

**** Draft for Public Input ****

**Evaluation Measurement and Verification (EM&V) Guidance
for Demand-Side Energy Efficiency (EE)**

U.S. Environmental Protection Agency

DRAFT FOR PUBLIC INPUT

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Public Comment Opportunity

The EPA invites the public to comment on the draft EM&V guidance and make recommendations for how it can be improved for the purpose of implementing the applicable EM&V provisions of the CPP.

Comments pertaining to aspects of the proposed model trading rule must be submitted in the regulatory docket for that action. Such comments should not be submitted to the email address below.

Important information about the comment process includes:

- The draft guidance can be accessed at: <http://www2.epa.gov/cleanpowerplanttoolbox>
- The public will have 90 days following the publication of the proposed model trading rule in the Federal Register to comment
- Comments pertaining to this EM&V guidance should be submitted to: ***emvinput@epa.gov***
- All comments received by the EPA will be considered as the EPA works to finalize the EM&V guidance
- The EPA invites the public and all interested stakeholders to comment on any aspect of the draft EM&V guidance; however, as the EPA works to finalize this document, the agency has particular interest in feedback on the following questions:
 - Does the guidance provide enough information to help EE providers determine what EM&V methods (i.e., project-based measurement and verification, comparison group methods, and deemed savings) to use for purposes of quantifying savings from specific EE programs, projects, and measures?
 - Does the guidance include sufficient information about the appropriate circumstances and safeguards for the use of deemed savings values? For project-based measurement and verification and comparison group methods?
 - Should the guidance specifically encourage greater use of comparison group approaches? Under what circumstances is the application of such empirical methods practical and cost-effective? Would additional guidance be useful on “top-down” econometric EM&V methods, and the ways in which such methods can be used to verify savings at a high level of aggregation?
 - Is the guidance in Section 3 on particular EE program types (consumer-funded EE programs, project-based EE, building energy codes, and appliance standards) helpful, clearly presented, and sufficient/complete? Can this guidance be reasonably implemented, considering data availability, cost effectiveness, accuracy of results, and other factors?
 - Is the guidance on important technical topics (e.g., common practice baselines, accuracy and reliability, verification) helpful, clearly presented, and sufficient/complete? Can this guidance be reasonably implemented, considering data availability, cost effectiveness, accuracy of results, and other factors?
 - How useful and usable is the guidance, overall? Does the relationship between the component parts (i.e., Sections 1-3 and Appendices A-C) clear and relatively easy to follow? Is each of these sections and appendices helpful, clearly presented, and sufficient/complete? What specific examples, graphics, or other visual elements would help illustrate concepts described in the

guidance?

- Does the guidance *not* cover any important EM&V topics relevant to fulfilling the EM&V related requirements of the emission guidelines? Is additional guidance needed to support the implementation of other eligible zero- and low-emitting measures that are directly metered? What topics, if any, are unnecessarily included?
- How can the guidance most effectively anticipate the expected changes and evolution in quantification and verification approaches over time (given the time horizon for the emission guidelines)?

Acronyms and Abbreviations

ANSI – American National Standards Institute
ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASME – American Society of Mechanical Engineers
CHP – combined heat and power (electricity generation systems)
C&S – Building Energy Code and Product Energy Standard
CPP – Clean Power Plan
CPB – common practice baseline
CSF – control savings factor (for lighting controls)
EGU – electricity generation units
EE – energy efficiency
EERS – Energy Efficiency Resource Standard
ESCO – Energy services company
EFLH – equivalent full load hours
EM&V – evaluation, measurement, and verification
EPA – (United States) Environmental Protection Agency
EUL – effective useful life
FEMP – (U.S. Department of Energy) Federal Energy Management Program
HVAC – heating, ventilating, and air-conditioning
HHV – high heating value
IE – independent third-party evaluator
IPMVP – International Performance Measurement and Verification Protocol
LED – light emitting diode
LHV – low heating value
MMBtu – million British thermal units
MFG – multi-fuel generator
MWh – megawatt-hour
PB-MV – project-based measurement and verification
RCT – randomized control trial
RTF – (Northwest Power and Conservation Council Northwest) Regional Technical Forum
RE – renewable energy
REC – Renewable Energy Certificate
RGU – renewable generating unit
RUL – remaining useful life
SEE ACTION – State and Local Energy Efficiency Action Network
T&D – transmission and distribution (system)
UMP – (United States Department of Energy) Uniform Methods Project
WHP – waste heat to power (electricity generation systems)

1. Introduction

The Clean Power Plan (CPP) supports the use of demand-side energy efficiency (EE) as a proven, cost-effective, and widely available emission reduction measure¹ for the power sector. States, private organizations and firms, and other entities around the country have already made substantial investments in EE programs and projects, resulting in lower electricity costs, reduced air emissions, and cleaner air. The EPA expects such investments to continue, and has established provisions in the CPP for crediting the resulting EE savings in certain state plans that demonstrate compliance in terms of an emission rate.

To ensure that EE measures are quantifiable and verifiable, the EPA's final emission guidelines require that all EE providers demonstrate that they will apply best-practice EM&V approaches (as discussed in Section VIII.K.3 of the preamble). One way to make this demonstration is to use the presumptively approvable EM&V approaches specified in the proposed model trading rule in Section IV.D.8. States may also submit other means of meeting the EM&V requirements so long as the state satisfactorily demonstrates in the state plan submittal that such alternative means of addressing requirements are as stringent as the presumptively approvable approach.

The EPA is providing this draft evaluation, measurement, and verification (EM&V) guidance as supplemental information to help states and EE providers successfully implement the EM&V provisions in the emission guidelines and proposed model trading rule. Contents of this document include background information, baseline definitions and applicable EM&V methods, the appropriate use of industry-standard protocols and guidelines, and other topics for successfully quantifying and verifying savings for purposes of generating emission rate credits (ERCs) and adjusting an emission rate.

The scope of the guidance is limited to EM&V for demand-side EE. For renewable energy and other zero- and low-emitting measures that generate electricity, all applicable requirements for quantification and verification are provided in the emission guidelines and proposed model trading rule, and no further guidance is offered at this time. The EM&V guidance similarly does not apply to states submitting mass (or tonnage) based plans. In these cases, compliance is determined solely by CO₂ emissions measurements at the affected source.

1.1 Experience with EM&V for Demand-Side EE

From the time that demand-side EE emerged as an important energy strategy in the 1970s,² efforts to quantify and verify the MWh savings of these actions have been critical to their success, credibility, and expansion. The earliest such efforts involved project-based measurement and verification (PB-MV) of individual projects; this was followed by an evolution and improvement in practices for a broad range of

¹ The emission guidelines use the term "measure" to refer to an eligible action that results in MWh that can be used to adjust an emission rate for compliance purposes. In the context of demand-side EE, "measure" refers to an installation or modification of equipment or systems at an end-use energy consumer facility – or strategy intended to affect consumer energy use behaviors – that reduces the amount of energy that would otherwise have been used to deliver an equivalent or improved level of end-use service.

² National Energy Program Fact Sheet on the President's Program, April 20, 1977. Available at <http://www.presidency.ucsb.edu/ws/?pid=7373>.

EE program strategies and delivery mechanisms across sectors.³ Today, these EM&V practices are applied by utilities, energy service companies (ESCOs), and other EE providers. They are also backed up by several well-established protocols and guidelines, and overseen by Public Utility Commissions (PUCs) and other implementing agencies and authorities. The EM&V industry is now comprises many large firms and hundreds of individual practitioners, and is supported by training and certification programs, as well as a rich library of published reports and publicly available data and technical resources.

The EM&V approaches in wide use today – including budget levels, oversight procedures, and preferred methods – are derived from PUC⁴ requirements for consumer-funded EE programs, as well as the Federal Energy Management Program’s (FEMP) requirements for ESCO projects. While the level of review varies somewhat by state and program, these oversight mechanisms have generated the majority of the protocols and best practices for quantifying savings in the industry. The specific EM&V approach that is applied to a given program or project depends on the type of EE, overall policy objectives, available budgets, and other factors. For consumer-funded EE programs and ESCO projects, savings are typically quantified on an annual basis.

With this evolution in the accuracy and reliability of EM&V, many states and utilities now routinely rely on EE to achieve energy (MWh) and capacity (MW) goals. In addition, two Independent System Operators (ISOs) – ISO New England (ISO-NE) and PJM – have established forward capacity markets (FCMs)⁵ that pay suppliers of EE programs and other demand-side resources to compete directly with electric generators to meet regional capacity needs. The oversight and quality control of EE resources that are bid into the market is governed by EM&V rules and requirements defined in evaluation manuals established by ISO-NE and PJM.

Despite improvements in EM&V over time, quantification knowledge is more robust for some EE program and policy types than for others. Additionally, there is limited experience applying EM&V procedures and protocols to emissions trading programs, where each MWh of replaced generation becomes a commodity that can be bought and sold by a regulated source. Environmental regulators, including the U.S. EPA and most state environmental agencies, have limited experience quantifying and verifying EE in this regulatory context. As a result, the EPA’s final emission guidelines include a number of safeguards and quality-control features that are intended to ensure the accuracy and reliability of the claimed EE savings.

1.2 Determining Baselines

The key challenge with quantifying EE savings is the identification of an accurate baseline from which to measure MWh results. Regardless of the protocols and procedures applied, all savings values are determined by comparing energy use with an EE program or project in place with the best estimate of the likely energy use in the absence of the project or measure (the “counterfactual” scenario, or baseline). In general, the entity overseeing or managing EE activities determines the applicable baseline prior to EE implementation on the basis of policy objectives and various programmatic considerations.

³ EM&V is defined to mean the set of procedures, methods, and analytic approaches used to quantify the MWh from demand-side EE and other eligible resources, and thereby ensure that the resulting savings and generation are quantifiable and verifiable.

⁴ These government entities are also referred to as a public service commission or a board of public utilities.

⁵ Forward capacity markets are intended to ensure sufficient electric generating capacity is available to meet future peak electricity demand.

MWh savings are then quantified relative to this baseline using EM&V methods determined by program type, available budgets, the magnitude of expected impact, and other factors.

Figure 1 illustrates observed energy use with an EE project installed, and a baseline of estimated EE use without that project. In this illustration, the baseline is determined using information on energy use patterns prior to installation. Other methods of determining baseline energy use apply, depending on the EE type and the EM&V method used, as described further in this document.

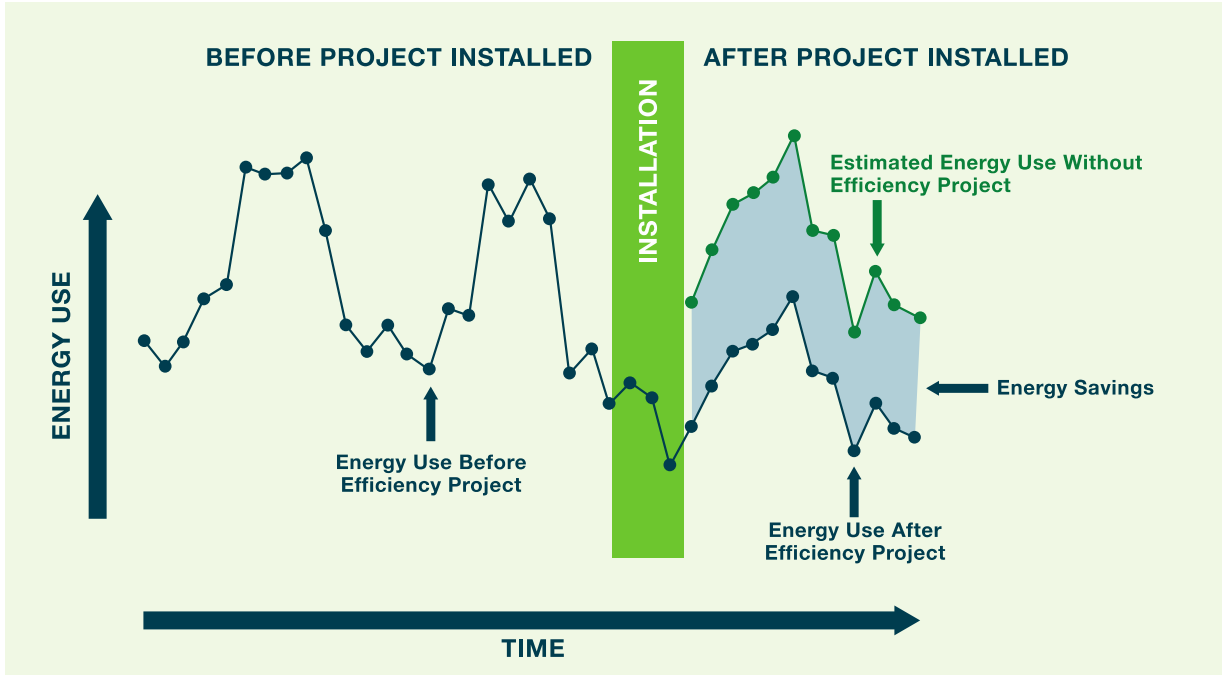


Figure 1-1. Energy Use Before, During, and After an EE Project is Installed⁶

1.3 Approach to EM&V in the Emission Guidelines

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)⁷ that outlined a general approach to establishing EM&V requirements and guidance. The TSD proposed that the EPA’s EM&V provisions could leverage the industry-standard practices, protocols, and methods currently utilized by the majority of states implementing demand-side EE and RE programs. The EPA further noted that many state PUCs, and other regulatory bodies and program management authorities, already have significant EM&V infrastructure in place, and some have been applying, refining, and enhancing their approaches for over 30 years.

Most public comments on this topic affirmed that the protocols and procedures already in place and widely used should indeed be leveraged in the EPA’s final emission guidelines. Commenters also provided numerous examples of well-regarded oversight approaches, quality-control practices, and

⁶ Ibid.

⁷ See discussion beginning on p. 34 of the State Plan Considerations TSD for the Clean Power Plan Proposed Rule: <http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-state-plan-considerations>.

quantification and verification methodologies that are currently applied (in addition to pointing out needed improvements to EM&V practices, especially relating to cross-jurisdictional inconsistencies in the way EM&V is applied). Additional perspectives shared in comments include the importance of striking a reasonable balance between EM&V rigor and accuracy on the one hand, and evaluation costs and effort on the other, and the need for the EPA to avoid excessive interference with EM&V practices that are already robust, transparent,⁸ and working well. Finally, commenters indicated that it is critical for the agency to support the continued evolution of credible EM&V practices into the future.

1.4 Applicability and Scope of this Guidance Document

This document establishes guidance to help states, affected EGUs, and EE providers (including the firms they hire) implement the requirements in the EPA’s emission guidelines, as well as the presumptively approvable EM&V approaches for quantifying and verifying MWh savings. As specified above, the guidance applies only in the context of rate-based state plans—including “emission standards” and “state measures” plan types—that explicitly credit MWh savings in the form of ERCs or other denominator rate adjustments.

In terms of programmatic applicability, this document applies to all EE activities initiated by EE providers such as investor-owned utilities (IOUs), public utilities, private organizations (such as energy services companies, or ESCOs), and the owners and operators of large commercial and industrial end-users. It is also applicable to programs implemented in all customer sectors, including low-income.⁹

What is *Not* Covered

This document provides guidance on the best practices, technical assumptions, and industry-standard protocols and procedures that can be used to quantify and verify MWh savings from demand-side EE.

This document *does not*:

- Apply to zero- or low-emitting measures other than EE.
- Prescribe which demand-side EE measures are eligible.
- Provide criteria for *projecting* the impacts of such measures.
- Offer information or resources about calculating displaced CO₂ emissions from EE.
- Address the accounting procedures for how a quantified and verified MWh can be used to adjust a rate, or for how cross-jurisdictional issues are addressed.
- Provide information on other state plan requirements, such as the operation of ERC tracking or emission trading systems.

Information about these aspects of state plan submissions is provided in Section VIII of the draft model trading rule.

⁸ E.g., providing an opportunity for public involvement in planning activities, internet access to EM&V plans and reports, and disclosure of relevant inputs, methods, and assumptions.

⁹ It is important to note that low-income programs are generally implemented for reasons other than maximizing energy savings. A primary goal of these programs is to lower the burden of energy costs for a disadvantaged population. Alleviating energy burden as broadly as possible is related to energy savings but has other dimensions. Such programs also serve other public policy objectives and produce co-benefits beyond electricity savings, including but not limited to health, safety and family stability. In addition, these programs typically are designed

This EM&V guidance does not apply to states electing to submit mass-based plans in which compliance is based on monitored emissions at the affected source¹⁰. Therefore, mass-based plans do not require explicit adjustments to emission rates based on demand-side EE.

1.5 How to Use this Document

This guidance is organized and intended to be used, as follows:

- **Section 2** provides a high-level discussion of 12 key EM&V topics and establishes guidance to help EE providers develop EM&V plans that document how the applicable regulatory requirements will be addressed. The guidance in this section applies to all demand-side EE used to generate ERCs and otherwise adjust an emission rate.
- **Section 3** establishes additional EM&V guidance—beyond the general guidance provided in Section 2—for several common EE program and project types. The specific program and project types addressed comprise:
 - Programs implemented using utility customer funds (“utility EE programs”)
 - Individual or aggregated EE projects, such as those implemented by ESCOs or at industrial facilities (e.g., water treatment plants)
 - Building energy codes
 - Appliance energy standards
- **Appendix A** provides a brief glossary of key terms used in this document. This glossary is intended to be consistent with industry-standard protocols and reference documents, and can be supplemented with the more complete glossary provided in the SEE Action Energy Efficiency Impact Evaluation Guide.¹¹
- **Appendix B** provides templates for program and project EM&V plans. These templates can be used (but are not required) to indicate how the relevant approaches, methods, and parameters required by the emission guidelines will be applied over the course of program and project implementation. As described below, EM&V plans are a required component of a qualification package used to generate ERCs from eligible resources.
- **Appendix C** discusses considerations involved in selecting and implementing the EM&V methods in Section 2.1. It also provides, for several common EE measures, illustrative examples of how PB-MV can be applied, with information about the applicable analytic steps and best practices.

with the intent to efficiently deliver bundled services. For all these reasons, energy savings is only one metric by which such programs are measured. The U.S. Department of Energy (DOE) Weatherization Assistance Program (WAP) that offers funding to states for weatherizing low-income homes, uses the number of homes weatherized as the primary metric to evaluate performance. While these additional considerations affect the decision criteria for determining cost-effectiveness of these programs, the methods for verifying their electricity savings are the same as those used for evaluating EE for non-low income consumers.

