Available at: http://www.calmac.org/publications/California_Evaluation_Framework_June_2004.pdf.

[54] DOE. 2016. *Federal Energy Management Program*. Available at: http://energy.gov/eere/femp/federal-energy-management-program.

[55] ASHRAE. 2016. *Resources & Publications*. Available at: https://www.ashrae.org/resources--publications.

[56] Analysis of whole-premises metered consumption data can also be used as a site-level direct M&V method (IPMVP Option C) as described in Section 2.2.3. Additionally, an evolving EM&V approach referred to as M&V 2.0 is of potential interest for EE providers seeking ERC issuance for an EE activity. M&V 2.0 refers to recently-developed approaches to measurement and verification of savings using automated retrieval and processing of whole-premise metering data at high resolution due to advances in advanced metering infrastructure (AMI). These automated consumption data analysis tools may be used to implement direct M&V method "Option C" of the IPMVP protocol as described in Section 2.2.3, or comparison group approaches as described in Section 2.2.4, provided they are applied consistent with the guidance for those methods. These tools and approaches are not a different category of EM&V method. Instead, they can be a means of implementing whole-building consumption analysis for individual cases that is consistent with the direct M&V category of methods described in the RMR.

how the comparison method produces savings relative to the appropriate CPB includes explaining how these two risks are addressed by the comparison group specification and analysis.

1. ***Applicability***—In addition to being similar to those who participate in an EE activity in other ways, the comparison group must consist of energy using consumers or facilities for which the EE activity would have been applicable. Identifying such consumers or facilities can be challenging.

2. ***Self-Selection***—Even if the entire pool of consumers is considered eligible, those who choose to implement an EE activity at a particular time may be different from those in the general population in ways that can affect electricity use. For example, participants in an EE activity who are interested in installing energy-efficient equipment may have more efficient buildings to begin with and their consumption may respond differently than the typical non-participant's to changes in weather, the economy, or other factors affecting all customers.

After random assignment, a next-best basis for a comparison group is a "natural experiment" in which there are two very similar groups of participants in an EE activity. An example is one group who has a particular EE program, EE project, or EE measure offering available to them and another group who did not. Another example is to implement the natural experiment over time, using customers who participate in a subsequent year as a comparison group for the participants who participate in a current year. This approach involves:

- The EE activity and other major economic conditions are similar over the measured year and the year of subsequent participation.
- There are minimal changes associated with the decision to participate in an EE activity in a particular year.

In jurisdictions where advanced metering infrastructure (AMI) systems or "smart meters" have been installed for the applicable customer sectors, using daily or hourly consumption data can reduce statistical uncertainty for the estimated savings. This improvement can make it possible to use comparison group methods for smaller magnitude savings than would otherwise be possible. On the other hand, use of daily or more frequent data involves more complex techniques to determine correctly the statistical accuracy of the savings estimate.

Comparison group methods are most commonly applied in contexts where the CPB is based on by the existing conditions. With the appropriate analysis structure, other contexts can also be addressed by this method. See the list of applicable resources below for examples.

Applicable Guidance

When to Use Comparison Group Approaches

- Use comparison group methods to measure impacts of an EE activity or a collection of participating buildings as a whole, not to determine savings for individual EE projects or EE measures.

- Apply comparison group methods only if the following are all true:
  - The proposed comparison group with the planned analysis structure will provide a good representation of the participating group absent the EE activity.

- The expected statistical accuracy is adequate based on a power analysis or on the results from a prior study with similar analysis and conditions to the planned study (Appendix D of the California Protocols provides an example of how this can be implemented).[57]
- Whole-facility metered electricity consumption data are available for the participating and comparison groups, with at least bimonthly meter reads.
- Key likely systematic differences between the comparison group and participant group can be controlled for via observable variables.
- The comparison group and analysis method yield savings relative to the appropriate CPB, per Section 2.1. If this condition is met, separately determining the baseline efficiency of individual pieces of equipment is not needed.

How to Apply Comparison Group

- Ensure that practitioners hired to prepare such analysis have the specialized expertise necessary to implement a random assignment process, specify a comparison group, and perform analysis to isolate the intervention effect to produce savings relative to the CPB.

- Where possible, specify comparison groups using random assignment following best practices such as those described in resources from the SEE Action Network (2012)[58] and CALMAC (2016)[59]. The random assignment design must be specified in advance of delivery of the EE activity, and the EE delivery process must follow the design and random assignments. If such an assignment process is not practical for the program, use a quasi-experimental method. Specify the basis for establishing the comparison group.
  - If random assignment is used:
    - Provide the random assignment design.
    - Document the steps taken to ensure delivery of the intervention according to the random assignments.
  - If the EE activity did not follow a random assignment design, use a quasi-experimental approach.
  - If a non-random-assignment comparison group is used, specify the basis for the comparison group specification and the likely self-selection effects, and qualitatively assess the resulting effects on savings.
  - In cases where the comparison group for a particular program year or set of EE activities is re-analyzed in successive years to provide direct quantification of savings from surviving EE projects or EE measures, include a discussion of the basis on which the comparison group remains appropriate and valid.

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[57] California Public Utilities Commission. 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. Prepared by: The TecMarket Works Team. Available at: http://www.calmac.org/publications/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf. Qualitatively, attaining good statistical precision depends on having sufficiently large savings with a sufficiently large and homogenous group of facilities or installations, such as several hundred residential or small commercial customers. That is, the magnitude of expected savings is large compared to the expected random differences between the participant and comparison group averages.

[58] SEE Action Network. 2012. *Energy Efficiency Program Impact Evaluation Guide*. Available at: https://www4.eere.energy.gov/seeaction/publication/energy-efficiency-program-impact-evaluation-guide.

[59] CALMAC. 2016. *A White Paper: Residential Portfolio Impacts from Whole-Premise Metering*. Prepared for the California Investor Owned Utilities. Available at: http://www.calmac.org/publications/Res_Portfolio_Impacts_White_Paper_(Final)_DNVGL_1-22-2016_.pdf.

- Provide the basis for interpreting the results as savings relative to the appropriate CPB.
- Design the sample sizes to be large enough to ensure statistically significant savings values.
- Ensure that savings are adjusted for independent factors that affect energy consumption, as relevant, in accordance with Section 2.5.1.
- Collect sufficient consumption data from before and from after the intervention to include observations from each season and all operating patterns in each of the two periods (before and after). Typically this coverage involves 9 to 12 months of data from each of the two periods.
- If the comparison group consists of participants who did not replace EE equipment and the appropriate CPB corresponds to standard new equipment, conduct a separate adjustment to produce savings relative to the correct baseline. For examples of adjustment processes, see Goldberg et al., 1997[60] or Agnew, 2009.[61]
- If daily or more frequent consumption data are used, document the steps taken to ensure correct calculation of statistical accuracy.
- Apply tools designed for automated analysis of consumption data[62] to quantify savings by comparison group methods, provided the general considerations described in this section are addressed. In particular:
    - Describe the calculation methods transparently.
    - Clearly describe the comparison group selection process and show the process is appropriate for the EE-activity.
    - Show how the analysis can provide savings relative to the appropriate CPB specification.

Documentation

Include the following as part of a comparison group analysis documentation:

- If random assignment is used, a description of the randomization design, how it was implemented, what steps were taken to ensure adherence to the random assignments, and what deviations, cross-contamination, or drop-outs occurred
- The rationale for the comparison group specification, what the comparison group represents, what conditions are controlled for by the analysis

[60] M. Goldberg, T. Michelman, C.A. Dickerson. 1997. *Can We Rely on Self Control?* Proceedings of the 1997 International Energy Program Evaluation Conference. Chicago, IL.

[61] K. Agnew, M. Goldberg, B. Wilhelm. 2009. *A Pacific Northwest Efficient Furnace Program Impact Evaluation*. Proceedings of the 2009 International Energy Program Evaluation Conference.