¹⁰ It should be noted that states with mass-based plans may have PUC-led EM&V requirements to ensure that consumer-funded EE programs are cost-effective and achieve incremental savings.

¹¹ State and Local Energy Efficiency Action Network. 2012. *Energy Efficiency Program Impact Evaluation Guide*. Prepared by Steven R. Schiller, Schiller Consulting, Inc., www.seeaction.energy.gov.

While this draft EM&V guidance is not an EM&V primer, it provides discussion and references to several industry-standard protocols, guidelines, and other resources such as the State and Local Energy Efficiency Action Network (SEE Action) EM&V Web portal¹² and the EPA's emission guidelines page.¹³

1.6 Intended Audience

This guidance is intended for state officials, providers of demand-side EE, and private firms (e.g., evaluators and verifiers) hired to help execute the EPA's provisions for quantification and verification of EE savings. For state air regulators, lay readers, and the public, the high-level descriptions of the 12 topics addressed in Section 2 may be helpful. These descriptions are followed by a discussion of applicable guidance that EE providers, evaluators, and verifiers can use as they develop and implement EM&V plans. The guidance can also be used by private organizations and firms, the public, and other parties interested in better understanding the EPA's EM&V requirements for purposes of participating in state plan development and similar processes.

1.7 Evolving EM&V Practices and Guidance Updates

The EPA recognizes that the best-practice EM&V approaches, protocols, and procedures that are now used by states, EE providers, and others – and upon which this guidance is largely based – will evolve and improve over time as new technologies emerge and the EE marketplace changes. To ensure that this guidance continues to be relevant and helpful over time, the EPA intends to periodically provide updates that reflect changes to what is considered best practice.

The agency may also release complementary guidance on how to manage EE policies, programs, and projects as a portfolio and strategically invest in EM&V to reduce uncertainty and better deliver on an aggregate level of energy savings. Such guidance would define a verification approach involving econometric analysis of aggregate consumption data for geographic areas over multiple years. The intent of such an approach would be to provide flexibility to states with established EE activity, to make strategic trade-offs across in their EE and EM&V investments across their EE portfolios, while ensuring that all EM&V-related regulatory requirements in the emission guidelines are satisfied.¹⁴ This approach can be a useful check and balance in assessing the aggregate impact of multiple policies, programs and measures.

¹² See: <https://www4.eere.energy.gov/seeaction/evaluation-measurement-and-verification-resource-portal>

¹³ <http://www2.epa.gov/cleanpowerplan>

¹⁴ This guidance would apply to states that elect to incorporate demand-side EE outside of an ERC trading program, and that manage their EE policies, programs and projects as a portfolio. EPA anticipates that a combination of elements will be required to demonstrate adequate stringency of verification at the portfolio level and will be issuing further guidance

2. EM&V Guidance Applicable to All Demand-Side EE

This section includes EM&V guidance for 12 key topics that is applicable to all demand-side EE that is used to generate ERCs or otherwise adjust an emission rate. It includes high-level background information, guidance, and terms to help EE providers develop EM&V plans. As previously described, the guidance provided here leverages and is consistent with current EM&V best practices, protocols, and procedures that are already used by the majority of states across the country. This guidance therefore balances the need for rigor and accuracy with the effort and cost associated with quantification and verification.

For each of the 12 topics, the guidance provided is generally consistent with EM&V best practices. This means that the guidance either (1) is consistent with established protocols or guidelines that have been developed with expert and stakeholder input; or (2) uses alternative methods that are well documented and have been subjected to and endorsed by peer review, but are not documented in established protocols or guidelines. The best practices recommended here generally falls into the first category.

This section of the guidance is supplemented with additional best practices and technical assumptions applicable to common EE program categories (Section 3) and illustration of how these approaches should be applied to certain EE project and measure types (Appendix C). For the 12 EM&V topics addressed below, the following information is provided:

- **Discussion:** This section includes a high-level overview, relevant background information, and applicability to the EPA's emissions guidelines.
- **Applicable Guidance:** This information is intended to help states, EE providers, and private firms hired to quantify and verify EE savings implement the regulatory requirements defined in the emission guidelines, as reiterated here. These approaches and assumptions expand upon, illustrate, and provide practical clarification of the preamble and emission guidelines and are based on industry best practices.
- **Key Terms:** Text boxes provide terminology for key EM&V concepts, consistent with industry-standard usage.

The EM&V topics covered in this section include:

1. EM&V methods
2. Electricity savings metrics and baselines

Key Terms

- **EE measure:** a single technology, energy-use practice or behavior that, once implemented or adopted, reduces electricity use of a particular end-use, facility, or premises; EE measures may be implemented as part of an EE program or as an independent privately-funded action.
- **EE project:** a combination of multiple technologies, energy-use practices or behaviors implemented at a single facility or premises for the purpose of reducing electricity use; EE projects may be implemented as part of an EE program or as an independent privately-funded action.
- **EE program:** Organized activities sponsored and funded by a particular entity to promote the adoption of one or more EE project or EE measure with similar characteristics for the purpose of reducing electricity use.

3. Reporting timeframes and considerations
4. Deemed savings
5. Independent factors affecting energy consumption and savings
6. Accuracy and reliability of quantified savings
7. Avoiding double counting
8. Effective useful life and persistence of savings
9. Savings quantification and verification cycles
10. Transmission and distribution (T&D) savings adders
11. Interactive effects
12. Use of EE EM&V Protocols and Guidelines

The presumptively approvable approaches for each of these topics are described in Section IV.D.8 of the proposed model trading rule.

2.1 EM&V Methods

2.1.1. Discussion

Three general categories of EM&V methods for quantifying the MWh savings include 1) **deemed savings** 2) **project-based measurement and verification**, and 3) **comparison group methods**. Each of these methods is defined in industry-standard protocols and commonly applied by EE providers, oversight entities, and the firms they hire to quantify and verify savings. The decision of which method or methods to apply for which EE activities or components involves consideration of factors such as objectives of the EE activity being evaluated, the scale of the activity, and evaluation budget and resources. PB-MV and deemed savings are commonly used for determining savings from individual EE measures and projects. By contrast, comparison-group methods are usually only used to estimate savings from EE programs, but the use of such methods could be expanded further.

Key Terms

- **Deemed savings values** are estimates of electricity savings for a single unit of an installed EE measure that (1) has been developed from data sources (such as prior metering studies) and analytical methods that are widely considered acceptable for the measure and purpose, and (2) is applicable to the situation under which the measure is being implemented. Common sources of deemed savings values are previous evaluations and studies that involved actual measurements and analyses. With deemed savings, the per-unit MWh values are determined and agreed to by parties prior to EE implementation. When deemed savings are used to quantify MWh savings, a separate verification process is needed to confirm the quantity of units installed.

Related to comparison group methods is the approach of using macroeconomic models, sometimes known as “top-down” EM&V. Top-down EM&V methods to evaluate portfolios of EE programs involves using (1) aggregate (e.g., utility service area, county, census block, etc.) energy use or per-unit energy consumption indices (e.g., energy consumption per-unit of output or per capita) and (2) energy-use driver data (e.g., income, prices, population) to determine savings from portfolios of programs. Some states have adopted this approach as a complement to the above-listed methods in order to confirm aggregate savings results obtained using other approaches. It could also be a useful approach for mass-based plans to ensure the overall effectiveness of EE efforts.

2.1.2. Applicable Guidance

- Determine which of the above allowable EM&V methods to apply for quantifying savings for each program or type of project. Refer to Appendix C and Table C-1 for examples of how different methods can apply to different types of EE. In general, less expensive methods (such as deemed savings) are acceptable for EE components that contribute relatively little savings, or where there is little uncertainty as to average unit savings. More rigorous methods (such as PB-MV) are recommended for larger, more variable, and more complex components of savings. Comparison group methods are ordinarily applicable only if:
 - A valid comparison group can be defined.
 - The program participants are relatively large in number, and relatively homogeneous, such as residential or small commercial customers.
 - The magnitude of expected savings is large compared to the expected random differences between the participant and comparison group averages.
- Provide a rationale in EM&V plans for this determination, and describe how it is consistent with industry best practice.

Key Terms (continued)

- **Project-based measurement and verification** is the process of determining savings from an individual EE measure or project (versus an EE program). The IPMVP, described in Section 3.12, defines **two retrofit isolation** and **two whole-facility PB-MV 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 Option C, review of energy bills or Option D, calibrated simulation).
- Some combination of the above.

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

- **Comparison group EM&V methods** determine program savings based on the differences in electricity consumption patterns between a comparison group the program participants. Comparison group approaches include randomized control trials (RCTs) and quasi-experimental methods using nonparticipants, and may involve simple differences or regression methods. Because the effects of implemented measures is reflected in the observed participant-comparison differences, separate verification is not required. These methods are generally used to estimate program-level savings, not facility- or project-level savings, and are therefore considered an evaluation method, as well as a PB-MV method.

- When determining the frequency of conducting EM&V for consumer-funded EE programs (every one, two, or three years per the proposed model-rule regulations), consider the following: the complexity of the program or project, the variability of the savings, the EM&V method being applied, and the relative scale and magnitude of savings. In general, less frequent verification is appropriate for EE components that contribute relatively little savings, or where there is little variability from year to year, and little uncertainty as to measures’ continued operation until the next verification period. More frequent verification is recommended for larger, more variable, more uncertain, and more complex components of savings.
- For comparison group approaches, apply best-practice protocols and guidelines such as those published by the SEE Action Network and the U.S. DOE’s Uniform Methods Project.
- For deemed savings approaches, follow the guidance provided in Section 2.4 on *Deemed Savings*, which provides terms, suggested approaches, and technical assumptions to ensure that appropriate safeguards for the use of **deemed savings** are implemented. When applying **PB-MV** methods, use one or more best-practice protocols and guidelines. Examples include:
 - International Performance Measurement and Verification Protocol (IPMVP, an international PB-MV guidance document),¹⁵
 - Federal Energy Management Program (FEMP) protocols and guidelines,¹⁶
 - American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) protocols and guidelines¹⁷, and
 - U.S. DOE, The Uniform Methods Project (UMP): Methods for Determining Energy Efficiency¹⁸
- Apply the guidance in Section 2.12 below on *Use of EE EM&V Protocols and Guidelines*, which provides guidance on determining what best-practice protocols and guidelines should be applied.
- Refer to Appendix C of this document for illustrative examples of how these methods can be applied in practice.
- Refer to Table 2-1 for which of the three general categories of EM&V methods can be appropriate for different situations or conditions of EE activities.

Table 2-1. Situations where each General Category of EM&V Methods Are or Are Not Applicable

Situation or Conditions for Applying EM&V	General Category of EM&V Method		
	Comparison Group	PB-MV	Deemed
Individual project	Method not applicable	OK	OK
Large numbers of relatively homogeneous participants (e.g., residential, small commercial)	Method requires this condition	OK	OK

¹⁵ <http://www.evo-world.org>

¹⁶ http://www1.eere.energy.gov/femp/pdfs/mv_guidelines.pdf

¹⁷ <https://www.ashrae.org/home>

¹⁸ <http://www.energy.gov/eere/about-us/ump-protocols> (version as of August 2015)

Well-defined, simple, consistent EE measures and conditions	OK	OK	Method requires this condition
Large savings per participant, or very large number of participants	Method requires this condition	OK	OK
Inconsistent measures and conditions across units	OK	OK	Method not applicable
Complex, unique measures	Method not applicable	Method is required for this condition	Method not applicable
Valid comparison group can be defined	Method requires this condition	OK	OK
EE program contributes relatively little savings to total EE provider EE portfolio	Method cost may not be justified	Method cost may not be justified	Method may be preferred
EE program contributes relatively large savings to total EE provider EE portfolio	Method is recommended if method requirements are also satisfied	Method is typically recommended	Method is not typically recommended

Note: "OK" indicates method may be applied in this situation.

2.2 Electricity Savings Metrics and Baselines

2.2.1. Discussion

Electricity savings from an EE activity is the difference between observed usage with EE in place and the usage that would have occurred in the absence of EE during the same time period. Defining what would have happened without the EE program or project (i.e., the "counterfactual baseline conditions") represents the fundamental challenge to quantifying savings, and therefore warrants a comparatively detailed discussion. Baselines are typically defined by the installed equipment at the time of retrofit, or some other standard alternative to the installed EE technology. The EPA, for purposes of the emission guidelines, defines EE savings as the difference between observed electricity usage and an appropriate "common practice baseline" (CPB). Such CPBs are specified below with respect to different EM&V methods and EE activities.

Key Term
<ul style="list-style-type: none"> • Gross savings: savings calculated with respect to a defined baseline. • Net savings: the difference between energy consumption with the program in place and that which would have occurred absent the program. • Baseline: conditions (including electricity consumption) that would have existed without implementation of the subject EE activity. Baseline is used to estimate measure-, project- and program-related savings. • Common practice baseline (CPB): default technology or condition that would have been in place at the time of project implementation absent the EE installation. Section 2.2.2 defines the CPB for different types of EE activity.

One benefit of using a CPB is that it inherently adjusts the baseline over time to reflect market conditions and naturally occurring improvements in efficiency over time. Establishing a well-defined and consistently applied CPB avoids crediting activity.

In the context of EE programs, the term gross savings refers to savings calculated with respect to a defined baseline, while net savings is due to the difference between energy consumption with the program in place and that which would have occurred absent the program.¹⁹ The CPB as defined in Section 2.2.2 is consistent with baseline definitions used for gross savings by many existing EE programs. Thus, for much of the EE activity within existing programs, the “gross savings” that would be determined using current methods and practices for those programs will be consistent with the savings relative to the CPB as defined here, and can be reported as MWh savings for purposes of the CPP.

2.2.2. Applicable Guidance

- When a well-designed comparison group method is used, use the control group (with randomized control trials) or the comparison group of non-participants (with quasi-experimental approaches) to quantify the CPB electricity consumption.
 - In these cases, separately determining the CPB efficiency of individual pieces of equipment is unnecessary.²⁰
 - Design the comparison group and analysis approach in a way that represents what the participants would have done absent the program or absent the EE intervention.
 - With comparison group specifications, describe how the comparison group was selected and what it is intended to represent.
- For the three EM&V methods addressed in Section 2.1, use the following CPB guidance:
 - For equipment that is **replaced on failure**, define the CPB as:
 - The federal standard or the market average industry/consumer practice at the time of implementation, whichever results in a lower savings value. This approach recognizes the dynamic nature of baselines in the context of changing market conditions.
 - For states (or EE providers operating in those states) that have product standards that are more stringent than the federal standard or market average, and where the state is counting the savings increment due to the more stringent product standard as a state measure, use the state product standard as the CPB for EE at higher efficiency than the state product standard. (See double counting Section 2.7)
 - For **early replacement activities**, with strong evidence that replacement of functioning equipment is due to program influence, a dual baseline is applicable:
 - Use existing conditions for defining the CPB for the remaining useful lifetime²¹ (RUL) of the replaced equipment or system. Use the CPB that would apply to new construction or replacement on failure for the remainder of the new equipment EUL.
 - For **building shell improvements of existing buildings**, define the CPB as:

¹⁹ For discussion and guidance on determination of net and gross savings, see the Uniform Methods Project Estimating Net Energy Saving: Methods and Practices. Net savings attempts to account for free ridership, spillover, and market effects (see Key Definitions text box).

²⁰ The comparison and control groups, in most cases, intrinsically account for free ridership and participant spillover, but do not account for nonparticipant spillover and long-term market effects.

²¹ Remaining useful life cannot exceed the effective useful life of the replacement measure.

- The existing condition of the building shell unless renovations are extensive enough to trigger new construction code compliance, in which case the following new construction guidance applies
- For **new construction**, the CPB is defined as follows:
 - For commercial buildings, the generally most stringent of:
 - the applicable state or local building code in effect as of January 1, 2013,
 - the market industry average practice in the state, or
 - ASHRAE 90.1-2007/2009 IECC.

“Generally most stringent” means that buildings built to this standard generally use the least energy, all else being equal. This baseline recognizes the dynamic nature of baselines in the context of changing market conditions.²²

- For residential buildings, the generally most stringent of:
 - the applicable state or local building code in effect as of January 1, 2013,
 - the market industry average practice in the state, or
 - ECC 2009.

“Generally most stringent” means that buildings built to this standard generally use the least energy, all else being equal. This baseline recognizes the dynamic nature of baselines in the context of changing market conditions.

- For states (or EE providers in those states) that are increasing the stringency of their state building codes, use the updated state code as a baseline if the state has included and is already counting those savings separately. (See double counting discussion in Section 2.7)

Table 7.1 of the 2012 SEE Action Impact Guide can be referred to for defining general approaches to determining baselines for specific EE activities.²³

The CPB as defined here applies to EE activities in the context of consumer-funded programs, ESCO-supported projects, and privately funded projects outside of consumer-funded programs and ESCOs. Where there is the possibility of the same EE activity being counted as part of two or more categories of EE activity --consumer-funded program, ESCO activity, or private activity—care must be taken to avoid counting the same savings more than once. See Section 2.7 on avoiding double counting.