[62] Examples of such tools and their uses and performance in EM&V and other contexts are described in:

- DNV GL. 2015. *The changing EM&V Paradigm - A Review of Key Trends and New Industry Developments, and Their Implications on Current and Future EM&V Practices*. Prepared for the Northeast Energy Efficiency Partnership Regional Evaluation, Measurement & Verification Forum
- Granderson, J, Touzani, S, Custodio, C, Fernandes, S, Sohn, M, Jump, D. 2015. *Assessment of Automated Measurement and Verification (M&V) Methods*. Lawrence Berkeley National Laboratory, July 2015. LBNL#-187225.
- Ethan A. Rogers, Edward Carley, Sagar Deo, and Frederick Grossberg. 2015. *How Information and Communications Technologies Will Change the Evaluation, Measurement, and Verification of Energy Efficiency Programs*. American Council for an Energy-Efficient Economy, Washington, DC.

- The estimation method and rationale, including how the analysis provides a valid estimate of savings with respect to the appropriate CPB, per Section 2.1
- The values of statistical accuracy
- A description of the data screening criteria used, and the data attrition at each screening stage
- The response rates if survey data are used in the analysis
- A discussion of the threats to validity of the analysis, including systematic errors and their potential magnitude

Resources

When applying comparison group methods, use one or more best-practice protocols and guidelines. Examples include:

- State and Local Energy Efficiency Action Network, Energy Efficiency Program Impact Evaluation Guide [63]
- U.S. DOE, The Uniform Methods Project (UMP): Methods for Determining Energy Efficiency Savings[64]
- CALMAC, A White Paper: Residential Portfolio Impacts from Whole-Premise Metering [65]
- Agnew et al., A Pacific Northwest Efficient Furnace Program Impact Evaluation[66]
- Goldberg et al, Can We Rely on Self Control?[67]

2.3. Effective Useful Life

Discussion

> **Key Term**
>
> **Effective useful life (EUL):** the duration of time an EE project or EE measure is anticipated to remain in place and operable with the potential to save electricity.

Electricity savings from an EE project or EE measure installed in a particular year accrue for the duration of time for which it is in place and operable. The typical practice for utility-customer funded EE programs and for many ESCOs is to apply one or more EM&V methods to quantify and report EE savings for the first year and then to credit savings based on this determined amount for each year of the lifetime of the project or measure. The length of time over which annual savings are credited is referred to as the effective useful life (EUL).

An alternative to specifying an EUL up front in the EM&V plan is annual verification, as described in the RMR. Annual verification means conducting installation verification activities on an annual basis and determining savings for each year using this new data collection. For relatively simple measures, the

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[63] SEE Action Network. 2012. *Energy Efficiency Program Impact Evaluation Guide*. Available at: https://www4.eere.energy.gov/seeaction/publication/energy-efficiency-program-impact-evaluation-guide.

[64] NREL. 2013-2015. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. Prepared by Cadmus Group. Available at: http://energy.gov/sites/prod/files/2013/07/f2/53827_complete.pdf.

[65] CALMAC. 2016. *A White Paper: Residential Portfolio Impacts from Whole-Premise Metering*. Prepared for the California Investor Owned Utilities. Available at: http://www.calmac.org/publications/Res_Portfolio_Impacts_White_Paper_(Final)_DNVGL_1-22-2016_.pdf.

[66] K. Agnew, M. Goldberg, B. Wilhelm. 2009. *A Pacific Northwest Efficient Furnace Program Impact Evaluation*. Proceedings of the 2009 International Energy Program Evaluation Conference.

[67] M. Goldberg, T. Michelman, C.A. Dickerson. 1997. *Can We Rely on Self Control?* Proceedings of the 1997 International Energy Program Evaluation Conference. Chicago, IL.

quantified and verified savings for each year may be the average savings per EE project or EE measure scaled by the counts of the number of installed or operating measures. For more complex EE projects or EE measures, annual direct M&V may be applied to determine changes in operating parameters. If the annual verification approach is used, the EM&V plan must specify how the results of the annual verification will be used to adjust the quantified and verified savings for each year.

The ideal basis for determining an EUL is by field observation. Of the three methods allowed by the RMR for establishing a pre-specified EUL (i.e., based on a recent applicable persistence study, deemed based on an applicable TRM, or based on an independent third-party laboratory lifetime testing protocol), a best-practice persistence study is the most accurate in most cases. A common interpretation and basis for estimating EULs from such a study is that an EUL is the median length of time that EE projects or EE measures are in place and operable. Interpretation of the EUL as a median or average life means that some projects or measures will fail or go out of service sooner and some will last longer.

Example EULs for particular EE activities are also provided. Table 2-3 identifies EULs based on a variety of industry sources. They are provided for illustration only and should not be assumed as best-practice EUL values for a particular EE activity.

Table 2-3. Illustrative Examples of EULs for Various EE Measure Types[68]

Sector	Measure Type	Illustrative EUL
Residential	Clothes Dryers*	12
Residential	Clothes Washers	11
Residential	Dishwasher	10
Residential	Faucet Aerator	10
Residential	Low Flow Shower Head	5
Residential	Pipe Insulation	13
Residential	Room Air Conditioners*	9
Residential	Water Heater – Heat Pump	11.2
Residential	Water Heater – Tankless	17.5
Nonresidential	Chiller	23
Nonresidential	HVAC Controls, VFD, Motors	15
Nonresidential	Walk-in Equipment (Nonres); Refrigerator and Freezers (Res)	12
Res/Nonres	Air Sealing (Package AC, Chiller Space Cooling, Heat Pump, Boiler)	11
Res/Nonres	Boilers	20
Res/Nonres	Furnaces*	15
Res/Nonres	Building Shell (Windows, Doors, Insulation)	19
Res/Nonres	Cool Roofs	15
Res/Nonres	Energy Management Controls	10
Res/Nonres	HVAC	15
Res/Nonres	Lighting – CFL*	5
Res/Nonres	Lighting – Other	11
Res/Nonres	Water Heater – Storage	13

[68] Values marked with an asterisk (*) are from U.S. EPA ENERGY STAR. Available at: https://www.energystar.gov/. All other values are from Savings Calculator Tool prepared by DNV GL for U.S. Department of Energy Office of Weatherization and Intergovernmental Programs, managed by Oak Ridge National Laboratory. Used for:

- April 2015 *National Evaluation of the State Energy Program*. Available at: http://energy.gov/eere/wipo/downloads/state-energy-program-national-evaluation.
- June 2015 *National Evaluation of the Energy Efficiency and Conservation Block Grant Program*. Available at: http://energy.gov/eere/wipo/about-energy-efficiency-and-conservation-block-grant-program.

Applicable Guidance

- Participate in collaborative and joint research to improve the breath and quality of EUL values (several such research activities are ongoing in states around the country).

Annual Verification

- If annual verification is used:
    - Specify in the EM&V plan that annual verification will be used and how the annual verification results will be used to determine the quantified and verified savings for each year.
    - For the initial year of installation and for each year thereafter, conduct verification in accordance with Section 2.4 to determine what portion of the total installed EE projects or EE measures remain in place and operable. Quantify savings based on the portion that is found to still be in place and operable.

Pre-Specified EUL

- Document the source of each pre-specified EUL for EE equipment installation or operational improvement, consistent with the three allowable categories in the RMR:
    1. Based on a recent applicable persistence study conducted according to the provisions of a best practice protocol for determining EUL values and with EUL estimated with 80/20 confidence/precision or better. An example of a best practices protocol for such studies is the Effective Useful Life Evaluation Protocol of the California Energy Efficiency Evaluation Protocols (2006).[69]
    2. Based on an applicable TRM, meeting the *Applicable Guidance* for specifying and updating deemed values under Section 2.2.2.
    3. Based on an independent third-party laboratory lifetime testing protocol.

- When a pre-specified EUL is used, the following lifetime equivalent EUL calculation may be applied to simplify annual quantification for dual baseline or combination measures. To apply this calculation, use a single lifetime equivalent annual savings (LEAS), as follows. Apply that savings quantity for each year from the first year of a dual-baseline EE project or EE measure installation through the full EUL, or for the longest EUL of a combination of measure denoted below by EUL_{max}.
    - For a dual baseline measure with annual savings S_1 from the first year through the RUL, and annual savings S_2 for the remainder of the EUL, calculate the lifetime-equivalent annual savings as:
      $$LEAS = (S_1 RUL + S_2(EUL-RUL))/EUL$$
    - For a combination measure with annual savings contributions S_c with EULs EUL_c for different measure components c, the lifetime-equivalent annual savings is quantified as:
      $$LEAS = \Sigma_c(S_c EUL_c)/EUL_{max}$$

[69] California Public Utilities Commission. 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. Prepared by: The TecMarket Works Team. Available at: http://www.calmac.org/publications/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf.