The definitions of CPB in terms of standard efficiency equipment for new or replacement-on-failure situations, and as dual baseline for early replacement are consistent with common approaches to defining gross savings for utility programs. Whether a particular utility’s gross savings determination is fully consistent with the guidance in this document depends on details of the standards used as baselines, and other particulars described here such as verification methods, EUL determination, and

²² Implementation of the EE project itself should not be a determinant for code or standard applicability. For example, if the project is a lighting retrofit and the lighting retrofit itself triggers a code requirement for upgraded lighting, the code would not necessarily be an applicable basis for a CPB. In this situation, the code would only be applicable as a CPB, if other, substantial, actions to the subject building (e.g., a major remodel) triggered the subject code.

²³ State and Local Energy Efficiency Action Network. 2012. *Energy Efficiency Program Impact Evaluation Guide*. Prepared by Steven R. Schiller, Schiller Consulting, Inc., www.seeaction.energy.gov. (Or current version.)

frequency of updates of deemed values or other key parameters.

Use of market average baselines where standards do not exist is not currently common practice for consumer-funded programs. This definition is intended to ensure that, in the absence of a clear standard, savings reflect movement of efficiency beyond what is already occurring in the market. Where standards do not exist, utility program evaluated net savings may under some circumstances be used in place of savings calculated relative to a market average baseline. To use utility net savings in this context, the state must provide an explanation of how net savings are calculated, and why this calculation is expected to be at least as stringent as savings relative to a market average baseline. Other aspects of the savings determination should also be consistent with the guidance in this document. For guidance on determination of net savings, see the Uniform Methods Project *Estimating Net Energy Saving: Methods and Practices*.

2.3 Reporting Timeframes and Considerations

2.3.1. Discussion

Current industry practices for reporting annual electricity savings varies across states and EE providers with regard to specific content requirements, definitions, and timing. Local policy objectives, the breadth of EE activities, and other factors typically drive decisions about such reporting attributes.

The reporting process for consumer-funded EE programs typically involves projecting and reporting savings as part of the planning phase, as well as ongoing annual reporting as savings accrue over time. This “ex-post” reporting is typically based on savings derived by applying one of the EM&V methods described above in section 2.1. In almost all cases, ongoing annual savings values are reported on an incremental and cumulative basis (see text-box terms).

Key Terms

- **Reporting-year incremental savings:** the electricity savings quantified and verified as a result of EE activities operating for the first time in the reporting year; reported in annual megawatt hours (MWh).
- **Reporting-year cumulative savings:** the electricity savings quantified and verified as a result of EE activities in the reporting year from both (a) EE activities operating for the first time in the reporting year and (b) EE activities initiated in prior years and still in effect; reported in megawatt hours (MWh).

The regulatory requirements for EE reporting, as defined in the EPA’s emissions guidelines, are intended to support greater consistency across jurisdictions and EE providers in how savings data are quantified and collected. In addition, the requirement to report both incremental and cumulative savings, and the associated timing provisions, are consistent with the Energy Information Agency’s (EIA) approach to collecting EE program data via Form 861²⁴.

2.3.2. Applicable Guidance

- When using stipulated effective useful life (EUL) values (see Section 2.8 on *Effective Useful Life and Persistence of Savings*) for reporting savings, report savings pro rata based on the day the EE activity began saving energy during the reporting year.

²⁴ See: <http://www.eia.gov/electricity/data/eia861/>

- For emission standard plans in which EE generates ERCs, annual savings can be quantified for any consecutive 12-month period.
- For state measures plans, report savings as if they started accruing on January 1 of the reporting year and continued in the program for a full year (irrespective of which day the EE activity began saving energy)²⁵.
- Report current year incremental and cumulative savings values on the basis of the best available information at the time of reporting. Incorporate new information gained from routine and ongoing EM&V activities on a going-forward basis.
 - The text box that illustrates how forward adjustments can be applied.

Example of Forward Adjustments to EE Savings

If a program is determined to save 10,000 MWh per year for 10 years starting in Year X, 10,000 MWh may be used as the amount of incremental savings in Year X and 10,000 MWh may be used for reporting cumulative savings in Years X + 1 through X + 9. If during Year X + 3 a better annual savings value for that program is determined to be 9,500 MWh, 9,500 MWh should be used for reporting cumulative savings starting in Years X + 3 through X + 9. Examples of significant new information that could cause an update in savings values include:

- Savings are adjusted because of verification activities; for example, savings might be zeroed for EE actions in facilities that have been shut down or savings are reduced if high level of savings degradation/performance is determined.
- Savings are adjusted because of new cycles of savings determination (see Section 2.9 on verification and evaluation cycles); for example, savings are updated when an applicable deemed savings value is modified/updated in an approved database.
- Savings values are updated when errors are found in prior-year savings calculations.

2.4 Deemed Savings

2.4.1. Discussion

As described in Section 2.1 above, one of the three categories of EM&V methods for quantifying savings is the application of deemed savings. Deemed values are appropriately applied only to relatively simple, well-defined efficiency measures such as light bulbs or specific pieces of equipment for which the performance characteristics and location-specific conditions are well known. In these instances, a deemed savings approach can provide reasonable reliable and accurate savings values, on average.

Because these stipulated values are agreed upon in advance, deemed savings can help alleviate some of the guesswork in program planning and design. Deemed savings can also result in a form of risk, in which overestimates or underestimates of savings can occur when EE projects or measures do not perform as expected, or if deemed values are applied in the wrong circumstances. The verification

²⁵ EE activities generate a stream of savings over a pre-determined number of years, or EUL. Regardless of the specific day that the EE activity was installed and began saving energy, it is assumed that savings begin on January 1 and that this counts as the first full year of the project or measure EUL.

activities commonly required by state PUCs and other oversight and management bodies can alleviate this risk²⁶.

For more complex efficiency projects or for projects with significant savings variability, measurement-based methods (i.e., PB-MV and comparison group methods) are more appropriate than deemed savings. However, deemed values can in some cases be properly applied to these projects if one or more key parameters is directly monitored over time at the project site. For example, in a high-efficiency motor program, actual operating hours could be monitored over a full work cycle²⁷.

Deemed savings values are usually documented in resources such as a document or database in formats that can vary from a spreadsheet to an online searchable database. The term of art for such resources is technical reference manuals (TRMs)²⁸. As of this document's publication, approximately 20 TRMs are in use across the United States at the state and regional level.²⁹ TRMs can be valuable, but methodologies for estimating savings and the actual values vary widely. Some TRMs include information based on prior-year evaluations including, in some cases, rigorous metering, and analysis. Many others have values based on computer simulations or engineering algorithms). Ongoing and new state, regional, and federal efforts to improve the quality and documentation of TRMs are encouraged and can support higher-quality savings values for compliance with the EPA's emissions guidelines and reduced EM&V costs.

Key Terms

- **Deemed savings values:** estimates of average annual electricity savings for a single unit of an installed EE measure that (a) has been developed from data sources and analytical methods widely considered acceptable for the measure and (b) is applicable to the situation and conditions in which the measure is implemented. Individual parameters or calculation methods also can be deemed, including EUL values. Deemed savings values are applicable for specific EE measures. A single deemed savings value may not be used for a program as a whole, nor for a multi-measure project, because of the degree of variation in how systems are used in different building types or market segments. Deemed savings are also called stipulated savings.

2.4.2. Applicable Guidance

- Apply deemed savings to relatively simple EE projects and measures (e.g., light bulbs or specific pieces of equipment) for which the performance characteristics and location-specific conditions have been evaluated and are well known.
 - Do not apply them to complex EE projects or measures with significant savings variability
- Each deemed savings value must indicate the conditions for which the value is applicable (e.g., climate, building type, end use, and measure implementation mechanism).

²⁶ The emission guidelines include regulatory requirements for verification, as described in section 2.9 of this document.

²⁷ This approach is consistent with the definition of IPMVP Option A. However using deemed savings alone is not considered a measurement and verification method, per se.

²⁸ TRMs generally include information about the technology or measure itself, the savings value, measure life, peak load impacts, engineering algorithms to calculate savings, source documentation, specific assumptions, and other relevant material to support the calculation of savings in particular applications.

²⁹ Many of these TRMs are listed in the following document: *Scoping Study to Evaluate Feasibility of National Databases for EM&V Documents and Measure Savings*. SEE Action Network. 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. www.eere.energy.gov/seeaction/pdfs/emvscoping__databasefeasibility.pdf. June 2011.

- Ensure that deemed savings values:
 - Are based on EE measure definition, applicability conditions, assumptions, calculations, and references that are well documented in work papers that are publicly available;
 - Are 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;
 - Are developed by independent, third parties and, whenever possible, are based on empirical techniques such as RCTs and quasi-experimental design.
- Apply deemed savings values only for the specific EE measures, program or project delivery mechanism (e.g., direct install versus point-of-sale rebates), end-uses (e.g., single-family versus multifamily residential), operating conditions (e.g., climate, operating hours), and other assumptions for which the values were developed.
- Update deemed savings values on a going-forward basis; see section 2.3 on *Reporting Incremental and Cumulative Savings*.

2.5 Independent Factors Affecting Energy Consumption and Savings

2.5.1. Discussion

Observed changes in electricity consumption are the result of a variety of independent factors and influences. These range from the outdoor temperature to occupancy levels in a building to production levels. To isolate the electricity savings that result from the EE activity in question, each of these independent factors must be taken into account.

Key Term

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

Determining the influence of these factors is critical to the credibility of savings estimates, and distinguishes properly determined savings from a simple and unreliable comparison of electricity use before and after implementation of a program, project, or measure. Each of the three EM&V methods described in Section 2.1 has a mechanism for accounting for independent factors. For deemed savings values, independent factors are implicitly quantified through the associated applicability conditions (see Section 2.4); for PB-MV, these factors are considered via the use of regression analyses, computer simulation modeling, or engineering calculation adjustments; and for comparison group methods, through random assignment, matched comparison groups, or through large-scale consumption data regression analyses.

2.5.2. Applicable Guidance

- Within a single EE program, quantify savings for the constituent EE projects or measures using consistent assumptions for independent factors.
- Quantify EE savings using values of independent factors that are expected to apply over the life of the EE measure, as follows:
 - Actual, normalized conditions that exist over the period when EE savings occur, if these conditions are measured throughout the measure life, for example as part of ongoing PB-MV.

- With this approach, adjust baseline electricity-consumption data to reflect actual independent factors observed after the measure is in place.
- Examples of adjusted independent factors are:
 - Observed weather conditions for a residential heating efficiency project,
 - Observed occupancy rates for a commercial building lighting efficiency project, or
 - Observed product production rates for an industrial efficiency project.
- 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 must be normalized to data on the independent factors, where reasonable and appropriate. Examples of normalized independent factors are:
 - Typical weather conditions for a residential heating efficiency project,
 - Typical occupancy rates for a commercial building lighting efficiency project, or
 - Typical product production rates for an industrial efficiency project.
- Where first-year savings values – derived by applying first-year independent factors – are used to represent annual savings for the EUL of the project or measure, provide a justification for why this is a reasonable assumption (i.e., justify why first-year independent factors can be shown to represent standard/typical conditions over the life of the measure).

2.6 Accuracy and Reliability of Quantified Savings

2.6.1. Discussion

It is a best practice in the EE industry for EM&V plans to include information on how the accuracy and reliability of EE savings will be determined based on the selected EM&V methods. The level of accuracy and reliability of quantified and verified MWh savings values is determined by the rigor of the EM&V methods applied, where rigor is typically quantified using statistical indicators such as confidence intervals and or the relative precision at a given confidence level (for annual MWh savings, or for a representative sample of an EE program population). The accuracy and reliability of quantified savings reflects the magnitude of the following two types of error:

- **Systematic error:** inaccuracies in the same direction, causing savings values to be consistently either overstated or

Key Terms

- **Accuracy:** A concept that refers to how close and estimate or measured value is likely to be to the true value. The term can also be used in reference to a model or a set of measured data, or to describe a measuring instrument's capability.
- **Reliability:** The quality of a measurement process that would produce similar results on (1) repeated observations of the same condition or event, or (2) multiple observations of the same condition or event by different observers. Reliability refers to the likelihood that the observations can be replicated.
- **Rigor:** the level of effort expended to minimize uncertainty in savings estimates such as sampling error and bias. The higher the level of rigor, the more confident one is that the results of the EM&V activities are both accurate and precise. Rigor may be quantified or described with metrics for reliability and certainty, such as statistical confidence and precision.

understated. Systematic errors (also referred to as bias) may result from incorrect assumptions, a methodological issue, or a flawed reporting system.

- **Random error:** error occurring by “chance” that may cause the savings estimates to be inconsistently overstated or understated. Random errors include an observed change in energy use due to unaccounted-for factors that affect energy use.

The magnitude of random error can be quantified based on the variations observed across different units. By contrast, systematic error or bias is not quantifiable based on the observations. For this reason, it is important to report the quantifiable random error, and to describe the steps that have been taken to minimize the potential for systematic error, and provide a subjective assessment of the potential effects of such error.

2.6.2. Applicable Guidance

- Assumptions required for savings quantification should be designed neither to provide optimistic savings estimates (aiming to err on the high side) nor to provide conservative estimates (aiming to err on the low side).
- If sampling is used for quantifying savings values, ensure that actual observed confidence/precision values are applied (versus ex-ante estimates of confidence/precision). If sampling is used to quantify savings, report the statistical precision of the associated estimates. Examples of use of sampling for savings quantification include:
 - PB-MV of the program savings, based on PB-MB for a sample of projects and installed measures.
 - A program-level estimate of savings or of key parameters used to calculate savings (e.g. lighting operating hours) derived from a random sample of units.
 - For savings determined by comparison group methods, the statistical confidence intervals or confidence/relative precision levels of the program effect measured by the comparison group analysis should be reported. Applicable guidance documents include:
 - SEE Action Guide on evaluating behavior programs,³⁰
 - Uniform Methods Project Sample Design Cross-Cutting Protocol (Section 11)³¹, and
 - Uniform Methods Project Whole-Building Retrofit Evaluation Protocol (Section 8)³²
- Apply and cite applicable industry-standard protocols and guidance documents for sampling. Best practices for statistical sampling are described in:
 - ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources.³³
 - The California Evaluation Protocols.

³⁰ State and Local Energy Efficiency Action Network. (May 2012). Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations. Prepared by Todd, A.; Stuart, E.; Schiller, S.; Goldman, C.; Lawrence Berkeley National Laboratory. www1.eere.energy.gov/seeaction/pdfs/emv_behaviorbased_eeprograms.pdf

³¹ See: <http://www.energy.gov/sites/prod/files/2013/11/f5/53827-11.pdf>

³² See: <http://www.energy.gov/sites/prod/files/2013/11/f5/53827-11.pdf>

³³ Current version is manual M-MVDR, revision 6, dated June 1, 2014

- Uniform Methods Project *Sample Design Cross-Cutting Protocol* (Chapter 11).
- For deemed savings:
 - Quantify random errors if applicable
 - Include the statistical precision (margin of error) of any EM&V parameters determined using sampling
- For all EM&V methods, discuss potential risks and biases (and associated quality-control measures) in EM&V plans and monitoring and verification reports.
- For states trading ERCs across borders, coordinate in an effort to apply the same or consistent EM&V approaches to ensure the savings values are determined with comparable levels of accuracy and reliability.

2.7 Avoiding Double Counting

2.7.1. Discussion

Double counting occurs when the MWh savings from a single EE program, project, or measure are counted more than once under the same regulation or program. This type of error must be prevented to maintain programmatic integrity and credibility, and to ensure that EE results in real and permanent reductions in CO₂ emissions. Tracking, accounting, and quality checks are steps that are routinely undertaken in states and regions across the country to avoid double counting. The purpose of these steps is to avoid the following circumstances:

- Savings from a single EE program or project being claimed by more than one EGU or state. For example:
 - Two EGUs claiming the savings from the same lighting retrofit program, or an EGU claiming the same savings that a state is claiming.
- Two or more EE programs or projects operating at the same time claiming savings from the same MWh savings. For example:
 - Some or all savings from the same retrofit being claimed by a residential behavior-based program and a retailer point-of-sale incentive program.³⁴
Savings from a single retrofit project being claimed by a utility incentive program and the ESCO that implemented the retrofit.
- Two or more programs operating during different years claiming savings from the same projects or measures, for example:
 - A 2020 program incenting an LED lamp operating for 10 years, with the lamp failing after 2 years and being replaced by a new LED lamp that receives an incentive from another program.
- Inconsistent baselines across a portfolio of programs, for example:
 - A state claiming (1) in one program savings from enacting a C&S with 100-percent compliance that results in savings above a prior C&S or common practice, and (2) in another program

³⁴ 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.

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 projects or measures.

- A state claiming credit for federal actions such as building code determinations or appliance standards

2.7.2. 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 programs and projects with identified consumers, track EE actions (type and number of measures implemented) at the utility-customer level using customer name, address, account number, and date of actions for each program.
 - For programs without identified consumers, such as point-of-sale rebates and retailer or manufacturer incentive programs, track applicable vendor, retailer, and manufacturer data. Include the appropriate specifications and quantities of program-incented units sold or shipped, with as much granularity as possible.
 - 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.
 - Identify and correct for duplicate EE activity records across 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 programs with identified consumers but without identified EE actions (e.g., an information or behavioral program) that apply comparison-group EM&V, use the comparison group’s tracked activity to determine the baseline activity in the other programs; the balance of the participant group’s tracked activity is incremental other-program activity.
 - The savings for this incremental activity is reflected both in the total tracked savings for the other programs and in the comparison-group-based savings for the informational program, and should be subtracted from one or the other total.
 - Use the SEE Action Guide or the UMP protocol for evaluating behavior programs for further guidance on applying this method³⁵.

³⁵ See: <https://www4.eere.energy.gov/seeaction/publication/evaluation-measurement-and-verification-emv-residential-behavior-based-energy-efficiency>

2.8 Effective Useful Life and Persistence of Savings

2.8.1. Discussion

While the full cost of an EE project or measure is typically borne at the time of purchase and installation, the resulting MWh savings accrue for the full duration of time for which the EE is in place. The typical practice of state PUCs (for consumer-funded EE programs) and ESCOs is to apply one or more EM&V methods to measure and report EE savings during the first year, and then to assume a constant (or in some cases, systematically declining) level of savings in each year for the full lifetime of the project or measure (or, alternatively, for a specified time horizon such as 10 years). This period of time is referred to as the effective useful life (EUL).³⁶

Key Term

- **Effective useful life (EUL):** an estimate of the duration of savings from individual EE measures, reported in years. Values are typically specific to individual EE measures or projects but also may be specified by program. EUL is defined through various means, including median number of years that the measures/projects installed under a program are still in place and operable.

EUL is a function of the *expected* life of the equipment and the number of years that the measure actually *persistence*, as determined using field measurements of on-the-ground conditions. The methods for determining EUL of a given measure vary somewhat across the country and by EE provider based on observable conditions (such as weather and climate), input assumptions (such as rates of measure failure), and other factors.³⁷ For commonly implemented measure types, it is typical for state, regional, or national entities to collaborate on mutually beneficial research to refine and improve EUL measurements, especially in light of ongoing industry trends and technology evolution over time.

2.8.2. Applicable Guidance

- Use Section 2.9 (*Savings Quantification and Verification Cycles*) of this document to inform first-year verification activities undertaken to determine whether measures were properly installed, functioning, and capable of generating savings.
- Determine deemed EUL values using either or both:
 - Documented best practices that are determined by independent entities and publically documented per the requirements indicated below in the subsection on *Deemed Savings*.
 - Persistence studies conducted by independent entities at least once every 5 years to determine values.
- If deemed EUL values are used:
 - Report incremental and cumulative savings with the assumption that savings revert to zero at the end of the applied EUL (after a period of time equal to the EUL has elapsed). This implies

³⁶ See: Energy Savings Lifetimes and Persistence: Practices, Issues and Data, Ian M. Hoffman, Steven R. Schiller, Annika Todd, Megan A. Billingsley, Charles A. Goldman, Lisa C. Schwartz, Lawrence Berkeley National Laboratory, February 2015.

³⁷ For example, technical measure life or equipment life usually is defined as the median number of years that a measure is installed or initiated and is operational. Less commonly, it is defined as the mean number of years to failure. Median value means the time at which half of the measures are removed from service or are otherwise no longer operating as assumed, and half remain operating as assumed.

that project or program participants do not continue the EE practice beyond “measure life,” and that if a new measure is implemented at the end of the prior measure’s EUL, a reassessment of the appropriate CPB is needed.

- Consider using ongoing field verifications to determine the actual (versus deemed) EUL values for measure lifetime and persistence of savings. If ongoing field verification is used, EE savings can be counted for as long as verification indicates that the project or measure persists.
- Apply persistence and/or degradation studies to establish and adjust deemed values (i.e., in lieu of conducting regular interval inspections to determine if measures are functioning and generating savings).
- If project or program persistence studies are conducted to determine the duration of savings, then savings can be counted as long as the verification activities indicate continued measure operation and performance.
 - Such studies should be conducted at least every five years
- Participate in collaborative and joint research to improve the breadth and quality of EUL values (several such research activities are ongoing in states around the country).

2.9 Savings Quantification and Verification Cycles

2.9.1. Discussion

Determining MWh savings from an EE activity is typically a two-step process: (1) verifying that a measure or project has been installed and (2) quantifying savings.

To illustrate the difference between the two activities, consider a project involving replacement of 100-watt incandescent lamps with 13-watt LED lamps.

Verification involves confirming that the replaced lamps are 100 watts, that the new ones are 13 watts, and that the lamps are installed and working. Verification confirms that the measure has the potential to save electricity, with the savings depending on how many hours the lamps operate. The number of hours the lamps operate might be determined by using a (1) deemed savings value for 13-watt lamps that replace 100-watt lamps or (2) verified based on metering at a sample of projects, using the IPMVP Option A or B.³⁸

Key Term

- **Verification (project or measure):** an assessment by an independent entity to ensure that the EE measures have been installed correctly and could generate the predicted savings. Verification may include assessing baseline conditions and confirming that the EE measures are operating according to their design intent. Site inspections, phone and mail surveys, and desk review of program documentation are typical verification activities.

2.9.2. Applicable Guidance

- Verify a sample of projects to represent the full program population in cases where many projects are implemented in a program (in cases where verifying every project is not feasible or practical). Determine sample sizes as defined in Section 2.6 on *Accuracy and Reliability of Quantified Savings*.
- Use verification findings to adjust annual electricity savings on a going forward basis.

³⁸ See: http://www.evo-world.org/index.php?option=com_content&view=article&id=272&Itemid=379&lang=en

- Apply the following verification strategies for these common EE activities:
 - For **EE retrofits**, verification can include confirming (1) installation rates of the indicated EE measures, (2) that these installations are above and beyond CPB and meet reasonable quality standards, and (3) that the measures are operating correctly per design intent and can generate the predicted savings.
 - For **EE new construction projects**, verification can include reviewing and confirming commissioning documentation.
 - For **EE point-of-sale rebate** or **distributor incentive programs**, verification can include confirming the sales data used for determining electricity savings and verification with a sample of end users.
- Use EM&V and the derived savings realization rates to adjust claimed annual electricity savings.
 - If savings quantification is conducted separately from savings verification (e.g., deemed savings and PB-MV methods), the savings quantification may determine savings per verified unit. This value can then be applied to the verified units.
 - When comparison-group methods are used, the analysis may be considered to provide a combination of savings quantification and verification. That is, the analysis yields both what was actually installed and operating, as well as the operational practices that affect savings. Separate verification activities are therefore not necessary.
 - To continue to count savings after the first year with comparison group methods, establish an EUL as described in Section 2.8.2 or continue the comparison group analysis in each year for which savings continue to be counted.
 - If the comparison group analysis is continued in successive years, include a discussion of the basis on which the comparison group remains appropriate and valid.

2.10 Transmission and Distribution (T&D) Savings Adders

2.10.1. Discussion

The difference between the electricity generated (busbar value) and consumed (meter value) is due to losses in the transmission and distribution (T&D) system. U.S. Energy Information Agency (EIA) data indicates that national, annual T&D electricity losses average about 6 percent of the electricity that is transmitted in the U.S.³⁹ Every unit of electricity consumption avoided at an end-use site also avoids losses that would have occurred as that electricity was delivered through the T&D system. Requirements and guidance on how T&D savings can be added to end-use electricity savings values follow.

2.10.2. Applicable Guidance

- Adjust MWh savings results from EE programs, projects, and measures by using a T&D line-loss adjustment factor (adder) based on the lesser of 6 percent of the site-level savings or the calculated statewide annual average T&D loss rate total electric supply minus direct electricity use divided by

³⁹ The national average loss from 1990 to 2012 is six percent. See: <http://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3>

direct electricity use)⁴⁰ expressed as a percentage and based on values in the most recent year and published in the U.S. EIA State Electricity Profile.

- For Voltage/VAR optimization and conservation voltage regulation (CVR) - that lower both line losses and facility-level MWh consumption – identify and document the procedures that will be used to quantify the portion of overall savings that occur on the customer-side of the utility.

2.11 Interactive Effects

2.11.1. Discussion

EE measures often have indirect impacts on electricity and fossil-fuel use in systems not directly affected by the subject measures. For example:

- Installing efficient lighting in a building's cooled and heated space can decrease the electricity use of cooling systems and/or increase natural gas consumption in heating systems.

This section provides guidance on how indirect electricity impacts, called interactive effects, should be addressed.

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 measure, project, or program. For example, reduction in lighting loads through an energy-efficient lighting retrofit can reduce buildings' air conditioning and increase heating requirements because less heat is generated by energy-efficient lighting systems compared with less efficient lighting systems.

2.11.2. Applicable Guidance

- Address quantification of interactive effects of *electricity consumption* in EM&V plans and referenced in monitoring and verification reports.
- Use the U.S. DOE's Uniform Methods Project (UMP)⁴¹ or other applicable protocols and methods to estimate interactive electricity effects.
- It is not necessary to quantify the *interactive effects* of *end-use fossil fuel use* (i.e., non-electricity fuels such as natural gas) for the purpose of the EPA's emissions guidelines for affected electric utility generating units.
 - However, it should be noted that that these cross-fuel effects have implications for overall greenhouse gas (GHG) emissions. Evaluating such effects is a best practice in many states.

⁴⁰ Estimated losses in MWh, total electric supply, and direct electricity use values are available in the U.S. EIA's State Electricity Profiles. See table on Supply and Disposition of Electricity (currently Table 10). Direct electricity use refers to the electricity generated at facilities that is not put onto the electricity grid, and therefore does not contribute to T&D losses.

⁴¹ See chapter 2: http://energy.gov/sites/prod/files/2013/07/f2/53827_complete.pdf (Version as of August 2015)

2.12 Use of EE EM&V Protocols and Guidelines

2.12.1. Discussion

A key aspect of industry best-practices with EE savings quantification is the use of one or more EM&V protocols and guidelines. Several such documents define, provide instructions for use, and generally govern the application of the three EM&V methods outlined in Section 2.1 above. Examples of these protocols and guidelines are provided in **Table 2-2**. EPA supports the use of these resources in state plans, and encourages their further development for demand-side EE savings as they relate to the requirements of the CPP.

As noted in Section 1 above, the development of these national, regional, and state-by-state protocols and guidelines is primarily an outgrowth of the utility-administered EE programs, as well as public- and private-sector ESCO projects, in place in most states throughout the country.

Table 2-2: Examples of Industry-Standard EE EM&V Protocols and Guidelines⁴²

Protocol/Guideline <i>Sponsor</i>	Website	Summary
Uniform Methods Project (UMP) <i>U.S. Department of Energy (DOE)</i>	http://www.energy.gov/eere/about-us/ump-protocols	Provides protocols for PB-MV for many common EE measures and technologies based on accepted methods for a core set of widely deployed EE measures (version as of August 2015).
Energy Efficiency Program Impact Evaluation Guide <i>SEE Action - U.S.DOE and U.S. Environmental Protection Agency (EPA)</i>	http://www.epa.gov/eeactionplan	Describes common terminology, structures, and approaches used for determining energy savings and avoided emissions and other non-energy benefits resulting from facility (non-transportation) EE programs. It provides context, planning guidance, and discussion of issues that determine the most appropriate evaluation objectives and best practices approaches for different efficiency portfolios.
Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans <i>U.S. EPA</i>	http://www.epa.gov/airquality/eere/pdfs/EEREmannual.pdf	Provides guidance for incorporating EE and renewable energy policies and programs into State and tribal implementation plans.

⁴² Table 2-2 lists of some of the protocols and guidelines that can be considered “established” and which are publically available and have been promulgated and/or adopted by a State, regional, national, or international organization. Stakeholders may request that EPA to recognize additional protocols and guidelines as they emerge over time.

Protocol/Guideline Sponsor	Website	Summary
NEEP Regional-Common EM&V Methods and Savings Assumptions Guidelines <i>Northeast Energy Efficiency Partnership</i>	http://www.neep.org/regional-emv-methods-and-savings-assumptions-guidelines-2010	Provides methods for determining gross energy and demand savings and savings assumptions for a priority set of EE program/project types or measures.
<i>California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals</i> <i>California Public Utility Commission</i>	http://www.calmac.org/publications/EvaluatorsProtocols%5FFinal%5FA doptedviaRuling%5F06%2D19%2D2006%2Epdf	Guides the efforts associated with evaluating California's EE programs and program portfolios.
California Evaluation Framework (2004) <i>California Public Utility Commission</i>	http://www.calmac.org/publications/California%5FEvaluation%5FFramework%5FJune%5F2004%2Epdf	Provides a consistent, systematized, cyclic approach for planning and conducting evaluations of California's EE programs.
International Performance Measurement and Verification Protocol (IPMVP) Efficiency Evaluation Organization	http://www.evo-world.org	Provides an overview of current best practices for determining savings from EE projects and measures; provides a framework and definitions that can help practitioners develop PB-MV plans for their projects.
FEMP PB-MV Guidelines U.S. DOE Federal Energy Management Program	http://www.mnv.lbl.gov/keyMnVDocs	Provides guidelines and methods for documenting and verifying the savings associated with federal agency performance contracts; contains procedures and guidelines for quantifying the savings resulting from energy efficiency.
ASHRAE Guideline 14, Measurement of Energy and Demand Savings <i>American Society of Heating, Refrigerating, and Air-Conditioning Engineers</i>	http://www.ashrae.org	ASHRAE is the professional engineering society that has been most involved in writing guidelines and standards associated with EE; compared with the FEMP PB-MV Guidelines and the IPMVP, Guideline 14 is technically more detailed and addresses the analyses, statistics, and physical measurement of energy use for determining energy savings.

Protocol/Guideline Sponsor	Website	Summary
Regional Technical Forum (RTF) <i>Northwest Power and Conservation Council</i>	http://www.rtf.nwcouncil.org	An advisory committee established to develop standards to verify and evaluate the savings from a wide range of EE and conservation measures; maintains an extensive and well documented database of deemed savings values.
ISO-NE Measurement and Verification of Demand Reduction Value from Demand Resources – Manual M-MVDR <i>Independent System Operator – New England</i>	http://www.iso-ne.com/participate/rules-procedures/manuals	Provides guidance and required criteria for measuring and verifying performance of demand resources participating in the wholesale electric markets administered by ISO.
PJM Manual 18B: Energy Efficiency Measurement & Verification <i>PJM Interconnection</i>	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_2ESjIdAP10sPjZb94Mw&sig2=Ydqecugs2P PnuJTwxmtPlw&bvm=bv.92291466,d.b2w	Provides guidance on measuring and verifying the demand reduction value of EE resources.

EE EM&V activities related to EPA’s emissions guidelines can benefit from applying established guidelines and protocols. It should be noted, that while EPA encourages the use of well-established EM&V guidelines and protocols, the agency recognizes that these resources do not provide a step-by-step “recipe” for quantifying savings. This is largely because:

- Approaches vary from state to state due to a variety of factors. These factors include the program, project, or measure being evaluated, whether savings values have been established in the past for the subject EE activity, and the overall magnitude of program impacts.
- Guidelines and protocols per se provide flexibility with respect to key EM&V issues, such as selection of methodologies and key parameters, the timeframe addressed by EM&V (short-term, first-year, or lifetime data collection and analyses of savings), and the desired accuracy of savings.

In this way, EPA recognizes that the application of EM&V guidelines and protocols requires professional judgment and assessment of the EE activities to determine the appropriate EM&V method, assumptions, other factors to apply, and applicability within the context of EPA emissions guidelines, calculations and other elements.

2.12.2. Applicable Guidance

- If EM&V plans and monitoring and verification specify the use of protocols or guidelines, provide a list of applicable minimum requirements and description of applicable sections, methods, and portions of the protocol or guideline.⁴³

⁴³ For example, simply referencing the IMPVP is not sufficient since it allows the use of four different options with flexibility with regards to a number of savings calculation assumptions

3. Supplemental Guidance for Specific Categories of EE

Section 3 provides EM&V guidance that is specific to several common categories of demand-side EE programs, projects, and measures. The EPA is providing guidance on these particular EE activities because they are commonly implemented (at scale) in all regions of the country, represent the significant majority of all EE savings currently being achieved, and because such guidance was requested by stakeholders. Each of these EE activities can also be characterized as having some form of state agency oversight or dedicated EM&V protocols and procedures.

The guidance in this section is intended to supplement Section 2, which applies to all demand-side EE savings (MWh). The best-practice approaches and technical assumptions provided below are not intended to provide a “recipe” for how EM&V should be implemented. Rather, this guidance is intended to inform decisions regarding certain EM&V parameters that are fundamental to the programs described. EE providers can apply the approaches and assumptions in Section 3 as they prepare EM&V plans for the specific program and project categories addressed.⁴⁴ As above, this section leverages and is consistent with prevailing industry best practices and assumptions currently being applied by state PUCs and other oversight and sponsoring entities. It applies only to rate-based state plans that allow the use of EE to generate ERCs or adjust an emission rate to comply with the emission guidelines.

The specific categories of demand-side EE covered in this section include:

- Utility and publicly administered EE programs
- Project-based EE (evaluated site-by-site)
- State and local government building energy code and compliance programs
- State and local government incremental product energy standards

By providing this additional guidance on these categories, the EPA is not intending to limit the EE activities that states may implement. Rather, the EPA is proposing that any demand-side EE program, project, or measure that results in MWh savings may be potentially eligible under the proposed model trading rule, provided that it meets the presumptively approvable provisions for eligibility described in section IV.C.3 of the model trading rule preamble, and that supporting EM&V is rigorous, transparent, credible, complete and fulfills the requirements provided in the emission guidelines and the state plan.