- The LEAS formulas may be applied to successive levels of aggregation of measures using a previously quantified LEAS in place of the savings S_c, and the corresponding full EUL or EUL_{max} on the right hand side of either formula.

2.4. Verification of EE Project or EE Measure Installation

Discussion

As described in Section 2.1, determining MWh savings from an EE activity involves both verification that an EE project or EE measure has been installed and quantification of total savings for the group of verified installations. Verification is applied for purposes of confirming both that the EE project or EE measure is in place and has the potential to save electricity. This means that the equipment or affected facility is in regular use. Site inspections, phone and mail surveys, and desk review of program documentation are typical verification activities. Verification may also include assessing baseline conditions and confirming that the EE projects or EE measures are operating according to their design intent.

Key Term

Verification (of EE project or EE measure installation): an assessment by an independent entity to ensure that the EE activities have been installed correctly and can generate the predicted savings.

Applicable Guidance

- Where practical (e.g. for an EE activity involving the installation of a small number of units or affecting a small number of facilities), conduct verification for each EE project or EE measure to confirm that the applicable equipment and systems are in place, capable of operating as intended, and have the potential to deliver the projected savings. Capable of operating as intended means that the equipment or affected facility is in regular use.
- In cases where verifying each EE project or EE measure is not feasible or practical:
  - Design a sample of such EE projects or EE measures, including corresponding sample expansion methods, using established statistical sampling and estimation practices. An example is described in Appendix B of the IPMVP.
  - Conduct verification for the sample.
  - Use the sample data and sample expansion methods to determine installation rates and other adjustment factors for the full EE activity.
- For the following common EE activities, use these verification strategies:
  - For **EE retrofits** or **early replacement**, confirm (1) installations of the indicated EE measures, (2) the efficiency levels and operating conditions of the installed measures and CPB, and (3) that the measures are operating correctly such that they can generate the predicted savings.
  - For **EE new construction projects** involving whole-building efficient design, confirm the building's actual specifications as built, confirm that the CPB specifications are appropriate, and review and confirm commissioning documentation.
  - For **EE point-of-sale rebate** or **distributor incentive programs**, confirm the sales data used for determining equipment counts and verify installation and operations with a sample of end-user purchasers.
- As described in Section 2.3:
  - If a **pre-specified EUL** is established, conduct verification once as part of the overall savings quantification and verification process.

  - If **annual verification** is used, repeat the verification each year for a given EE project or EE measure, and quantify a revised savings value for the surviving units based on verification findings.

- If **comparison-group methods** are applied as described in Section 2.2.4 or **direct M&V methods are applied using whole-facility analysis** as described in Section 2.2.3, the analysis is considered to provide a combination of savings quantification and verification. That is, the electricity savings quantified using a comparison group or direct M&V is based on electricity consumption data that reflect both what was actually installed and operating as well as the operational practices that affect savings. Separate verification activities are therefore not necessary.

- If direct **M&V methods** are applied as described in Section 2.2.3 in a manner that combines the M&V samples and processes, the M&V savings results may provide an adjustment factor to *ex ante* savings that reflects both installation verification and savings quantification. Therefore, a separate estimate of the installation rate or adjustment factor based on verification alone is not needed.

2.5. Additional Aspects of Savings Quantification

2.5.1. Independent Variables Affecting Electricity Consumption and Savings

Discussion

Observed changes in electricity consumption are the result of changes in a variety of independent variables and influences, in addition to the effect of the EE activity. These independent variables range from the outdoor temperature to occupancy levels in a building to industrial production levels. To isolate the electricity savings that result from an EE activity, each of these independent variables that is material to the savings determination must be controlled for. Controlling for independent variables is critical to the credibility of savings estimates, and distinguishes properly quantified savings values from a simple and unreliable comparison of electricity use before and after implementation of an EE activity.

Controlling for the independent variables means ensuring that:

- The quantified savings do not inadvertently include effects of changes in independent variables.
- The savings are quantified for correct values of the independent variables.

Independent variables are controlled for either by confirming that they are constant over the quantification periods, or by explicitly adjusting consumption or savings calculations to what would have occurred at other levels of the variables using engineering or statistical methods. Independent variables that are constant over the periods of interest – and that are consistent with assumptions used when applying one of the three allowable EM&V methods – do not involve explicit analysis or adjustment.

As described in Section 2.1, determination of the baseline consumption level depends on both the CPB and the operating conditions. Operating conditions are specified in terms of independent variables. Many EE activities affect equipment and systems in place, but don't affect how the equipment or facility is used (e.g., hours that a piece of equipment is operating). For such activities, the operating hours or other indicators of how the equipment is used are among the independent variables that must be considered in calculating savings. Operating conditions for determining baseline consumption are the post-installation operating conditions.

Key Term

Independent variables: variables (e.g., weather, occupancy, production levels) that affect electricity consumption and savings, and vary *independently* of the EE activity under study.

Other EE activities, such as installation of equipment control systems or new operating practices do affect how equipment or facilities are used. For these activities the operating pattern for determining baseline consumption is the practices that would have been in place during the post-installation period without the effect of the EE activity. In these cases, the independent variables that must be controlled for in the electricity savings calculations may be higher level indicators of the level of activity in the facility, rather than the runtime of the equipment. Since the runtime of the equipment is affected by the EE activity, it is not an independent variable.

For example, if the efficient lighting installed does not affect hours of lighting use, baseline consumption is calculated at the post-installation hours of use. If the efficient lighting activity includes new controls to reduce hours of lighting use, baseline consumption is calculated at the hours of lighting use that would have occurred in the post-installation timeframe absent the new controls. If the facility operating hours are different between the pre- and post-installation periods, the hours of lighting use for the baseline consumption calculation are based on the hours of use that would have been needed in the post-installation period, if the lighting controls were not present.

Each of the three EM&V methods described in Sections 2.1 has a mechanism for accounting for independent variables. For deemed savings values, independent variables are implicitly controlled for through the associated applicability conditions (see Section 2.2.2). For direct M&V, these variables are adjusted for via the use of regression analyses, computer simulation modeling, or engineering calculation (non-routine) adjustments. For comparison group methods, independent variables are controlled for through the comparison group specification and consumption data regression analyses.

Applicable Guidance

- Identify the independent variables that affect energy consumption and savings for the EE activity. At a minimum, consider the following and control for them as described below, unless they can be assumed to be constant over the life of the EE activity, or they will not affect energy savings for the activity.
    - Weather
    - Equipment or facility hours of operation
    - Activity level as measured by variables such as occupancy, number of shifts, manufacturing production level, or number of meals served.
- Within a single EE program, quantify savings for the constituent EE projects or EE measures using consistent assumptions for independent variables across different projects and measures. For example, use consistent forecasts of future weather within a given geographic area, and use consistent operating hours assumptions within a given market segment. Assumptions may vary across market segments and geographies based on known characteristics.
- Quantify EE savings using values of independent variables that are expected to apply over the life of the EE activity, using one of the following two approaches:
    - Actual conditions that exist over the period when EE savings occur, if these conditions are measured throughout the EUL (e.g., via ongoing direct M&V or annual verification)
        - With this approach, adjust baseline electricity consumption data to reflect actual independent variables observed after the measure is in place and fully operating.
        - Examples of independent variables based on actual post-installation conditions are:
            - Observed weather conditions for a residential heating efficiency project

- Observed occupancy rates for a commercial building lighting efficiency project
- Observed equipment production rates for an industrial efficiency project

> **Key Term**
>
> **Interactive effects:** increases or decreases in the use of electricity or fossil fuels that occur outside of the end uses targeted by a specific EE activity. For example, reduction in lighting loads through an energy-efficient lighting retrofit can reduce a building's air conditioning and increase heating requirements because less heat is generated by energy-efficient lighting systems compared with less efficient lighting systems. For purposes of the RMR, only interactive effects on electricity consumption are addressed.