3.1 Demand-Side EE Programs

3.1.1. Program Description

Demand-side EE programs refer to a wide range of activities to support the efficient usage of electricity. These activities may be funded from different sources through different mechanisms and be

⁴⁴ Should conflicts arise between the guidance in this section and the guidance in Section 2, this guidance has precedence (since it is tailored to the specific programs and projects listed here). When preparing EM&V plans and monitoring and verification reports, the applicable industry protocols and guidelines listed in this document should be referenced.

administered by various entities, including investor-owned utilities (IOU), public utilities, state energy offices (SEO), and non-profit entities sanctioned by state legislators and public utility commissions. Examples of demand-side EE programs range from marketing, education, and outreach to the direct installation of efficient appliances in low-income households and complex industrial upgrades. In 2013, utility EE programs alone were reported to have gross incremental⁴⁵ electricity savings of approximately 24,000 GWh⁴⁶ with an estimated 16 million metric tons of avoided CO₂.

Demand-side EE programs can include direct and indirect action programs:

- *Direct action programs* are those that result in the *direct, explicit implementation* at end-use energy consumer facilities, of installed pieces of equipment or systems, as well as modifications of equipment, systems, or operations that reduce the amount of electricity that would otherwise have been used to deliver an equivalent or improved level of end-use service. Examples include:
 - Consumer product rebates,
 - Prescriptive and custom HVAC and lighting retrofit incentives,
 - Incentives or technical assistance for construction of new energy efficient buildings,
 - Whole-house retrofits,
 - Street lighting retrofits,
 - Commissioning and retrocommissioning, and
- *Indirect action programs* are those intended to *facilitate or indirectly result in implementation*, at end-use energy consumer facilities, of installed pieces of equipment or systems, as well as modifications of equipment, systems, or operations that reduce the amount of electricity that would otherwise have been used to deliver an equivalent or improved level of end-use service. Examples include:
 - Consumer behavior programs,
 - Marketing education and outreach programs,
 - Workforce education and training programs,
 - Financing programs,⁴⁷ and
 - Energy audit programs.

Note that both direct and indirect programs can be specifically directed toward low-income households and disadvantaged communities. Specific EM&V guidance is organized by whether the subject program relies on direct or indirect actions, as described above.

⁴⁵ Incremental savings include all energy savings that accumulated in 2013 from new 2013 participation in existing energy efficiency programs and all participants in new 2013 programs.

⁴⁶ CEE Annual Industry Report, 2014 State of the Efficiency Program Industry, May 2015,

http://www.library.cee1.org/sites/default/files/library/12193/CEE_2014_Annual_Industry_Report.pdf

⁴⁷ Some direct action programs have financing components and the savings of those programs can be assessed as described for direct action programs. However, for programs that only offer financing, their ability to generate incremental savings can be assessed using the indirect program suggested approaches and assumptions provided herein.

3.1.2. Applicable Guidance – Direct Action EE Programs

The following EM&V guidance reflects industry best practices and technical assumptions, and is intended to assist EE providers as they implement direct action EE programs.

- **EM&V methods** – The savings from direct action EE programs can be determined using the full suite of EM&V methods defined in Section 2.1: *PB-MV, comparison group approaches, and deemed savings*.
- **Baselines** – CPBs are applicable for direct action EE programs and should be defined consistently within a given action, as described in Section 2.2.
- **Independent factors** – To ensure that electricity savings are calculated consistently, each project in a single program should apply the same approach to independent factor conditions, as described in Section 2.5.
- **Accuracy and reliability of reported savings values** – As indicated in Section 2.6, reported accuracy and reliability should address both random error, quantified in terms of statistical precision, and systematic bias, addressed via discussion of potential sources of bias and their likely effects.
- **Avoiding of double counting** – Procedures to avoid double counting are described in Section 2.7.
- **Evaluation cycles** – Section 2.9 describes the requirements, including frequency, for verification to confirm measures were installed and are operating to produce savings, and for quantification of savings, and for their combination via comparison group methods..

3.1.3. Applicable Guidance – Indirect Action EE Programs

- **EM&V methods** – The EM&V methods that can be used for indirect action EE programs depend on the program structure and delivery, as follows.
 - Comparison group methods using RCT approaches are widely considered reliable and rigorous, and are encouraged by the EPA. However, use of these methods require that the program can be delivered to certain customers while excluding others from its influence, with random assignment of who receives the program incentive and who does not.
 - When including comparison group methods in a quasi-experimental design, the EE provider should justify the validity of the quasi-experimental comparison group as a representation of the participants in the absence of the EE intervention. The approach to ensuring validity should also be described.
- **Baselines**
 - When direct comparison is used to quantify savings using comparison group methods, the MWh usage of the comparison group of non-participants defines the equivalent of a CPB. When regression methods are used, the regression estimate that corresponds to the participant condition absent the EE intervention represents the CPB. Direct comparison is commonly used with RCT, while regression is more commonly used with quasi-experimental design, but either analysis method may be used with either design. The rationale for the design and analysis method used should be specified in the EM&V plan. In particular, the plan should describe how the specified comparison group represents the participants absent the intervention.
 - When deemed or PB-MV methods are used, baselines for indirect action programs should be defined consistently with baselines for similar EE actions in direct programs.

- **Independent factors** – Comparison group methods can be applied to produce savings for the particular conditions of the consumption data included in the analysis, or on a weather-normalized basis.
- **Accuracy and reliability of reported savings values** – As indicated in Section 2.6, reported accuracy and reliability should address both random error, quantified in terms of statistical precision, and systematic bias, addressed via discussion of potential sources of bias and their likely effects.
- **Avoiding double counting** – Applicable procedures for avoiding double counting are described in Section 2.7. In addition, if an indirect action program is operated on the same participants for successive years, savings may be counted as a persistent effect of a prior year or as the current program effect, but not both simultaneously in the same year.
- **Effective useful life and persistence of savings** – With indirect action programs using comparison group methods, the persistence of savings should be determined each year (or as discussed above possibly every other or third year). Savings are simply quantified until they are shown to fall to a zero or near-zero. For deemed or PB-MV methods, a value for the EUL of program savings should be quantified for that period.
- **Evaluation cycles** – Section 2.9 describes the requirements, including frequency, for verification to confirm measures were installed and are operating to produce savings, and for quantification of savings, and for their combination via comparison group methods.
- **Verification** – When comparison groups are the basis for PB-MV, verification for indirect action EE programs is the same as for direct action EE programs. That is, the savings determined by the comparison group analysis implicitly reflects both what actions were taken and quantification of associated savings.
 - The following alternate verification approaches, however, are suggested for comparison and control group approaches:
 - With *quasi-experimental* approaches, verification activities should be undertaken to ensure the actual installation of measures. Examples include confirming the number of students that took a training class and the curriculum of the class for a workforce education and training program, or confirming that marketing or educational program materials were actually distributed for a marketing program. The recommended frequency of verification depends on program specific considerations, but should be between once per year and no less than every 3 years.
 - With *RCT control groups*, verification should confirm the proper (random) selection of treatment and control group members.

3.2 Project-Based Energy Efficiency

3.2.1. Description

Project-based EE involves implementation of one or more EE projects, retrofit or new construction, by private firms (including ESCOs, contractors, or site owners/developers) at public or privately owned facilities in any market sector (e.g., residential, multifamily, commercial). Project examples include retrofits at a school or university campus, retrofits of individual office or apartment buildings, and retrofits at industrial facilities; many projects are completed for the municipal, schools and hospitals

(MUSH) market, including water treatment plants. This category can also include projects such as direct load control and EE projects at water treatment plants.

A distinguishing characteristic of project-based EE is that it applies PB-MV, or measure-based deemed savings values, instead of program-based EM&V methods. That is, savings are quantified for each project. By contrast, program-level savings quantify and verify savings only for a sample of projects (to represent all projects in the full program), or by conducting participant or market studies to determine factors that apply to the program as a whole.⁴⁸

During 2012, ESCO projects were estimated to have achieved gross incremental electricity savings of about 2,500 GWh and 34,000 GWh of ongoing project savings. It should be noted that some of these savings could overlap with demand-side EE program savings, and care should be taken to avoid double counting between these two categories.⁴⁹

3.2.2. Applicable Guidance – Project-Based Energy Efficiency

- **EM&V methods** – This EM&V guidance provides for the use of any of the EM&V methods defined in Section 2.1 (i.e., PB-MV, comparison group methods, and deemed savings). In practice, however, comparison group methods are typically not practical for individual projects. This is due to the difficulty in finding a proper comparison, or control, group for a single project or a small group of projects.⁵⁰
 - Therefore, the recommended methods are PB-MV and deemed savings, as described Section 2.4. In practice, PB-MV is often used in combination with deemed savings approaches.⁵¹ In practice, the suggested and more common PB-MV methods for retrofit projects are IPMVP Options A, B and C and, for new construction or replace on failure, IPMVP Option D.
- **Baselines** – As indicated in Section 2.2, CPBs are the regulatory requirement for quantifying savings. These baselines should be defined consistently across a portfolio of individual projects. Although the individual projects might apply differing baselines (e.g., because of the applicability of a code or standard, or the condition of replaced equipment), the requirements for defining baselines should be consistent.

For private EE contracts with consumers such as ESCO contracts, the baselines for savings calculation may be set according to the needs and preference of the customer. However, for states reporting savings to EPA, savings from these projects must be calculated using CPBs as defined in Section 2.2. Thus, for state reporting of privately implemented project savings, a second set of

⁴⁸ This is because the savings from individual projects are assigned to the responsible entity, whether a contractor or consumer, and not to a program administrator as in the case with EE programs.

⁴⁹ Estimating Customer Electricity Savings From Projects Installed by the U.S. ESCO Industry, Juan Pablo Carvalho, Peter H. Larsen, Charles A. Goldman, Lawrence Berkeley National Laboratory, LBNL-6877E, May 2015.

⁵⁰ For example, finding the right comparison facility, occupants, and owner for retrofits at a college campus, office building, or factory. With PB-MV, one could say that the “comparison group” is the affected facility before the efficiency retrofit. This approach is known as pre-post analysis. However, because of how the comparison group is defined, it does not have the benefits of more rigorously implemented quasi-experimental methods.

⁵¹ For example with IPMVP Option A, some information used to determine savings is gathered through metering and other information is based on deemed savings values. In contrast to the application of deemed savings alone, IPMVP Option A involves the application of facility-specific data and parameters in the quantification of savings. Advances in metering and analyses technologies and practices (such as advances in the use of data available from smart meters) are lowering the cost and increasing the reliability of PB-MV savings quantification.

calculations may be required in addition to those used to establish and administer the contract between the provider and its customer.

Commonly, the baseline for calculating savings for such contracts is the existing equipment. As indicated in Section 2.2, the CPB for calculating savings corresponds to existing equipment only in the case of retrofit, and then only for the remaining useful life (RUL) of the equipment. For replace-on-failure or new construction, and for early replacement after the RUL, the CPB is standard efficiency or market common practice equipment. Since it will not ordinarily be possible to take measurements under standard efficiency or market practice conditions, an adjusted calculation should be used to determine savings relative to the CPB as required.

If deemed methods are used to calculate savings for purposes of the private contract, an alternative deemed calculation using the CPB as defined in Section 2.2 should be used to calculate savings for purposes of reporting savings to the EPA.

If PB-MV is the basis for the savings determined for the private contract, the measured values should be used also in an alternative calculation of determine savings relative to the CPB. This means that the CPB efficiency level should be substituted for the existing equipment efficiency in the savings calculations or simulations developed from the measured data. If the PB-MV method is based on measured differences between the prior existing and new equipment, the savings relative to the CPB can be calculated from the savings relative to prior equipment as follows:

Savings|CPB

$$= \text{Savings|Existing} \times (1/\text{EFF}_{\text{CPB}} - 1/\text{EFF}_{\text{NEW}}) / (1/\text{EFF}_{\text{EX}} - 1/\text{EFF}_{\text{NEW}})$$

where

Savings|CPB = Savings relative to the CPB

Savings|Existing = Savings relative to the existing equipment

EFF_{CPB} = efficiency of the CPB equipment

EFF_{NEW} = efficiency of the new equipment

EFF_{EX} = efficiency of the existing equipment.

Industry-Standard Protocols and Guidelines

The following are industry best practices PB-MV guidelines and protocols for project-based EE

- IPMVP – International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings Volume I, EVO-10000 - 1.2007, Efficiency Valuation Organization. www.evo-world.com
- FEMP – M&V Guidelines: Measurement and Verification for Federal Energy Projects, Version 4.0, Prepared for the U.S. Department of Energy Federal Energy Management Program.
- ASHRAE – Guideline 14-2002: Measurement of Energy and Demand Savings, American Society of Heating, Refrigerating, and Air-Conditioning Engineers
- U.S. DOE UMP – Uniform Method Project: <http://www.energy.gov/eere/downloads/uniform-methods-project-methods-determining-energy-efficiency-savings-specific>
- For deemed savings practices, the operating procedures of well-established deemed savings databases, such as the one operated by the Northwest Regional Technical Forum. <http://www.rtf.nwccouncil.org> contains a list of protocols that can be applied, with appropriate explanation in EM&V plans and reports.

Alternative methods to calculate savings relative to the CPB may also be used.

- **Independent factors.** As indicated in Section 2.5.2, the same values of the independent factors should be assumed for the baseline or baseline period as for the with- EE conditions. These values may be either actual values of the independent factors observed during the period when savings occur, or may be estimated typical values. With PB-MV methods, the savings typically are based on actual conditions. In contrast, normalized or typical conditions are recommended as the basis for calculating deemed savings values. Caution should be used when combining PB-MV methods with deemed savings methods within a single project to ensure that independent factors are considered consistently in savings quantification.
- **Accuracy and reliability of reported savings values.** As discussed in Section 2.6, the certainty of reported savings values should be described in monitoring and verification reports via a written discussion of the PB-MV or deemed savings method(s) used, potential risks and biases, and related quality-control measures utilized. It is particularly important to indicate the sources of any deemed savings values, and to specify how the metering (what is metered, for how long, etc.) provides representative data. If sampling is used to determine savings, the confidence and precision of the sample's metric (e.g., lighting operating hours) must be reported. If the savings relative to the CPB are calculated as an adjustment to savings relative to a different baseline used for the private contract, the method and rationale for the determination of savings relative to the CPB should be described.
- **Avoiding double counting.** Procedures to avoid double counting are described in Section 2.7.3. Particular caution should be used to avoid double counting if the project was also part of a direct action EE program or might be influenced by an indirect action EE program that induces a consumer to save energy (e.g., a behavior program). This could otherwise result in an outcome where some of the same savings are claimed twice. If a project also participates in a direct action program, the appropriate steps include coordinating across initiatives and adequately documenting savings claims.
- **Effective useful life and persistence of savings.** On a project-by-project basis, the persistence of savings (i.e., the number of years after initial installation that savings are counted) can be determined with deemed EUL values. Persistence of savings, however, is typically based on periodic verification of all projects or a sample of representative projects. Verification, involving site inspections to ensure that EE measures are still operating correctly, can occur each year for a subset of projects on a rotating cycle, which should occur every 2 or 3 years. These verification results should be used to adjust annual savings.
- **Evaluation cycles.** Section 2.9.2 describes the requirements, including frequency, for verification to confirm measures were installed and are operating to produce savings, and for quantification of savings.

3.3 Building Energy Codes

3.3.1. Description

Local building energy codes are enforceable EE requirements that apply to the design and construction of buildings in many jurisdictions.⁵² According to the U.S. DOE, “model building energy codes and standards have the potential to save U.S. consumers an estimated \$330 billion by 2040. This equates to nearly 80 quads of cumulative full-fuel-cycle energy savings and over 6.2 billion metric tons of avoided carbon dioxide emissions.”⁵³

Specific building energy code actions that states and local governments may take include:

- Adoption of new energy codes with greater EE requirements than codes that have already been determined by the federal government to be cost effective, and

Ex-ante estimates of building code impacts are completed regularly as codes are

developed and adopted. In contrast, ex-post quantification of energy savings from building energy code adoption and compliance activities is not as common or well established. The primary code adoption and compliance impact evaluation work to-date has been completed in six states (Arizona, California, New York, Oregon, Rhode Island, and Washington) and at Pacific Northwest National Laboratory

Key Building Energy Code Definitions

- **Code:** Specifically, legal EE requirements that apply to the design and construction of buildings, usually for new buildings and for renovations and additions applying to existing buildings.
- **Adoption:** The process and actions required to put a code in place formally, such as a rulemaking process.
- **Compliance:** The process of meeting the code requirements and demonstrating that these requirements have been satisfied. Compliance is the responsibility of the builder or contractor.
- **Enforcement:** The process of verifying that a building meets the code. This process is typically conducted by a building code official.
- **Naturally Occurring Market Adoption (NOMAD):** The proportion of savings or application of measures equivalent to the code that would have taken place in the market even if the code had not been adopted.

Source: *Attributing Building Energy Code Savings to Energy Efficiency Programs*, IEE/IMT/NEEP Report, February 2013, The Cadmus Group, Inc., Energy Futures Group NMR Group, Inc. Optimal Energy

⁵² Energy codes are adopted by State and local governments and govern the design and construction of new residential and commercial structures in their jurisdictions, as well as in some cases the retrofitting of existing structures. Energy codes reference areas of construction such as wall and ceiling insulation, window and door specifications, HVAC equipment efficiency, and lighting fixtures. Usually, there are two methods for compliance. The most common that codes take is the prescriptive approach, in which the code stipulates the stringency of the materials and equipment the builder must use. The other method is the performance approach, the code allocates a total allowable energy use for a building, and the builder can choose the materials and equipment that will meet this target. State-level policies on building energy codes vary widely across the 50 States, the District of Columbia, and the five U.S. territories, and sometimes even within States, e.g. home rule States. Two foundational model building energy codes may be adopted by States and local jurisdictions to regulate the design and construction of new buildings: the *International Energy Conservation Code*® (IECC) and the *ANSI/ASHRAE/IESNA Standard 90.1 Energy Standard for Buildings except Low-Rise Residential Buildings*.⁵² The IECC addresses all residential and commercial buildings. ASHRAE 90.1 covers commercial buildings, defined as buildings other than single-family dwellings and multi-family buildings three stories or less above grade.

⁵³ <https://www.energycodes.gov/status-state-energy-code-adoption> - accessed June 12, 2015

(PNNL)⁵⁴ for U.S. DOE. These states have regulatory structures that define acceptable procedures for quantifying savings from code programs and attribute code program savings to EE program administrators.⁵⁵

3.3.2. Applicable Guidance – State and Local Government Building Energy Code and Compliance Programs

- **EM&V methods** – Achieved electricity savings from energy codes may be determined using a bottom-up approach that uses this equation, or a structurally similar analysis:

Annual electricity savings = (affected construction and retrofit area per year) × (electricity savings per unit of area) × (compliance rate) = square footage per year × (MWH savings/square foot) × (percentage)

For determining electricity savings per unit of area (for code adoption programs) or compliance rates and energy savings (for compliance rate programs), acceptable options are *direct empirical* and *indirect estimation*:

- *Direct Empirical*: These approaches are based on data collection for a representative sample of existing buildings that have been built or renovated subject to the subject code.
- With the *modeling version of this approach*, an empirically tested building energy simulation model is used with typical weather data and actual characteristics for the sample buildings. With the *billing/energy data analysis approach*, energy bills from buildings built or renovated under the new code are compared with energy bills of buildings constructed prior to the new code., The models or billing analyses are used for:
 - *Electricity savings* (net of compliance) – estimated by comparing the modeled energy use of an as-built building to modeled use of the same configuration building if it were built to meet the prior code exactly, or comparing buildings built under the new code to similar buildings built prior to the new code.
 - *Compliance rates* – estimated by comparing the modeled energy use of an as-built building to modeled use of the same building if it were built to meet the current code exactly.⁵⁶
- *Indirect Estimation*: This approach is associated primarily with assessing code compliance rates using secondary information, such as documents filed with building departments, building audits, or surveys of code officials. The DOE/PNNL checklist, developed under the American Reinvestment and Recovery Act (ARRA), is an example of a method that provides such an approach for assessing code compliance.⁵⁷

The recommended approach for determining electricity savings involves accounting for naturally occurring market adoption (NOMAD) of measures that are required by the code. NOMAD may be estimated through collection of market data or through expert judgment techniques. Acceptable

⁵⁴ <http://www.energycodes.gov/resource-center>

⁵⁵ *Attributing Building Energy Code Savings to Energy Efficiency Programs*, IEE/IMT/NEEP Report, February 2013, Prepared by: The Cadmus Group, Inc., Energy Futures Group NMR Group, Inc. Optimal Energy

⁵⁶ The preferred way to determine compliance rates is with modeling or billing analyses of actual buildings that were built or renovated and which were subject to the code. However, such analyses can be enhanced by, or possibly replaced with interviews with key trade allies and/or experts in the building standard development process.

⁵⁷ <http://www.energycodes.gov/compliance/evaluation>

approaches include conducting literature searches on the penetration rates of similar technologies with similar product characteristics, the use of expert opinions (e.g., via a Delphi process) on the expected penetration rates in the absence of a code requirement, and reviewing relevant market data. Use of multiple approaches is encouraged.

Data on the amount of construction and retrofits that would be affected by the new code each year (i.e., how many square feet of each building type will be built or renovated in a given year) are available from various resources such as:

- Industry statistics published by construction trade organizations
 - Publicly available building and renovation permit reports
 - Data purchased from market research firms
 - U.S. Census data (used to scale national numbers to state-specific values)
- **Electricity Savings Metrics and Baselines** – Electricity savings from building energy codes and compliance enhancement programs should be determined with respect to a *common practice baseline (CPB)*. With building energy codes, the CPB should be determined with consideration of naturally occurring market adoption (NOMAD) of efficiency building practices in the absence of an energy code or a prior energy code. (See text box for definition of NOMAD and related terms).

The baseline needs to be estimated with consideration of building practices assumed to have occurred in the absence of the code. Baseline building efficiency levels may be below, at, or even above the efficiency of the code-mandated efficiency

- **Accuracy and reliability of reported savings values** – As discussed in Section 2.6, the certainty of reported savings values should be described in monitoring and verification reports with a discussion of the EM&V method(s) used, potential risks and biases, and related quality-control measures utilized. It is particularly important to specify the *source(s) of construction and renovation data, per-unit savings estimates, compliance rates, and NOMAD*. If sampling is used to determine savings, the confidence and precision of the sample metric (e.g., compliance rates) should be reported.
- **Avoiding double counting** – Procedures to avoid double counting particularly between code initiatives and programs or projects are described in Section 2.7. To avoid double counting among multiple code efforts, a simple way may be to assume the baseline for the new code is the prior code, assuming NOMAD has not moved building efficiency practices beyond the prior code.
- **Effective useful life and persistence of savings** – At a minimum, code savings can be assumed to continue until at least the time at which a new state or local code is put into place. More realistically, however, savings from structural measures in a building built under a new code may be assumed to continue up to the time of the next natural major renovation of the building.
- **Evaluation cycles** – Construction/renovation square-footage data should be updated at least biennially and per-unit electricity savings values updated at least once every 4 years or whenever new building energy codes are put in place for the building type(s), whichever is more often. The principle metrics that should be *updated at least every 4 years* are baselines with respect to:
 - Any new state or local building energy codes that have come into force, and

- NOMAD – as construction practices, with respect to efficiency, would be expected to change over time, in the absence of codes, so that the CPB in, for example, 2029 might be much more “efficient” than in 2025.

Select EM&V Resources for Quantifying Savings from Building Codes

The following studies reflect the state-of-the-art regarding ex-post impact evaluation for building codes:

- Building Energy Codes Program: National Benefits Assessment, 1992–2040. 2014. Pacific Northwest National Laboratory
- Measuring State Energy Code Compliance. 2010. Pacific Northwest National Laboratory
- Residential Energy Code Compliance Evaluation: Guidance for Project Teams, Draft. November 2014. Pacific Northwest National Laboratory. PNNL-23538
- California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals, Codes And Standards And Compliance Enhancement Evaluation Protocol, April 2006, Prepared for the California Public Utilities Commission by The TecMarket Works Team
- Attributing Building Energy Code Savings to Energy Efficiency Programs, Prepared by The Cadmus Group, Inc., Energy Futures Group, NMR, and Optimal Energy for the Northeast Energy Efficiency Partnerships (NEEP) and its funding partners, the Institute for Market Transformation (IMT) and IEE. February 2013
- Statewide Codes and Standards Program Impact Evaluation Report for Program Years 2010-2012. August 2014. Prepared for: California Public Utilities Commission Prepared by Cadmus, Energy Services Division and DNV GL
- Resource Guide for Policy Makers. June 2011. U.S. DOE Building Energy Codes Program

The following are reports that use or discuss “top down” (econometric) evaluation of codes:

- The Impact of State Level Building Codes on Residential Electricity Consumption, Anin Aroonruengsawat, Maximilian Auffhammer, and Alan H. Sanstad, Energy Journal 2012, Volume 33, Number 1
- Are Building Codes Effective at Saving Energy? Evidence From Residential Billing Data In Florida, Grant D. Jacobsen and Matthew J. Kotchen*, The Review of Economics and Statistics, March 2013, 95(1): 34–49
- Analysis of Energy Saving Impacts of New Residential Energy Codes for the Gulf Coast. Lucas, R., “” The Pacific Northwest National Laboratory contract DE-AC05-76RL01830 (2007)

3.4 Incremental Product Energy Standards

3.4.1. Description

Appliance and equipment (product) energy standards are EE requirements that specify the minimum efficiency levels of specific products. Federal standards⁵⁸ currently apply to about 55 categories of appliances and equipment sold in the United States.⁵⁹ For products not subject to existing national standards (and thus not subject to federal pre-emption⁶⁰), states may adopt their own product standards for sales within their borders. Within the past decade, states have set standards for products ranging from DVD players to swimming pool pumps to water dispensers. Since 2001, Arizona, California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island, and Washington have each passed several rounds of state product standards.^{61,62}

In setting the actual product standards, the U.S. DOE and state energy offices adhere to an extensive and robust analytical process. This typically involves conducting detailed energy savings (and economic impact) potential studies of the anticipated future effects of these standards. In contrast, only a limited number of ex-post energy saving studies have been completed. California has conducted three cycles of energy code and appliance standard evaluations for the statewide Codes and Standards Program (implemented by four utility program administrators). The evaluation approach used in California is based on bottom-up analyses and is the primary basis for the following suggested EM&V approaches.

3.4.2. Applicable Guidance – State and Local Government Incremental Product Energy Standards

- **EM&V methods** – Achieved electricity savings from product standards should be determined on a product-by-product basis using a bottom-up approach and this equation:

Annual electricity savings =
(products sales volume per year) × (per unit electricity savings of sold products subject to standard)

There are two approaches that can be applied, each with a different metric for sales volume:

- The first approach is based on the view that a standard moves the entire market, with:

⁵⁸ Electricity savings associated with federal product standards or adopting codes that the federal government has already determined to be cost-effective cannot be used for compliance with EPA's emissions guidelines.

⁵⁹ Standards usually include the test procedures needed to measure the efficiency of these products and some guidance on how equipment that meets these standards needs to be labeled or included in directories. A recent study indicated that existing Federal standards alone will produce annual electricity savings in 2035 of about 720 TWh, saving about 14 percent of what the projected annual electricity consumption in that year would have been without standards, along with annual emissions reductions in 2035 of around 470 million metric tons of CO₂. From: The Efficiency Boom: Cashing In on the Savings from Appliance Standards, Updated from and supersedes report ASAP-7/ACEEE-A091, Amanda Lowenberger, Joanna Mauer, Andrew deLaski, Marianne DiMascio, Jennifer Amann, and Steven Nadel, March 2012. Report Number ASAP-8/ACEEE-A123. For a list of States that have adopted national standards, see: <http://www.appliance-standards.org/federal> and <http://www.energy.gov/eere/buildings/appliance-and-equipment-standards-program>

⁶⁰ Federal regulation becomes the law and supersedes any State regulation. Once the Federal government establishes an energy-efficiency standard, no State may have a regulation different from the Federal standard. This is referred to as Federal pre-emption.

⁶¹ Quoted directly from <http://www.appliance-standards.org/standard-basics-DOE-state-legislature-product-requirements> accessed 12/30/14.

⁶² For list of State standards see <http://www.appliance-standards.org/states>

- Product sales volume = total applicable market sales
- Per unit electricity savings = the difference in sales-weighted average energy use of products sold under NOMAD vs after the new standard.
- The second approach is based on the view that the standard eliminates only the least efficient units, with:
 - Product sales volume = applicable market sales currently below the new standard
 - Per unit electricity savings = difference between the new standard and sales-weighted average energy use of products that would not meet the new standard under NOMAD.

Sources of product sales data are:

- Industry statistics published by product-manufacturing trade organizations
- Publicly available market characterization reports
- Data purchased from market research firms, such as point-of-sale data and surveys of vendors, retailers, and contractors
- U.S. DOE Technical Support Documents for appliance and equipment standards
- U.S. Census data (used to scale national numbers to state-specific values)

Caution should be used when applying these data as they can be based on limited market surveys or might be missing certain products or models subject to the standard, but not necessarily tracked.

Per-unit electricity savings should be based on:

- Established laboratory-based test methods to determine *average* unit energy savings. A source of laboratory-testing requirements could be those established by industry groups, DOE, and the California Energy Commission.⁶³ The baseline should include assumptions about NOMAD to calculate a conservative correction factor for the unit-energy savings.
- Use of field measurements with NOMAD adjustments.

⁶³ Singh, Harinder, Ken Rider, Betty Chrisman, and Jared Babula. 2014. *2014 Appliance Efficiency Regulations*. California Energy Commission. Publication Number: CEC-400-2014-009-CMF

At this time, NOMAD estimates are typically determined by using a Delphi technique. These NOMAD estimates should include consideration of effects of prior-year standards and standards support programs.

- **Electricity Savings Metrics and Baselines** – Determine savings from product energy standards with respect to a CPB. For product standards, determine CPB with consideration of NOMAD of higher efficiency products in the absence of a standard.
 - NOMAD is a projection of what the annual sales,⁶⁴ over time, of products meeting the standards would have been if the standards had not been adopted.
 - Once the standard is in effect, the natural market no longer exists or can exist in reality. Methods for determining NOMAD are discussed in the next item on EM&V methods.
- **Accuracy and reliability of reported savings values** – As discussed in Section 2.6, the certainty of reported savings values should be described in monitoring and verification reports with a discussion of the EM&V method(s) used, potential risks and biases, and related quality-control measures that were used. Particularly important to indicate are the source(s) of product sales data, per-unit savings estimates, and NOMAD. If sampling is used in the process of determining savings, however, the confidence and precision of the sample’s metric (e.g., field measured electricity consumption) can and should be reported.
- **Avoiding double counting** – Procedures to avoid double counting particularly between code initiatives and programs or projects are described in Section 2.7. Updated product standards should be considered so that prior and new state or local standards for the same product(s) do not double count the same increments of savings.
- **Effective useful life and persistence of savings** – At a minimum, savings should be assumed to continue until at least a new federal, state or local standard is put into place.

Relevant EM&V protocols

- Following are a protocol and a guidebook that can be consulted for guidance on product standard EM&V:
 - California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals, Codes And Standards And Compliance Enhancement Evaluation Protocol, April 2006, Prepared for the California Public Utilities Commission by The TecMarket Works Team
 - Section 9 of this document: Energy-Efficiency Labels and Standards: A Guidebook For Appliances, Equipment, And Lighting 2nd Edition, Stephen Wiel and James E. McMahon, Collaborative Labeling And Appliance Standards Program (CLASP) Washington, D.C. USA, February 2005. LBNL Report Number: LBNL-45387(A)
 - Related *EM&V reports* that can provide valuable information are:
 - *Statewide Codes and Standards Program Impact Evaluation Report for Program Years 2010–2012*. August 2014. California Public Utilities Commission Prepared by Cadmus, Energy Services Division, and DNV GL.
 - *Realized and Prospective Impacts of U.S. Energy Efficiency Standards for Residential Appliances*, Stephen Meyers, James McMahon, Michael McNeil, Xiaomin Liu, Environmental Energy Technologies Division Lawrence Berkeley National Laboratory, LBNL-49504, June 2002.

⁶⁴ Not only sales, but also installation of the sold equipment should be assessed, but for the purposes of this guidance document, only sales data are described as involved in determining electricity savings.

- **Evaluation cycles** – Electricity savings values, which are reported for each year, are based on per-unit electricity savings values and sales volume data. Sales volume data should be updated at least biennially and per-unit electricity savings values updated at least once every 4 years or whenever new standards are put in place for the same product(s), whichever is more often. The principal metrics that likely would be updated at least every 4 years are baselines with respect to:
 - Any new state or federal product standards that have come into force.
 - NOMAD – it is expected that product efficiencies will change over time, in the absence of the standard, so that the CPB in, for example, 2029 might be much more “efficient” than in 2025.

Appendix A. Glossary of Terms

This glossary includes only terms that are used in this draft EM&V guidance.⁶⁵

Accuracy: concept that refers to the relationship between the true value of a variable and an estimate of the value. The term can also be used in reference to a model or a set of measured data, or to describe a measuring instrument's capability.

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

Baseline: conditions (including electricity consumption) that would have existed without implementation of the subject EE activity. Baseline conditions are used to estimate measure-, project-, and program-related savings.

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

Common practice baseline (CPB): default technology or condition that would have been in place at the time of project implementation without a decision to install a more efficient system or measure, for example, the system(s) or measure(s) a typical consumer/building owner would have continued with or installed at the time of project implementation.

Comparison group EM&V methods: approaches to determine program savings by taking the difference between a comparison group's electricity consumption and the consumption of program participants. Comparison group approaches include RCTs and quasi-experimental methods using nonparticipants.⁶⁶ These methods are generally used to estimate program-level savings versus facility- or project-level savings

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

⁶⁵ 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. State and Local Energy Efficiency Action Network. 2012. *Energy Efficiency Program Impact Evaluation Guide*. Prepared by Steven R. Schiller, Schiller Consulting, Inc., www.seeaction.energy.gov.

⁶⁶ With PB-MV, one could say that the "comparison group" is the affected facility before the efficiency retrofit. This approach is known as pre-post analysis and some people categorize it as a quasi-experimental method. However, because of how the comparison group is defined, it does not have the benefits of more rigorously implemented quasi-experimental methods and is not considered a comparison group method for the purposes of this guidance.

Deemed savings values: Also called **stipulated savings**, deemed savings values are estimates of electricity savings for a single unit of an installed EE measure that (1) has been developed from data sources (such as prior metering studies) and analytical methods that are widely considered acceptable for the measure and purpose, and (2) is applicable to the situation under which the measure is being implemented.

Individual parameters or calculation methods can also be deemed; for example, effective useful life of a measure or the annual operating hours of light fixtures in an elementary school classroom. Common sources of deemed savings values are previous evaluations and studies that involved actual measurements and analyses. With deemed savings, the per-unit MWh values are determined and agreed to by parties prior to EE implementation.

EE measure: at an end-use energy consumer facility, an installed piece of equipment or system; a strategy intended to affect consumer energy use behaviors; or modification of equipment, systems, or operations that reduces the amount of energy that would otherwise have been used to deliver an equivalent or improved level of end-use service.

EE program: activity, strategy, or course of action undertaken by an implementer or administrator. Each program is defined by a unique combination of the program strategy, market segment, marketing approach, and energy efficiency measure(s) included. Programs consist of a group of projects with similar characteristics and installed in similar applications.