- o Normalized or standardized (typical) conditions that can be reasonably expected to occur throughout the EUL
  - With this approach, both baseline and performance period data on electricity consumption are normalized to data on the independent variables, where reasonable and appropriate. Examples of normalized independent variables based on typical conditions are:
    - Typical weather conditions for a residential heating efficiency project
    - Typical occupancy rates for a commercial building lighting efficiency project
    - Typical equipment production rates for an industrial efficiency project

- Where first-year savings values—derived by applying first-year independent variables—are used to represent annual savings for the EUL of the EE project or EE measure, provide a justification for why this is a reasonable assumption (i.e., justify why first-year independent variables can be shown to represent standard/typical conditions over the life of the measure, consistent with the second sub-bullet of the previous main bullet).

2.5.2. Interactive Effects

Discussion

EE activities often have indirect impacts on electricity and fossil-fuel use in end-use systems not directly affected by the subject measures. There are two primary types of Interactive effects:

Equipment and facility improvement interactions. When multiple EE measures are installed at the same time, the savings from the combination of measures is often different from the sum of the savings that would result from installing each one absent the others. For example, savings from the combination of high-efficiency electric equipment, building shell improvements, and building controls is less than the sum of the savings from installing each of these without the others. The interactive effect can be addressed in one of two ways:

1. As an integrated calculation. Determine consumption with the combination of measures without any of the measures in place, and take the difference.
2. As a sequence of EE measure-specific calculations. In this case the order in which the measures are assumed to be installed matters. In the example above, taking the measures in the indicated order, savings would be calculated for the following:
   a. the high-efficiency electric equipment by itself
   b. the building shell improvements with the high-efficiency electric equipment included in the baseline specification

c. the building controls, with the high-efficiency equipment and building shell improvements included in the baseline specification.

Both these methods should produce the same savings for the combination, but the second method allocates savings to the separate EE measures, according to the assumed installation sequence.

Inter-end-use interactions: Certain EE measures indirectly affect an end use or system other than the one directly affected by the measure. For example, installing efficient lighting in a building's cooled and heated space can decrease the electricity use of cooling systems and/or increase energy use in heating systems. To address inter-end-use interactive effects, it is necessary to identify the other end uses affected by the measure, and calculate the associated change, usually using engineering calculations. For example, the change in heating and cooling loads due to a lighting improvement is determined by applying an interactive factor to the lighting energy savings. The interactive factor accounts for the proportion of the lighting energy that is consumed in heated or cooled space. (See for example UMP Chapter 2 on Commercial and Industrial Lighting Evaluation, Section 3.)

Applicable Guidance

- Specify in EM&V plans how interactive effects on *electricity consumption* will be quantified.
  - If interactive effects are treated as zero, justify why this is an appropriate assumption.
  - If **deemed savings** methods are used, include interactive effects in the deemed savings values or separately estimate these effects using deemed methods.
  - If **direct M&V** methods are used,
    - Quantify interactive effects explicitly if methods based on sub-facility measurements, such as isolated retrofits or partially isolated retrofits, are used.
    - Incorporate interactive effects directly into the savings calculations if building simulation is used. Most building simulation tools and approaches are designed to incorporate interactive effects in their savings calculations.
  - If **comparison group** methods are used, do not make an additional adjustment for interactive effects. With these methods, interactive effects on the same fuel are automatically incorporated in the savings calculations.

- Use the UMP[70] or other applicable protocols and methods to estimate interactive electricity effects.

- The RMR does not address the issue of quantifying the interactive effects on end-use fossil fuel use (i.e., non-electricity fuels such as natural gas). However, these cross-fuel effects have implications for overall CO_2 emissions and assessing them is therefore a best practice in many states.

2.5.3. Transmission and Distribution (T&D) Savings and Adders

Discussion

The difference between the electricity generated (busbar value) and consumed (end-user meter value) is due to losses in the transmission and distribution (T&D) system. U.S. Energy Information Agency (EIA) data from 1990 to 2012 indicates that national, average annual T&D electricity losses are about 6 percent of the

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[70] U.S. DOE's Uniform Methods Project (UMP) is one such example. See UMP chapter 2 for details.

NREL. 2013-2015. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. Prepared by Cadmus Group. Available at: http://energy.gov/sites/prod/files/2013/07/f2/53827_complete.pdf.

electricity that is transmitted in the United States.[71] Every unit of electricity consumption avoided through EE activities at an end-use site also avoids losses that would have occurred as that electricity was delivered through the T&D system. *Applicable Guidance* on how T&D savings can be added to end-use electricity savings values follows.

Key Terms for Accuracy

Accuracy: how close an estimate is to the true value it estimates. The term can be used in reference to a point estimate resulting from a sequence of analytic steps, model coefficients, a set of measured data, or a measuring instrument's capability.

Applicable Guidance

- For EE projects and EE measures that do not otherwise incorporate avoided T&D losses in their quantification, a T&D loss factor may be calculated in accordance with the RMR. The total savings for an EE project or EE measure can then be adjusted by multiplying the total verified energy savings by the T&D loss factor. The T&D line-loss rate should be rounded to the nearest thousandth (i.e., expressed in no more than three decimal points) before applying the adjustment.
    - For example if total savings were 100,000 MWh and the calculated T&D loss factor was 0.050, then total claimed energy savings inclusive of T&D losses would be 105,000 MWh.

- Include references to EIA 861 data and explicit variables used in calculation of the T&D loss factor, the type loss factor applied (i.e., utility specific or statewide), and rationale for selection of the loss factor.

2.5.4. Accuracy of Savings

Discussion

A best practice for EM&V planning among customer-funded EE programs administered by utilities is to characterize the accuracy of how EE savings will be determined based upon the selected EM&V methods. The accuracy of quantified savings is a function of the following two types of error:

- **Systematic error:** estimation errors that may cause an estimate (such as an electricity savings value) to be consistently either overstated or understated. Systematic errors are also referred to as bias, and may result from incorrect assumptions, a methodological issue, or a flawed reporting system.
- **Random error:** estimation errors occurring by chance that may cause an estimate (such as an electricity savings value) to be overestimated or underestimated with no systematic tendency in either direction, resulting from uncontrolled and unobservable factors affecting the underlying measurements.

The magnitude of random error can be quantified based on the variations observed across different EE projects or EE measures. It is important to report such random error, describe the steps that have been taken to minimize the potential for systematic error, and provide a subjective assessment of the potential effects of both types of error.

The key sources of quantifiable random error that can result from applying EM&V methods include:

- **Random sampling error**, including error that results from the selection of samples of customers, EE projects, or EE measures within an EE program; selection of individual EE measures to be observed within a facility; and random assignment in the context of comparison group methods

[71] EIA. 2016. *How much electricity is lost in transmission and distribution in the United States*? Accessed September 14, 2016. Available at: http://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3.

- **Modeling error**, when a regression model or other statistical estimation is used to estimate savings or savings parameters

Applicable EM&V Approach

- Design assumptions needed for savings quantification to provide neither optimistic savings estimates (aiming to err on the high side) nor conservative estimates (aiming to err on the low side).

- If sampling is used to quantify savings values, report the achieved confidence/precision of the associated estimates.

- Apply and cite applicable best-practice protocols and guidelines documents for sampling. Examples of best practices for statistical sampling are described in the following resources:
    - ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources[72]
    - The California Evaluation Protocols[73]
    - Uniform Methods Project *Sample Design Cross-Cutting Protocol* (Chapter 11) [74]

- For states trading ERCs across borders, coordinate across jurisdictions in an attempt to apply the same or consistent EM&V approaches to ensure the savings values are quantified with comparable levels of accuracy.

- For all EM&V methods, document potential sources of quantifiable statistical error (and associated quality-control measures) in EM&V plans and monitoring and verification (M&V) reports.

- For **deemed savings**:
    - Describe reasons the deemed savings values or parameters may not be valid in the context of their applicability conditions.
    - Quantify random errors if applicable.
    - Calculate and report the statistical error of any EM&V parameters determined using sampling.

- For savings determined by **comparison group** methods, report the statistical confidence intervals or confidence and relative precision levels of the program savings measured by the comparison group analysis. Examples of protocols and guidelines that describe how this can be implemented include:
    - SEE Action Guide on evaluating behavior programs[75]

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[72] ISO-NE. 2012. *Measurement and Verification of Demand Reduction Value from Demand Resources*. Available at: http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/mrkts/mtrls/2012/apr10112012/a05_m_mvdr_redlined_04_04_12.pdf.