EE project: activity or course of action involving one or multiple energy efficiency measures at a single facility or site.

Effective useful life (EUL): an estimate of the duration of savings from individual EE measures, reported in years. Values are typically specific to individual EE measures or projects but also may be specified by program. EUL is defined through various means, including median number of years that the measures/projects installed under a program are still in place and operable.

Electricity savings: change in electricity use resulting from the implementation of EE measures and practices, reported in units of megawatt-hours (MWh).

Enforcement: process of verifying that a building meets the code. This process is typically conducted by a building code official.

Free ridership: portion of a program's supported savings that would have occurred in the absence of the program.

Gross savings: change in energy consumption and/or demand that results directly from program-related actions taken by participants in an energy efficiency program, regardless of why they participated.

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

Independent factors: the explanatory factors (e.g., weather or occupancy) that affect the variable under study (e.g., electricity consumption) and can vary *independently* of the variable under study.

Inspections: site visits to facilities at which an EE project or 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 can or might not include review of commissioning or retro-commissioning documentation.

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 measure, project, or program. For example, reduction in lighting loads through an energy-efficient lighting retrofit can reduce buildings' air conditioning and increase heating requirements because less heat is generated by energy-efficient lighting systems compared with less efficient lighting systems.

Market effects: changes in the supply chain for energy efficient equipment or the behavior of participants and market actors resulting from market intervention(s).

Project-based measurement and verification: PB-MV is the process of using measurements to determine electricity savings associated with individual projects or measures reliably. PB-MV can be applied to a census or sample of projects (measures) in a program (project) to determine average savings for the program (project). With PB-MV, baseline electricity consumption is compared with post-project (or post-measure) electricity consumption measurements, along with analyses and documented assumptions to quantify savings. The IPMVP defines **two retrofit isolation** and **two whole-facility PB-MV options** used in the efficiency industry:

Retrofit isolation – assessing savings from each EE measure individually (IPMVP Options A & B). Although Option A allows some stipulation of factors, Option A differs from the use of deemed saving values in that all PB-MV options require some project site measurements.

Whole facility – analyzing savings from each EE measure in a project/facility collectively – (IPMVP Option C, review of energy bills or Option D, calibrated simulation).

Some combination of the above.

See Chapter 5 for more information on the IPMVP options.

Naturally occurring market adoption (NOMAD): proportion of savings or application of measures equivalent to the code that would have taken place in the market even if the code had not been adopted.

Net savings: change in energy consumption and/or demand that is attributable to a particular energy efficiency program. This change in energy use and/or demand may include, implicitly or explicitly, consideration of factors such as free ridership, participant and non-participant spillover, and induced market effects. These factors may be considered in how a baseline is defined (e.g., common practice) and/or in adjustments to gross savings values.

Random error: error occurring by “chance” that may cause the savings estimates to be inconsistently overstated or understated. Random errors include an observed change in energy use due to unaccounted-for factors that affect energy use.

Realization rate: the ratio of electricity savings an independent third party determines divided by the savings claimed by the measure, project, or program provider(s). The ratio's deviation from 1.0 can be due to (1) adjustments for data errors, (2) differences in implemented measure counts or other claimed information because of verification activities, or (3) other performance differences revealed through the PB-MV activities.

Reliability: quality of a measurement process that would produce similar results on (1) repeated observations of the same condition or event, or (2) multiple observations of the same condition or event by different observers. Reliability refers to the likelihood that the observations can be replicated.

Reporting year cumulative savings: the amount of electricity savings quantified and verified as a result of EE activities in the reporting year from both (a) EE activities operating for the first time in the reporting year and (b) EE activities initiated in prior years and still in effect; reported in annual megawatt hours, MWh.

Reporting year incremental savings: the amount of electricity savings quantified and verified as a result of EE activities operating for the first time in the reporting year; reported in annual megawatt hours, MWh.

Spillover: additional reductions in energy consumption that are due to an EE program's influences beyond those directly associated with the installed EE measures—these include participant and nonparticipant spillover.

Systematic error: inaccuracies in the same direction, causing savings values 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.

Verification: an assessment by an independent entity to ensure that the EE measures have been installed correctly and could generate the predicted savings. Verification may include assessing baseline conditions and confirming that the EE measures are operating according to their design intent. Site inspections, phone and mail surveys, and desk review of program documentation are typical verification activities.

Appendix B. Optional EM&V Plan Template for Demand-Side EE

The following guidance, in the form of an optional EE EM&V Plan template is provided to help EE providers develop EM&V plans that document how the applicable requirements in the final emission guidelines will be implemented. Such plans should be completed for each individual EE program or project to be used to generate ERCs or otherwise adjust an emission rate. For program-level EM&V plans, any one or more of the EM&V methods addressed in Section 2.1 above may be applied. Plans for EE projects must apply PB-MV, which is also defined and described in 2.1. Completion of the following template results in a stand-alone EM&V plan that contains complete information regarding the EM&V to be undertaken, why, when, and how.

B.1. EM&V Plan Template

Part A. Document Information

1. Program/project name and jurisdiction (e.g., state where the program will be implemented)
2. EE provider and EM&V plan author
3. Contact person for information about the EM&V plan
4. Date and version of the EM&V plan

Part B. Program/Project Background

1. Short description of the program or project being evaluated
 - a. EE measures offered or strategies implemented
2. Entities
 - a. EE provider, including associated implementation contractors (if any)
 - b. State agency or other entity with oversight or implementing responsibility
 - c. Target market sector and delivery mechanism (for EE programs only)
3. Implementation schedule
4. Projections for annual electricity savings over the effective useful life (EUL) of the EE program/project⁶⁷
5. Program/project budget

Part C. EM&V Overview

1. Savings quantification
 - a. Metric definition – i.e., annual MWh of adjusted gross savings based on a CPB
 - b. EM&V method – describe the value of the metric(s); include summary description of data collection approach, sample design, analyses methods, and significant assumptions; indicate the industry best-practices, protocols (e.g. IPMVP and the specific option) being applied.
 - c. Persistence of savings – if stipulated EULs are utilized, indicate source of such values and why they are applicable to the subject program; describe any other approaches utilized.
 - d. Independent factors – list and describe to be considered and supporting data that will be used to determine these variables' value; include how these factors are analyzed to quantify savings.

⁶⁷ Program life may be estimated as the average life of the measures being offered under the program.

- e. Description of whether savings will be based on conditions during performance period or normalized to standard/typical conditions (or other conditions); define standard conditions if applicable.
 - f. Deemed savings – if used, describe the version of the deemed savings database to be applied and/or the source of deemed savings; and how correct application of deemed savings values is ensured.
 - g. Sampling – if used, describe the sampling design and targeted confidence and precision for resulting savings.
 - h. T&D losses – if applied to savings values, specify the value of the loss factor, its source, and the applicable methodology.
 - i. Interactive effects – describe how interactive effects are calculated, their values, data sources and how the values are factored into measure saving values; if interactive effects are not included, explain why.
2. Verification activities – indicate intended verification activities, including:
 - a. When they will occur and who will conduct
 - b. How they will be used to adjust savings values as needed
 3. Avoiding double counting – indicate sources of potential double counting of savings and how it will be avoided including the tracking and accounting procedures that will be applied.
 4. Accuracy and reliability of reported savings values – indicate expectations for overall certainty of savings estimates, how the certainty of quantified MWh savings values will be assessed, and the methods to be used to control the types of error inherent to the applied EM&V methods, including:
 - a. Statistical indicators of certainty such as confidence and precision
 - b. Discussion of the threats to validity and potential risks, bias or error inherent to the applied EM&V methods
 - c. Methods for minimizing bias and other threats to validity
 - d. Quality-control procedures

Appendix C. EM&V Methods for Common EE Programs, Projects, and Measures: Best Practices and Resources

This appendix discusses existing best practices for quantify and verify savings, with relevance for the processes of EM&V planning, implementation, and ex-post documentation. The purpose of Appendix C is to provide illustrative examples of how EE savings can be quantified and verified at the program, project, and measure level, and to offer associated information resources and lessons gained from experience over the last several decades. Much of this information can similarly be applied to EE programs, projects, and measures that are not explicitly covered.

C.1. EM&V Methods for Select EE Program Types

Table C-1, *Common EM&V Methods and Activities for Typical Consumer-Funded EE Programs*, identifies the actual evaluation activities that are typically undertaken when a particular EM&V method is selected and applied. This table is offered as an information resource, as applied to most of the common EE programs in use today. It does not cover all program types and circumstances, does not prescribe one way to conduct EM&V (i.e., there are valid and appropriate reasons why a certain situation may call for a different method or set of EM&V activities).

Table C-1. Common EM&V Methods and Activities for Typical Consumer-Funded EE Programs

Type of Energy Efficiency Program	EM&V Method			Typical Evaluation Activities	Example Guidance and References	Links
	Comparison	M&V	Deemed			
Residential Audit Programs	X	X	X	<ul style="list-style-type: none"> Residential building simulation Savings algorithms Billing analysis Surveys to determine actions taken, together with deemed savings per unit or measure 	Uniform Methods Project, Chapter 8: <i>Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol</i> See also SEE Action’s Evaluation Measurement and Verification Portal for more references on evaluation methods and Technical Resource Manuals for deemed savings estimates by state or region	http://www.energy.gov/sites/prod/files/2013/11/f5/53827-8.pdf https://www4.eere.energy.gov/seeaction/evaluation-measurement-and-verification-resource-portal

Type of Energy Efficiency Program	EM&V Method			Typical Evaluation Activities	Example Guidance and References	Links
	Comparison	M&V	Deemed			
Residential Whole House Retrofit Programs	X	X	X	<ul style="list-style-type: none"> Billing/regression analysis Limited onsite data collection Building Simulation analysis Surveys to determine actions taken, together with deemed savings 	Uniform Methods Project, Chapter 8: <i>Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol</i>	http://www.energy.gov/sites/prod/files/2013/11/f5/53827-8.pdf
Residential Lighting Retrofit Programs		X	X	<ul style="list-style-type: none"> Onsite lighting loggers & lighting inventory Deemed hours of use (HOU) and coincidence factor (CF) Baseline matching of equivalent light output (lumens) for technologies not covered by federal standards 	Uniform Methods Project; Chapter 21: <i>Residential Lighting Protocol</i> (December 2014)	http://energy.gov/sites/prod/files/2015/02/f19/UMPC_hapter21-residential-lighting-evaluation-protocol.pdf
Residential HVAC Retrofit Programs		X	X	<ul style="list-style-type: none"> Onsite metering to determine full load hours (EFLH), capacity and CF Deemed EFLH and CF Gather data on system efficiency levels and charge 	Uniform Methods Project, Chapter 4: <i>Small Commercial and Residential Unitary and Split Cooling Systems protocol</i> (April 2014)	http://energy.gov/sites/prod/files/2013/11/f5/53827-4.pdf
Residential Water Heating Retrofit Programs		X	X	<ul style="list-style-type: none"> Onsite Data collection on water usage and temperatures Deemed system efficiencies and water usage profiles Deemed savings values per unit capacity 	Most recent study on stimulating adoption of high efficiency water heating is useful <i>Residential Water Heating Program Facilitating the Market Transformation to Higher Efficiency Gas-Fired Water Heating</i> , Prepared for the CEC by Gas Technology Institute, December 2012	http://www.energy.ca.gov/2013publications/CEC-500-2013-060/CEC-500-2013-060.pdf

Type of Energy Efficiency Program	EM&V Method			Typical Evaluation Activities	Example Guidance and References	Links
	Comparison	M&V	Deemed			
Residential Refrigerator Recycling Programs		X	X	<ul style="list-style-type: none"> Gather equipment model numbers to estimate removed units' consumption and part-year usage Regression analysis to estimate usage reduction Deemed savings values per unit capacity 	Uniform_Methods_Project; Chapter 7: <i>Residential Recycling Protocol (April 2013)</i>	http://energy.gov/sites/prod/files/2013/11/f5/53827-7.pdf
Residential Consumer Electronics Replacement Programs		X	X	<ul style="list-style-type: none"> Gather data on equipment energy hourly and energy usage, and load profiles Deemed baseline usage and savings algorithms Deemed savings values per unit capacity 	No protocols but useful references include: (1) <i>Set-Top-Box Pilot and Market Assessment (Research into Action, April 2015)</i> (2) <i>Literature Review of Miscellaneous Energy Loads (MELs) in Residential Building</i> , Prepared by Energy Solutions, 2014	http://www.calmac.org/publications/SCE_STB_Report_04_30_2015_FINAL.pdf
Low income Energy Efficiency Weatherization Programs	X	X	X	<ul style="list-style-type: none"> Onsite data collection to verify measure installation Billing analysis Building simulation models Surveys to determine actions taken, together with deemed savings 	Uniform Methods Project, Chapter 8: <i>Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol</i> "Evaluation of a Low-Income Energy Efficiency Program," by Jacqueline Berger, APPRISE, Paper published in ACEEE 2014 Summer Conference Proceeding	http://www.energy.gov/sites/prod/files/2013/11/f5/53827-8.pdf
Residential Behavior Programs	X			<ul style="list-style-type: none"> Billing Analysis using randomized control trials Website usage statistics to inform billing analysis 	Uniform_Methods_Project; Chapter 17: <i>Residential Behavior Protocol</i> (January 2015) http://eetd.lbl.gov/sites/all/files/publications/behavior-based-emv.pdf	http://energy.gov/sites/prod/files/2015/02/f19/UMPC_hapter17-residential-behavior.pdf

Type of Energy Efficiency Program	EM&V Method			Typical Evaluation Activities	Example Guidance and References	Links
	Comparison	M&V	Deemed			
Residential New Construction Programs		X	X	<ul style="list-style-type: none"> • Building Simulation Analysis • HERS ratings and onsite data collection to verify system installed • Surveys to estimate baseline & naturally occurring market adoption (NOMAD) • Surveys to determine actions taken, together with deemed savings 	California Energy Efficiency Evaluation Protocols: <i>Codes And Standards and Compliance Enhancement Evaluation Protocol</i> , April 2006, California Public Utilities Commission <i>Attributing Building Energy Code Savings to Energy Efficiency Programs</i> , IEE/IMT/NEEP Report, February 2013, Prepared by: The Cadmus Group, Inc., Energy Futures Group NMR Group, Inc. Optimal Energy	http://www.calmac.org/publications/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf
Non Residential Lighting Programs		X	X	<ul style="list-style-type: none"> • Onsite lighting loggers & lighting inventory • Deemed HOU and CF • Baseline matching of equivalent light output (lumens) for technologies not covered by standards • Surveys to determine actions taken, together with deemed savings 	Uniform Methods Project, <i>Chapter 2 Commercial and Industrial Lighting Evaluation Protocol</i> (April 2013)	http://energy.gov/sites/prod/files/2013/11/f5/53827-2.pdf
Non Residential Lighting Controls Programs		X	X	<ul style="list-style-type: none"> • Onsite metering of lighting EFLH to estimate control savings factor (CSF) • Deemed CSF • Whole building analysis if control savings expected to exceed 10% of building usage • Surveys to determine actions taken, together with deemed savings 	Uniform Methods Project, <i>Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol</i> (April 2013)	http://energy.gov/sites/prod/files/2013/11/f5/53827-3.pdf

Type of Energy Efficiency Program	EM&V Method			Typical Evaluation Activities	Example Guidance and References	Links
	Comparison	M&V	Deemed			
Compressed Air Programs		X	X	<ul style="list-style-type: none"> • Engineering estimates (with or without simulation models) based on (a) spot measurements to determine airflow, line pressure, compressor specific power, part-load performance, and operating hours and/or (b) metering to estimate compressor power, operating load and energy consumption • In some cases onsite leakage measurement for programs that seek to seal leaks • Surveys to determine actions taken, together with deemed savings 	Uniform Methods Project, Chapter 22: <i>Compressed Air Evaluation Protocol</i> (November 2014)	http://energy.gov/sites/prod/files/2015/01/f19/UMPC_hapter22-compressed-air-evaluation.pdf
Commercial New Construction Programs		X	X	<ul style="list-style-type: none"> • Onsite visits to gather or confirm data on building operation and characteristics • Building simulation models • Data collection to estimate baselines and NOMAD • Surveys to determine actions taken, together with deemed savings 	Uniform Methods Project, Chapter 13: <i>Commercial New Construction Evaluation Protocol</i> (September 2013)	http://energy.gov/sites/prod/files/2014/10/f18/Chapter%202015--Commercial%20New%20Construction%20Protocol.pdf

Type of Energy Efficiency Program	EM&V Method			Typical Evaluation Activities	Example Guidance and References	Links
	Comparison	M&V	Deemed			
Large Commercial and Industrial Custom Measure Programs		X		<ul style="list-style-type: none"> Spot or short term metering of end uses and processes affected by retrofit to gather energy use and performance data Gather data on independent variables driving consumption, including production Develop and validate engineering savings equations using regression analysis and above indicated data 	IPMVP – International Performance Measurement and Verification Protocol: <i>Concepts and Options for Determining Energy and Water Savings Volume I</i> , EVO-10000-1.2007, Efficiency Valuation Organization.	http://www.evo-world.org/index.php?view=download&alias=1543-2012-ipmvp-volume-i-in-english-27-20&option=com_docman&Itemid=1585&lang=en
Non Residential Retrocommissioning Programs		X		<ul style="list-style-type: none"> Gather data on independent variable driving usage pre and post installation of BAS and meter data for relevant systems within boundary for engineering or computer simulation analyses Regression analysis to adjust savings based on changes in independent variables 	Uniform Methods Project, Chapter 16: <i>Retrocommissioning Protocol</i> (September 2014)	http://energy.gov/sites/prod/files/2014/10/f18/Chapter%2016--Retrocommissioning%20Evaluation%20Protocol.pdf

Key for Evaluation Methods

C = Comparison of usage, billing analysis to estimate net savings

M&V = Measurement and verification of key parameters used to estimate savings

D = Deemed values for key parameters used to estimate savings

C.2. Project-Based Measurement and Verification for Common EE Technologies

As discussed in Section 3.1, *PB-MV* is a set of procedures for quantifying savings from an individual EE measure or project, versus an EE program. The information provided in this section illustrates how many of the EM&V topics introduced in Section 2 above are typically applied in practice to quantify and verify savings. It describes the PB-MV approaches frequently applied to quantify savings for specific technologies at the project and measure level, but does not provide guidance on whether PB-MV or deemed savings is the preferred approach (this section assumes that the decision to use PB-MV has already been made). As discussed in Section 2.1, selecting an EM&V method involves tradeoffs between cost, accuracy, and value of the resulting information in light of available budgets and desired levels of accuracy and reliability.