[73] California Public Utilities Commission. 2006. *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals*. Prepared by: The TecMarket Works Team. Available at: http://www.calmac.org/publications/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf.

[74] NREL. 2013. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures: Chapter 11: Sample Design Cross-Cutting Protocols. Available at: http://www.energy.gov/sites/prod/files/2013/11/f5/53827-11.pdf.

[75] State and Local Energy Efficiency Action Network. 2012. Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations. Prepared by Todd, A.; Stuart,

- Uniform Methods Project Sample Design Cross-Cutting Protocol (Section 11)[76]
- Uniform Methods Project Whole-Building Retrofit Evaluation Protocol (Section 8)[77]

- To determine the quantifiable statistical error for the sum of quantified savings from several EE programs, projects, or measures, the following formula may be used if the savings estimates were all based on independent samples or data sets:

  $RP(S_{TOT}) = [\Sigma_k (S_k\, RP(S_k))^2]^{1/2}/S_{TOT}$

  Where

  S_k = quantified savings for program k
  $S_{TOT} = \Sigma_k S_k$
  RP(S) = relative precision of S at 90% confidence, that is the half-width of the 90% confidence bound, as a percent of the point estimate.[78]

- To determine the quantifiable statistical error for quantified savings that is the product of a series of adjustment factors to an *ex ante* estimate, where the factors are all determined from different independent data sets, the following approximation may be used:

  For $S = A_1A_{2\ldots}A_kS_0$, where S_0 is known (not statistically estimated)

  $RP(S) \simeq [RP(A_1)^2 + RP(A_2)^2 + \ldots + RP(A_k)^2\,]^{1/2}$

- To determine the quantifiable statistical error for quantified savings for EE activities in which the individual EE project and EE measure project savings estimates are not statistically independent, statistical theory can be used to show that the relative precision at 90 percent confidence is not more than 10 percent (versus determining the exact confidence interval for the sum of estimates). Specifically, statistical theory shows that the relative standard error[79] of the sum is less than or equal to the savings-weighted average of the individual standard errors:[80]

  $RSE(S_{TOT}) \leq SUM_j\,(S_j/S_{TOT})RSE_j$

E.; Schiller, S.; Goldman, C.; Lawrence Berkeley National Laboratory. Available at: https://www4.eere.energy.gov/seeaction/system/files/documents/emv_behaviorbased_eeprograms.pdf.

[76] NREL. 2013. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures: Chapter 11: Sample Design Cross-Cutting Protocols. Available at: http://www.energy.gov/sites/prod/files/2013/11/f5/53827-11.pdf.

[77] NREL. 2013. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures: Chapter 8: Whole-Building Retrofit with Billing Analysis Evaluation Protocol. Available at: http://www.energy.gov/sites/prod/files/2013/11/f5/53827-11.pdf.

[78] For example, if the 90% confidence interval is 50 ± 10, the relative precision at 90% confidence is 10/50 = 20%. The half-width is 10, the "±" quantity, since the confidence interval width, from 50-10 to 50 +10, is twice this quantity.

[79] The standard error of the estimate is a measure of the accuracy of the estimate, and is used to calculate the confidence interval. For large samples under common assumptions, the 90 percent confidence interval is the estimate + 1.645 times the standard error.

[80] For example, suppose the EE activity addresses two EE programs where savings for program A is 25 percent of the total and has an 8 percent relative standard error, and savings for program B is 75% of the total and has a 4 percent relative standard error. Then the standard error for the sum of A and B has relative standard error less than or equal to 0.25 x 8% + 0.75 x 4% = 5.0% of the sum. If the normal distribution applies, the relative precision at 90 percent confidence is then less than or equal to 1.645 x 5.0% = 8.2 percent, so that the requirement for less than or equal to 10 percent relative precision is satisfied.

2.5.5. Avoiding Double Counting

Discussion

Double counting occurs when the MWh savings from a single EE program, EE project, or EE measure are counted more than once. It is critical to prevent this type of error to maintain programmatic integrity and credibility, and to ensure that EE activities result in real and permanent reductions in CO_2 emissions. Tracking, accounting, and quality checks are steps that are routinely undertaken in states and regions across the country to avoid double counting of EE activities. The purpose of these steps is to avoid the following circumstances:

- Savings from a single EE activity being claimed by more than one EE provider. For example:
  - Some or all savings from the same retrofit being claimed both by a residential behavior-based program and a retailer point-of-sale incentive program[81]
  - Savings from a single retrofit project being claimed by a utility incentive program and the ESCO that implemented the retrofit

- Two or more EE activities operating during different years both claiming savings from the same EE projects or EE measures. For example:
  - A 2020 program incenting an LED lamp with a pre-specified EUL of 10 years, with the lamp failing after 2 years and being replaced by a new LED lamp that receives an incentive from another program

- Two or more EE activities claiming savings that result from interactive effects between EE projects or EE measures, as described in section 2.5.2 (*Interactive Effects*)

- Inconsistent baselines across a portfolio of EE programs. For example:
  - One EE program claiming savings from enacting a Building Energy Code and Equipment Energy Standard (C&S) with 100-percent compliance that results in savings above a prior C&S or common practice, and another program claiming savings with a baseline defined below the new C&S (e.g., a baseline defined by a prior C&S) for the same types of EE activity
  - A state claiming credit for federal actions such as building code determinations or appliance standards

Applicable Guidance

- Implement systematic tracking and accounting procedures, including the use of well-structured and well-maintained tracking and reporting systems such as those already being used by many states and EE providers.

- Implement the following procedures to avoid or correct for double counting:
  - For EE activities with identified consumers, conduct tracking (type and number of EE projects or EE measures implemented) at the utility-customer level using customer name, address, account number (where available) and applicable dates for each activity.
  - For EE activities without identified consumers, such as point-of-sale rebates and retailer or manufacturer incentive programs, track applicable vendor, retailer, and manufacturer

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[81] This potential for double counting is particularly important in the context of randomized encouragement programs, where part of the savings seen in treatment/control differences is due to increased participation in general offering programs.

data. Include the appropriate specifications and quantities of EE equipment sold or shipped.
  - Where practical, such as where multiple EE providers share a common tracking database, use the consumer-level data to identify and correct for duplicate EE activity records across programs with "trackable" consumers and across non-program projects such as private-sector transactions for projects sponsored by an ESCO.
  - Where it is not practical to identify overlap by matching records from tracking data, conduct surveys to collect information to estimate the degree of overlap.
  - Identify and correct for duplicate EE activity records across EE programs and non-program projects such as private-sector transactions for projects sponsored by an ESCO.
  - Identify instances where tracked consumer activity is likely to be double counted with upstream activity and subtract the estimated overlap from one or the other's savings claims.

- For EE activities with identified consumers but without identified equipment or installations (e.g., an information or behavioral program), apply the following steps to eliminate double counting with EE activities that do not have identified consumers (e.g., upstream programs):
  - Use surveys of the participating and control groups to estimate the extent of incremental non-tracked EE activity (such as from upstream EE programs) among the participating group.
  - Subtract the savings from this incremental non-tracked activity amount from either the informational/behavioral EE program or the upstream program total, or split the amount to be subtracted between the two.
  - See the SEE Action Guide[82] or the UMP protocol[83] for evaluating behavioral programs for further information.

2.6. Timeframes for Reporting Savings and ERC Issuance

Discussion

Current practice with utility customer-funded EE programs for reporting electricity savings varies across states and EE providers with regard to the specific content requirements, definitions, and timing. Local policy objectives, the breadth of EE activities addressed, and other factors typically drive decisions about such reporting considerations. Public utility commissions (PUCs) that oversee such customer-funded EE programs typically set requirements for how to report incremental and also whether to report continuing savings. Other sources of reporting formats and structures apply to projects funded by the Federal Energy Management Program

> **Key Terms for Savings Reporting**
>
> **Reporting-period incremental savings:** the electricity savings quantified and verified as a result of EE activities operating for the first time in the reporting period.
>
> **Reporting-period continuing savings:** savings that occur in a particular reporting period as a result of EE activity implemented in a prior reporting period.

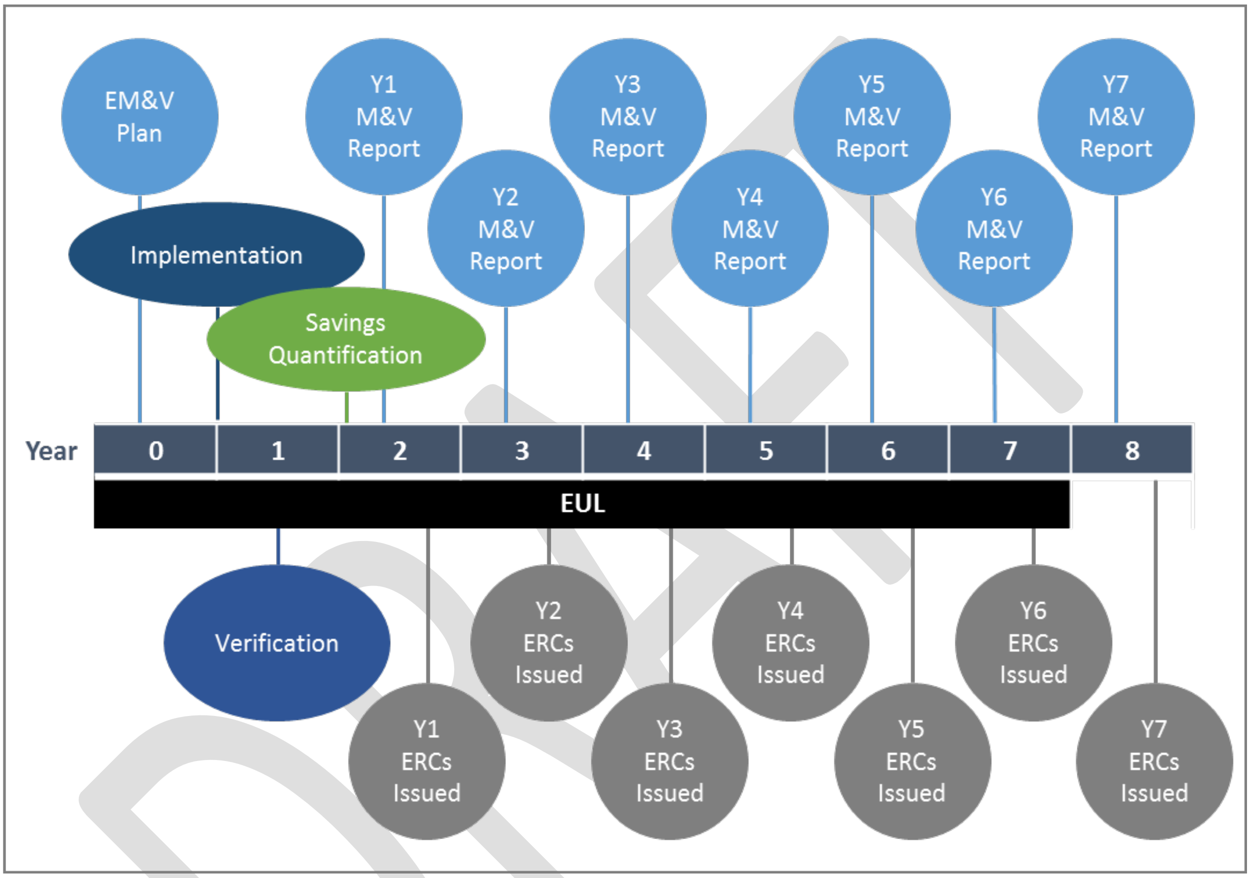
[82] SEE Action. 2012. Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations. Available at: https://www4.eere.energy.gov/seeaction/publication/evaluation-measurement-and-verification-emv-residential-behavior-based-energy-efficiency.

[83] NREL. 2013. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Prepared by Cadmus Group. Available at: http://energy.gov/sites/prod/files/2013/07/f2/53827_complete.pdf.

and data reported via the Energy Information Agency's (EIA) Form 861.[84] In the context of *ex-post* reporting to PUCs, EE providers almost universally quantify savings by applying one of the EM&V methods described above in Section 2.1.

For purposes of the RMR, the applicable reporting provisions are described in Section V.C.4.e and are not repeated here. As an example of how this could work in practice, the figure below presents one possible scenario for ERC issuance to an EE provider and shows the hypothetical timeframe from when an EM&V plan is developed to when ERCs are issued.

Figure 2-2. Illustration of Timeframes from EM&V Plan through ERC Issuance



This example is not intended as a substitute for a thorough review of the applicable RMR provisions. In the event of any discrepancy between the CPP or RMR and this *Draft Guidance*, the CPP and RMR is controlling. In this example:

- The EM&V Plan is filed the year before the Year 1 implementation.
- The pre-specified EUL established in the EM&V plan is 7 years.
- The EE activity is implemented in Year 1 (Y1).
- Verification is completed in the same year as implementation.
- EE savings quantification is completed in Year 2 (Y2), for EE activity completed in Year 1 (Y1).

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[84] DOE. 2016. *Federal Energy Management Program*. Available at: http://energy.gov/eere/femp/federal-energy-management-program.

EIA. 2016. Electric power sales, revenue, and energy efficiency Form EIA-861 detailed data files. Available at: http://www.eia.gov/electricity/data/eia861/.http://www.eia.gov/electricity/data/eia861/.

- Quantified savings for the Y1 activity are submitted in an M&V report in the same year as the completion of the savings quantification. Savings include incremental savings occurring in Y1 from the Y1 program year.
- ERCs are issued for the Y1 activity upon approval of the M&V report in Year 2.
- ERCs for successive years through the EUL are issued at the end of each of Years 3 through 8, after an M&V report is submitted and approved for the previous year based on the M&V report completed in Year 2. Each M&V report includes incremental savings from that year, plus continuing savings in that year from the previous program years. For example, the Y3 M&V report (submitted in Y4), includes incremental savings from the Y3 program year, plus continuing savings occurring in Y3 from the Y1 and Y2 program years.[85]
- No additional ERCs are issued for those measures installed in Year 1 implementation beyond the end of the EUL.

The actual timing will vary across EE activities and by EE provider. *Applicable Guidance* is provided below.

Applicable Guidance

Considerations for Submitting an M&V Report and Claiming ERCs

- For an ongoing EE program, submit an M&V report for ERCs for a particular EE program period's EE savings only if the EM&V for EE projects and EE measures installed in that program period is completed and documented.

- Do not report for continuing savings that will occur in a future period, even if the EM&V for the EE activity has been completed and the savings for a future period are projected.

- For EE programs that involve the ongoing installation of EE projects and EE measures, report both incremental and continuing savings. That is, report incremental savings (the savings from EE newly implemented in that period) and continuing savings (the sum of savings from previously implemented EE) for each period.

- The savings quantity for a given EE activity for a particular period may vary over the EUL in the following circumstances: if a dual baseline is used, if the EE activity is a combination of EE projects or EE measures with different EULs, or if the savings change over different periods within the EUL due to factors addressed in Section 2.3.

- If the EUL is not a whole number, but is a whole number plus a fraction less than one, for the final, fractional part-year quantify the savings as the annual savings times the fraction. For example if the EUL is 6.4 years, in the 7th year the quantified savings will be 0.4 times the annual value for that year.

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[85] This example assumes that the EE providers submit an M&V report and are issued ERCs one time per year. Note however that the RMR provides for a rolling ERC issuance process rather than annual issuance. A full discussion of the associated requirements, process, and roles and responsibilities of different parties involved in ERC issuances can be accessed at Section V.C.4.e of the RMR. In the event of any discrepancy between the CPP or RMR and this *Draft Guidance*, the CPP and RMR is controlling.

- If deemed savings values, formulas, or parameters are revised, apply the revisions only to EE activities implemented after the revisions are formally adopted, not to continuing savings from previously implemented EE.

2.7. Best Practice EE EM&V Protocols and Guidelines

Best practices for quantifying EE savings are documented in a series of publicly available EM&V protocols and guidelines. As previously noted, these resources are an outgrowth of the utility customer-funded EE programs and private-sector ESCO projects in place in most states across the country. Table 2-4 lists a set of commonly used protocols and guidelines that define, provide instructions for use, and generally govern the application of EM&V methods. The EPA supports the use of these resources in state plans, and encourages the ongoing development and refinement of such best-practice resources over time. Because the protocols and guidelines listed below are not designed specifically for purposes of satisfying the applicable RMR provisions, they should be interpreted and implemented on a case by case basis with consideration of a particular state's rate-based state plan.

Table 2-4. Examples of Best-Practice EE EM&V Protocols and Guidelines[86]

Protocol/Guideline *Sponsor*	Website	Summary
Federal Resources		
2013 to 2015 Published Protocols of the Uniform Methods Project (UMP) (2013-2016) *U.S. Department of Energy (DOE)*	http://www.energy.gov/eere/about-us/ump-protocols	Applied protocols for quantifying savings from common EE programs, measures, and technologies based on widely accepted methods.
Uniform Methods Project (UMP) Whole-Building Retrofit Evaluation Protocol. Chapter 8: Whole-Building Retrofit with Billing Analysis Evaluation Protocol (2013) *U.S. Department of Energy (DOE)*	http://energy.gov/sites/prod/files/2013/05/f0/53827-8.pdf	Applied protocol for quantifying savings from whole-building retrofits.
Energy Efficiency Program Impact Evaluation Guide (2012) *State and Local Energy Efficiency Action Network - U.S. Department of Energy and U.S. Environmental Protection Agency (SEE Action)*	https://www4.eere.energy.gov/seeaction/publication/energy-efficiency-program-impact-evaluation-guide	Information resource and guide describing common terminology, methods, and assumptions used to determine electricity savings, avoided emissions, and other non-energy benefits resulting from facility (non-transportation) EE programs.
Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans (2012) *U.S. EPA*	https://www.epa.gov/sites/production/files/2016-05/documents/eeremanual_0.pdf	Information resource and guide for incorporating EE and RE policies and programs into State and Tribal implementation plans (SIPs/TIPs).

[86] Table 2-4 lists of some of the protocols and guidelines that can be considered best-practice, are publically available, and have been promulgated and/or adopted by a state, regional, national, or international organization.

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Protocol/Guideline *Sponsor*	Website	Summary
Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations (2012) *State and Local Energy Efficiency Action Network - U.S. Department of Energy and U.S. Environmental Protection Agency (SEE Action)*	https://www4.eere.energy.gov/seeaction/system/files/documents/emv_behaviorbased_eeprograms.pdf	Information resource and guide that describes methodologies for quantifying savings from residential behavior-based EE programs.
FEMP M&V Guidelines (2008) *U.S. DOE Federal Energy Management Program*	http://portal.hud.gov/hudportal/documents/huddoc?id=doc_10604.pdf	Applied protocol for quantifying EE savings associated with federal agency performance contracts.
Other Resources		
International Performance Measurement and Verification Protocol (IPMVP) (2016) *Efficiency Evaluation Organization*	http://www.evo-world.org	Applied protocol for determining savings from EE projects and measures. The IPMVP does not apply to EE programs consisting of many EE projects or measures.
Regional Technical Forum (RTF) (2016) *Northwest Power and Conservation Council*	http://rtf.nwcouncil.org/	Advisory committee established to develop standards for quantifying savings from a wide range of EE projects and measures. The RTF also maintains an extensive and well documented database of deemed savings values.
PJM Manual 18B: Energy Efficiency Measurement & Verification (2015) *PJM Interconnection*	https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB8QFjAA&url=https%3A%2F%2Fwww.pjm.com%2F~%2Fmedia%2Fdocuments%2Fmanuals%2Fm18b.ashx&ei=m9xHVceiEMvJtQXviYDoDw&usg=AFQjCNEQb0Z65Y_2ESjjdAP10sPjZb94Mw&sig2=Ydqecugs2PPnuJTwxmtPIw&bvm=bv.92291466,d.b2w	Applied protocol for quantifying and verifying the demand reduction value of EE programs, projects, and measures for the PJM capacity market, referred to as the Reliability Pricing Model (RPM).
ASHRAE Guideline 14, Measurement of Energy and Demand Savings (2014) *American Society of Heating, Refrigerating, and Air-Conditioning Engineers*	http://www.ashrae.org	Applied protocol for quantifying EE savings from EE projects and measures.

Protocol/Guideline ***Sponsor***	**Website**	**Summary**
ISO-NE Measurement and Verification of Demand Reduction Value from Demand Resources – Manual M-MVDR (2014) *Independent System Operator – New England*	http://www.iso-ne.com/participate/rules-procedures/manuals	Applied protocol for quantifying and verifying the demand reduction value of EE programs, projects, and measures for forward capacity market (FCM) administered by ISO-NE.
NEEP Regional-Common EM&V Methods and Savings Assumptions Guidelines (2010) *Northeast Energy Efficiency Partnership*	http://www.neep.org/regional-emv-methods-and-savings-assumptions-guidelines-2010	Information resource and guide that describes best-practice approaches for quantifying gross energy/demand savings and identifying input assumptions for key EE program types.
California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals (2006) *California Public Utility Commission*	http://www.calmac.org/publications/EvaluatorsProtocols%5FFinal%5FAdoptedviaRuling%5F06%2D19%2D2006%2Epdf	Applied protocol and guide that documents acceptable EM&V approaches and procedures for quantifying and verifying savings from California's EE programs and program portfolios.

It should be noted, that while EPA encourages the use of best-practice EM&V protocols and guidelines, it recognizes that these resources do not provide a step-by-step "recipe" for quantifying savings under the RMR. The EPA also recognizes that the application of EM&V protocols and guidelines requires professional judgment and assessment of the EE activities to determine the appropriate EM&V method and other assumptions to apply. For this reason, the RMR includes provisions to ensure that EM&V plans provide a detailed description of how such protocols and guidelines will be applied.

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Glossary of Terms

This glossary includes only terms that are applied in this *Draft Guidance*.[87]

Accuracy: how close an estimate is to the true value it estimates. The term can be used in reference to a point estimate resulting from a sequence of analytic steps, model coefficients, a set of measured data, or a measuring instrument's capability.

Adoption: process and actions required to put a code in place formally, such as a rulemaking process.

Affected EGU: any steam generating unit, integrated gasification combined cycle (IGCC) facility, or stationary combustion turbine that is affected by the CPP.

Baseline consumption: the electricity consumption that would have occurred at the baseline efficiency level and operating conditions.

Baseline efficiency: the efficiency level that would have been in place without implementation of a specific EE activity.

Code: legal EE requirements that apply to the design and construction of buildings, usually for new buildings and for renovations and additions to existing buildings.

Common Practice Baseline (CPB): the level of energy performance that would occur, in the absence of the EE project or EE measure, at the more energy efficient of either: (1) the highest level of energy efficiency required by the applicable federal, state, or local building energy code or product or equipment standard, if any (i.e., the code or standard that corresponds to the lowest electricity consumption of the buildings or equipment it applies to, all else equal); or (2) the expected technology, operating conditions, or practices that would have existed at the time of implementation or the likely subsequent replacement within the EUL of the EE project or EE measure, in the absence of the EE project or EE measure.

Comparison group EM&V methods: an electricity savings quantification approach, based on the differences in electricity consumption patterns between a population of premises with EE projects or EE measures in place and a comparison group of premises without the EE projects or EE measures. Comparison group approaches include randomized control trials (RCTs) and quasi-experimental methods using nonparticipants and may involve simple differences or regression methods.

Compliance (Code): process of meeting the code requirements and demonstrating that these requirements have been satisfied. Compliance is the responsibility of the builder or contractor.

Conservation voltage regulation (CVR): an EE measure that produces electricity savings by reducing (or regulating) voltage at the electrical feeder level.

Deemed formulas: pre-specified formulas for calculating savings, using some deemed parameters and some inputs that are specific to each project or measure.

Deemed parameter values: pre-specified values of parameters that are used to calculate savings using a

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[87] Certain states, EE providers, and other stakeholders may currently apply variations of these terms. For additional information, readers can consult the glossary of the SEE Action EM&V Guide (SEE Action Network. 2012. Energy Efficiency Program Impact Evaluation Guide. Available at: https://www4.eere.energy.gov/seeaction/publication/energy-efficiency-program-impact-evaluation-guide).

deemed formula.

Deemed savings EM&V methods: methods to quantify savings using deemed savings values, or deemed formulas with deemed parameter values.

Deemed savings values: pre-specified estimates of average annual electricity savings for an EE project or EE measure.

Demand-side energy efficiency (demand-side EE): an installed piece of equipment or system, a modification of existing equipment or system, or a strategy intended to affect consumer electricity-use behavior, that results in a reduction in the electricity use (in MWh) required to provide the same or greater level of service at an end-use facility, premises, or equipment connected to the delivery side of the electricity grid. Demand-side EE is implemented through EE programs, projects, or measures.

Direct measurement and verification EM&V method: an electricity savings quantification approach that uses onsite observations, engineering calculations, statistical analyses, and/or computer simulation modeling using measurements to determine savings from an individual EE project or EE measure.

Dual baseline (baseline efficiency level): a baseline corresponding to existing efficiency up to the remaining useful life (RUL) of the existing equipment, systems, or construction, and market/standards efficiency for the remainder of the effective useful life (EUL) of the EE activity.

Effective useful life (EUL): the duration of time an EE project or EE measure is anticipated to remain in place and operable with the potential to save electricity.

Electricity savings: the savings that results from a change in electricity use resulting from the implementation of a demand-side EE project or EE measure.

Eligible resource: a resource that meets the eligibility requirements of the CPP and has been registered with the EPA-administered ERC tracking system or an ERC tracking system approved in a state plan by the EPA. An eligible resource is not an affected EGU.

Energy efficiency activity (EE activity): an EE measure, EE project, or EE program.

Energy efficiency measure (EE measure): a single technology, energy-use practice or behavior that, once installed or operational, results in a reduction in the electricity use (in MWh) required to provide the same or greater level of service at an end-use facility, premise, or equipment connected to the delivery side of electricity grid; EE measures may be implemented as part of an EE program or an EE project.

Energy efficiency program (EE program): organized activities sponsored and funded by a particular entity to promote the adoption of one or more EE projects or EE measures that, once installed or operational, result in a reduction in the electricity use (in MWh) required to provide the same or greater level of service in multiple end-uses, facilities, or premises.

Energy efficiency project (EE project): a combination of measures, technologies, energy-use practices or behaviors that, once installed or operational, results in a reduction in the electricity use (in MWh) required to provide the same or greater level of service; EE projects may be implemented as part of an EE program.

Emission rate credit (ERC): a tradable compliance instrument with an assigned vintage year that meets the requirements of § 60.5790(c)(2) of the RMR.

Evaluation, measurement, and verification (EM&V): the set of procedures, methods, and analytic approaches used to quantify the MWh from demand-side EE and renewable energy and other measures, which ensure that the resulting savings and generation are quantifiable and verifiable. EM&V must be conducted in a manner that meets the requirements of the CPP Emission Guidelines §60.5830.

Evaluation, measurement, and verification (EM&V) plan: an evaluation measurement and verification plan that meets the requirements of § 62.16455 of the RMR.

Ex ante savings: projected savings prior to implementation of an EE activity.

Ex post savings: savings determined after implementation of an EE activity.

Existing efficiency (baseline efficiency level): the efficiency level of equipment, systems, or construction in place prior to the EE activity.

Facility: all buildings, structures, or installations located in one or more contiguous or adjacent properties under common control of the same person or persons.

Gross savings: difference between electricity consumption of the affected equipment or facility with versus without the EE project or EE measure in place, without consideration of program influence or attribution. Gross savings is calculated relative to a specified baseline determined without regard to program influence.

Independent variables: variables (e.g., weather, occupancy, production levels) that affect electricity consumption and savings, and vary *independently* of the EE activity under study.

Interactive effects: increases or decreases in the use of electricity or fossil fuels that occur outside of the end uses targeted by a specific EE activity. For example, reduction in lighting loads through an energy-efficient lighting retrofit can reduce a building's air conditioning and increase heating requirements because less heat is generated by energy-efficient lighting systems compared with less efficient lighting systems. For purposes of the RMR, only interactive effects on electricity consumption are addressed.

Market efficiency (baseline efficiency level): the average efficiency level of applicable new equipment in the market in place prior to the EE activity.

Market/standards efficiency (baseline efficiency level): the higher of standard efficiency and market efficiency in place prior to the EE activity. Use market efficiency if there is no applicable federal, state, or local code or standard or if market efficiency is above standard efficiency.

Measurement: (a) the act of metering or monitoring, or (b) a measured or monitored metric (dimension).

Measurement and Verification (M&V) report: a monitoring and verification report that meets the requirements of § 62.16460 of the RMR.

Metering: The collection of energy-consumption data over time. These data may be collected at the end use, a circuit, a piece of equipment, or a whole building (or facility).

Monitoring: The collection of data relevant to how a piece of equipment operates, including but not limited to energy consumption or emissions data (e.g., energy and water consumption, temperature, humidity, volume of emissions, hours of operation) for the purpose of savings analysis or to evaluate equipment or system performance for verification.

Net savings: the difference between energy consumption with the program or intervention in place and that which would have occurred absent the program or intervention, accounting for program influence and attribution.

No operational change (baseline operating condition): for EE activities including O&M improvements, the operating conditions that would have existed in the post-intervention period without those O&M improvements.

Operating conditions: the conditions in which the EE project or EE measure or affected facility or equipment is used or operated.

Post-completion operating conditions: for new construction and major renovation that trigger a code requirement, the average operating conditions after the construction is completed and at normal ongoing operations, averaged over the EUL of the activity.

Post-installation operating conditions: the average operating conditions in the period after the EE activity is implemented, over the EUL of the activity.

Post-installation operating conditions without the add-on or operational improvement: the average operating conditions in the period after the EE activity is implemented, over the EUL of the activity, but without the add-on or operational improvement.

Random error: estimation errors occurring by chance that may cause an estimate (such as an electricity savings value) to be overestimated or underestimated with no systematic tendency in either direction, resulting from uncontrolled and unobservable factors affecting the underlying measurements. The magnitude of random error can be quantified based on the variations observed across different units.

Reporting-period continuing savings: savings that occur in a particular reporting period as a result of EE activity implemented in a prior reporting period.

Reporting-period incremental savings: the electricity savings quantified and verified as a result of EE activities operating for the first time in the reporting period.

Site inspections: site visits to facilities at which an EE project or EE measure was implemented. Inspections document the existence, characteristics, and operation of baseline or EE project equipment and systems and the factors that affect energy use. Inspections may include review of commissioning or retro-commissioning documentation.

Standards efficiency (baseline efficiency level): the efficiency level for the most stringent applicable federal, state, or local equipment standard or building code (if any) in place prior to the EE activity.

Systematic error: estimation errors that may cause an estimate (such as an electricity savings value) to be consistently either overstated or understated. Systematic errors (also referred to as bias) may result from incorrect assumptions, a methodological issue, or a flawed reporting system.

Technical reference manual (TRM): resource document that includes information used in program planning and reporting of energy efficiency programs. It can include savings values for measures, engineering algorithms to calculate savings, impact factors to be applied to calculated savings (e.g., net-to-gross ratio values), source documentation, specified assumptions, and other relevant material to support the calculation of measure and program savings—and the application of such values and algorithms in appropriate applications.

Transmission and distribution (T&D) loss: the difference between the quantity of electricity that serves a load (measured at the busbar of the generator) and the actual electricity use at the final distribution location (measured at the on-site meter).

Transmission and distribution measures (T&D measures): an EE activity intended to improve the efficiency of the electrical T&D system by decreasing electricity losses on the system.

Underlying equipment efficiency (baseline efficiency level): for an add-on or operational EE activity, the efficiency of the equipment that the add-on or operational change applies to (without the add-on or operational change). In cases of early replacement, add on efficiency would be calculated using a dual baseline for underlying equipment efficiency.

Verification (of EE project or EE measure installation): an assessment by an independent entity to ensure that the EE activities have been installed correctly and can generate the predicted savings. Verification may include assessing baseline conditions and confirming that the EE activities are operating according to how they were designed to operate. Site inspections, phone and mail surveys, and desk review of program documentation are typical verification activities.