C.3. Residential Lighting

C.3.1. Definition

These projects involve installing efficient lighting products in residential dwelling, such as Light Emitting Diode (LED) lamps, and dimmable lights and. In all cases, the measure installed is designed to promote lamps with higher efficacy (lumens/Watt) and the same or better color resolution index. This guidance is applicable to at least the following four common program design approaches, for both new construction and retrofit applications of residential lighting measures:

- Direct installation of lighting products, including Energy Service Company (ESCO) projects
- Consumer incentives (e.g., rebates, coupons)
- Giveaways (installed for free during audits or mailed to homeowners)
- Upstream/Mid-stream/Downstream buy downs of retail lamp/fixture prices (e.g., point of sale rebates)

C.3.2. Key Challenges in Estimating Energy Savings

The primary measurement challenges for estimating lighting technology savings evaluation are:

1. **Operating hours** – Determining the operating hours for the lighting systems (baseline and project operating hours) where in many cases the exact location, building type, and fixture type are not known or cannot be easily found.
2. **Baseline wattage** – Determining the baseline wattage of lamps being replaced by more efficient lamps (baseline wattage) when in many cases the lumen output of the baseline bulb is not known and it is not known if the more efficient lamps provides lower, higher or equivalent lumens output. In addition, for upstream programs it is not known if the more efficient bulb simply replaced a bulb of similar efficiency or efficacy.
3. **Indirect savings or additional electricity use resulting from interaction with HVAC systems** – Estimating the indirect effects of installing more efficient lamps on the energy use of existing heating, ventilation and cooling systems.
4. **Free Riders and Technical Progress**– Estimating underlying market adoption rates is challenging. Particularly in lighting where product innovation is occurring a rapid pace. Consequently, programs that incent switching to current long-lived technology (e.g. a CFLs installed in 2010 persist through 2020 in a light use application) may yield short term energy savings but also reduce longer-term

savings that would have occurred if the consumer had later voluntarily switched to more efficient options (e.g. shifting directly from incandescent to a higher efficiency LED in 2015).

The most common evaluation methods for dealing with each challenge are discussed below:

A. Estimating Hours of Operation (HOU)⁶⁸

M&V Approach ⁶⁹	Typical Application
Self-reports from homeowner	Sites where trained auditors/contractors have installed more efficient bulbs as part of residential audit or direct install program
Deemed hours from previous evaluations or TRM	Evaluation of savings from upstream programs where retailers or distributors have received rebates to buy down incremental cost of bulbs, exact location of bulb installation is not known and the evaluation budget is not sufficient to cover cost of metering.
Install lighting loggers for short-term (from weeks to months) measurement and to extrapolate result to annual usage	Most common application in states where lighting programs have been operated for many years, lighting represents a significant portion of portfolio savings and results can be used by multiple program administrators

B. Estimating Baseline wattage

M&V Approach	Typical Application
In-home Inspection of a sample of baseline bulbs	Direct-install programs, Residential Audit Programs where CFL or LED's are installed for low cost or free
Use multiplier factors taken from TRM or previous evaluations to directly convert tracking data on energy efficient bulb wattage to estimated delta watts ⁷⁰	Upstream lighting programs where location of bulb installation is not known, tracking systems are not completely developed and program is in first few years of operation
Use Energy Star Lumen Equivalence Method with adjustment for EISA standards to estimate delta watts. ⁷¹	Upstream lighting programs where tracking systems have matured and shelf data exists to adjust baseline usage to account for EISA standard impact and possible sell through of existing product

⁶⁸ Note the range of recently evaluated residential lamp operating hours range from 1.7 to 3.0 hours per day.

⁶⁹ Note all of these approaches assume that hours of use for the new efficient bulbs is equivalent to the hours of use for the baseline bulbs. This assumption may need to be tested as saturation of LED's increase.

⁷⁰ Savings=multiplier * efficient bulb wattage. This multiplier is usually based on a bin match of the lumens produced by specific baseline and more efficient bulbs

⁷¹ Examples of equivalent wattage tables can be found in Massachusetts Technical Reference Manual 2011 (<http://www.ma-eeac.org/index.htm>), the New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs 2010 (<http://www.dps.ny.gov/TechManualNYRevised10-15-10.pdf>), and the Database for Energy Efficiency Resources (<http://www.deeresources.com>)

C. Estimating Interactive effects from efficient lighting on HVAC system usage

M&V Approach	Typical Application
Estimate indirect savings impacts using Waste Heat factors taken from previous evaluation studies or TRMs from adjacent states or regions.	Lighting Programs or Direct Project installations where efficiency of existing HVAC systems is not known
Use simulation modeling	Lighting Programs have been in effect for many years and the evaluation budget is sufficient to gather data on the system efficiency of HVAC systems where lamps have been installed

D. Other important evaluation issues

Finally, it is important to note that as lighting efficiency programs mature and the saturation of CFLs and LED increase, there will be a higher possibility that efficient lighting products will be used to replace in situ or existing efficient lighting products previously purchased. This possibility can be assessed using survey of homeowner purchase patterns or limited on site visits to a sample of participants.

C.3.3. Relevant protocols or evaluation studies for more information

1. Uniform Methods Project; Chapter 21: Residential Lighting Protocol (December 2014) <http://www.energy.gov/sites/prod/files/2015/02/f19/UMPCChapter21-residential-lighting-evaluation-protocol.pdf>
2. KEMA, Inc.; Cadmus Group, Inc. (February 8, 2010). Final Evaluation Report: Upstream Lighting Program. Prepared for California Public Utilities Commission, Energy Division. http://www.calmac.org/publications/FinalUpstreamLightingEvaluationReport_Vol2_CALMAC.pdf
3. Navigant Consulting; Itron; Opinion Dynamics; Michaels Energy (October 23, 2013). Residential Energy Star Lighting PY5 Evaluation Report. Presented to Commonwealth Edison Company. http://www.ilsag.info/comed_eval_reports.html
4. Nexus Market Research, Inc.; RLW Analytics, Inc. GDS Associates (January 20, 2009). Residential Lighting Markdown Impact Evaluation. Prepared for Markdown and Buydown Program Sponsors in Connecticut, Massachusetts, Rhode Island, and Vermont. <http://www.env.state.ma.us/dpu/docs/electric/09-64/12409nstrd2ae.pdf>

C.4. Small Commercial and Residential Unitary and Split Cooling Systems

C.4.1. Definition

These projects involve installing efficient cooling systems in residential and small commercial applications. Typical projects involve packaged systems with capacities between three and 20 tons and split systems with capacities $\leq 65,000$ BTU/hour (5.4 tons). This guidance is applicable to at least the following common program design approaches, for both new construction and retrofit applications of small commercial and residential unitary and split systems measures:

- Direct installation of cooling systems, including ESCO projects
- Consumer incentives (e.g., rebates, coupons)
- Upstream/Mid-stream/Downstream buy downs of retail cooling system prices (e.g., point of sale rebates)

C.4.2. Key Challenges in Estimating Energy Savings

The two most difficult or primary measurement challenges for this technology are:

1. Determining baseline efficiency conditions and
2. Determining Equivalent Full Load Hours (EFLH) for cooling system use.

The most common evaluation methods for dealing with each challenge are discussed below:

A. Determining Baseline Efficiency Conditions or System Ratings

M&V Approach	Typical Application
Gather baseline efficiency ratings from HVAC system equipment nameplates from a sample of participating homeowners or survey HVAC contractors to determine the CPB	For situations where contractor or homeowner reports cooling system is being replaced early or before the end of its useful life.
Use minimum efficiency level required by building or appliance code to estimate savings	For situations where the cooling system is being installed because equipment is failing or burned out or as part of a new construction project

B. Determining Equivalent Full Load Hours for Cooling System Use

M&V Approach	Typical Application
Simulate hours of HVAC system use using building simulation models based on prototypes of typical homes and climate conditions	Situations where size, climate conditions and layout of homes is known with reasonably accuracy based on current or previous data collection
Conduct short-term metering of system use during cooling season for a short period of time, at least one month, during typical occupancy conditions),	Situations where accurate estimates of impacts on peak use are needed and there is sufficient evaluation budget to support the metering.
Use deemed hours of cooling use from neighboring state, or regional TRMs	Situations where programs are just starting out and or it is not practical to measure or meter system hours of use

C.4.3. Relevant Protocols and Sources for readers interested in more detailed information

1. Uniform Methods Project, Chapter 4: Small Commercial and Residential Unitary and Split Cooling Systems protocol (April 2014)
2. ASHRAE. (2010). Performance Measurement Protocols for Commercial Buildings.
3. Consortium for Energy Efficiency (CEE). (2009). Commercial Unitary AC and HP Specifications, Unitary Air Conditioning Specification. Effective January 16, 2009. www.cee1.org/com/hecac/hecactiers.pdf. ISO-New England, Inc. (June 2010).
4. ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources Manual (M-MVDR).
5. KEMA. (February 10, 2010). Evaluation Measurement and Verification of the California Public Utilities Commission HVAC High Impact Measures and Specialized Commercial Contract Group

Programs 2006-2008 Program Year.

[www.calmac.org/publications/Vol 1 HVAC Spec Comm Report 02-10-10.pdf](http://www.calmac.org/publications/Vol_1_HVAC_Spec_Comm_Report_02-10-10.pdf).

C.5. Residential Whole Building Retrofits

C.5.1. Definition

These projects involve installing multiple EE measures, such as insulation, weather stripping, set-back thermostats, efficient lighting and/or efficient heating and cooling systems in residential dwellings. The savings from individual measures usually interact with each other, so it is not appropriate to estimate the savings from individual measures and sum them.

This guidance is applicable to common program-design approaches such as Home Performance with Energy Star (HPwES), residential audit programs, and any other program that seeks to reduce overall energy use in residential dwellings using measures that address both building shell and building system improvements.

C.5.2. Key Measurement Challenges

The key challenge in estimating energy savings from this program type is to isolate the electricity savings from the installation of multiple measures in the participating houses from market, weather, economic and other factors that affect household electricity consumption. Three different evaluation methods to deal with this challenge and their typical applications are described in the tables below.

M&V Approach	Typical Application
<i>Randomized Control Trials</i> applied to a sample of participants and non-participants in the program ⁷²	Programs or projects where customers can be randomly assigned the opportunity to participate in the program and do not have to be recruited.
<i>Quasi Experimental Design to Select Participant and Comparison Groups</i> and control for self-selection bias using regression and pooled techniques. ⁷³ Two approaches include: <ol style="list-style-type: none"> 1. Two-stage⁷⁴ regression approach using past and future participants as the comparison or control group 2. Pooled fixed effects regression approach if there is insufficient data on past or future participants to create the comparison group 	Most common program situation where customers must be recruited to join programs and install measures, billing data is available and evaluation budget is sufficient to gather detailed data on home characteristics.

⁷² 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 A. Todd, E. Stuart, S. Schiller, and C. Goldman, Lawrence Berkeley National Laboratory. <http://www.behavioranalytics.lbl.gov>.

⁷³ Uniform Methods Project, Chapter 8: Whole-Building Retrofit with Consumption (Data Analysis Evaluation Protocol (Prepared by Mimi Rosenberg and Ken Agnew for the National Renewable Energy Laboratory NREL, April 2013) <http://www.energy.gov/sites/prod/files/2013/11/f5/53827-8.pdf>

⁷⁴ Two stages in this regression approach refers to the first stage of the regression analysis where changes in usage

M&V Approach	Typical Application
<i>Building simulation models</i> to estimate savings using Building Characteristic Data Gathered by Program contractors or implementers	Situations where it is difficult to access sufficient billing data and or administrator has confidence in implementer’s building simulation models because it has been calibrated to billing energy usage.

C.5.3. Relevant Protocols for More Information

See Uniform Methods Project, Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol reference. <http://www.energy.gov/sites/prod/files/2013/11/f5/53827-8.pdf>

C.6. Commercial Lighting

C.6.1. Definition

These projects involve installing efficient lighting products (ballasts, lamps, and fixtures) in nonresidential buildings such as offices, grocery stores, restaurants, warehouses, retail, and multifamily housing units. Example projects include installing T5/T8 fluorescent lighting systems for general area lighting and more focused LEDs for task lighting. There are three common program delivery approaches:

- Direct installation of lighting products, including ESCO projects
- Consumer incentives (e.g., rebates)
- Upstream/Mid-stream/Downstream buy downs of lamp and fixture prices (e.g., distributor incentives).

C.6.2. Key Measurement Challenges

Key measurement challenges include: 1) Ensuring lighting logger readings are carefully reviewed and screened to ensure accurate estimates of hours of use in rooms where daylighting and occupancy fluctuations can cause flicker problems. 2) Accurately weighting these use area specific HOU results into an average hours of use for the entire building 3) Determining baseline wattage of lighting systems where the precise physical location is unknown and inventories of lighting systems that do not meet current code are still available for sale.

The most common evaluation methods for dealing with each challenge are discussed below:

A. Determining Average HOU by Room Type and Whole Building

M&V Approach	Typical Application
Collect average hours of usage by area use type ⁷⁵ from a representative sample of buildings using self-	Project or program evaluations of new lighting projects or measures where there is insufficient

or savings are estimated using past or previous participating customers and then in a second stage of analysis where changes in usage are estimated for the current participant sample. Savings are estimated using a difference of differences approach across the entire group. Use of past or future participants as a comparison group helps avoid biases in savings estimates introduced by customer self-selection into the program.

⁷⁵Examples of area use types include conference room, offices, halls, bathrooms, storage rooms, or retail display.

reports from building managers and or HOU estimates from forecasting models.	time or resources to install lighting loggers and collect usage data over a 6 to 12 week period.
Retrieve hours of lighting system or fixture usage by room type from building energy management systems or time clocks	Evaluations at sites where sophisticated energy management systems log lighting usage and schedules.
Install lighting loggers in a representative sample of area use types within a sample of participating buildings.	Evaluations where savings from lighting projects constitute the majority of portfolio savings and no recent studies of lighting HOU have been conducted in available TRMS or recent evaluations

B. Determining Baseline Lighting System Wattage

M&V Approach	Typical Application
Collect detailed fixture wattage inventory by area usage type before the lighting retrofits are installed.	For accelerated or early retirement of existing lighting systems before the projected or anticipated end of their useful lives from building manager’s perspective.
Determine the CPB conditions using most recent state or federal product standards for equivalent lumens or trade ally input if market baseline is more efficient than standards. Potentially make adjustments for non-qualifying equipment that is still available in distributor warehouses.	For new construction, normal replacement, or replace on burnout projects where the baseline replacement system is most likely to be a lighting system that just meets minimum efficiency requirements
Install lighting loggers in a representative sample of room usage types within a sample of participating buildings. Develop a lighting logger quality-control protocol to ensure HOU estimates are accurate.	Evaluations where savings from lighting projects constitute the majority of portfolio savings and no recent studies of lighting HOU have been conducted in available TRMS or recent evaluations

C.6.3. Relevant Protocols for readers interested in more detailed information

1. Uniform Methods Project, Chapter 2: Commercial and Industrial Lighting Evaluation Protocol (April 2013)
2. California Public Utilities Commission (CPUC). (2008). <http://www.deeresources.com>.
3. Federal Energy Management Program (FEMP). (2008). M&V Guidelines: Measurement and Verification for Federal Energy Projects Version 3.0. http://www1.eere.energy.gov/femp/pdfs/mv_guidelines.pdf
4. Massachusetts Program Administrators. (October 2011). Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures 2012 Program Year–Plan Version. www.masssave.com.

C.7. Commercial Chiller Systems

C.7.1. Definition

These projects involve installing or retrofitting electricity consuming chillers and/or associated auxiliary equipment. Chillers provide mechanical cooling for commercial, institutional, multiunit residential, and industrial facilities. Cooling may be required for facility heating, ventilation, and air conditioning (HVAC) systems or for process cooling loads (e.g., data centers, manufacturing process cooling).

C.7.2. Key Challenges in Quantifying Energy Savings

Key measurement challenges include: (1) Determining annual electricity consumption of the existing chiller system, (2) Determining the length of the appropriate monitoring periods for collection of system data, and (3) Normalizing savings to performance period independent variables such as weather and changes in occupancy.

Baseline Energy Consumption

Methods for determining baseline electricity consumption of Chiller Systems are outlined in the table below.

M&V Approach	Typical Application
<p><i>IPMVP Option A – Retrofit Isolation</i> Key parameter measurements include cooling load, outside air temperature and part-load efficiency factors from manufacturer testing</p>	<p>Project level evaluation where expected variation in occupancy and chiller loads is likely to be relatively low over a typical year</p>
<p><i>IPMVP Option C – Whole Building Billing Analysis</i> Pre and post installation over at least a year period</p>	<p>For early replacement projects where estimated costs of metering are high and the estimated savings are large compared to normal variations in total building energy usage</p>
<p><i>IPMVP Option D – Calibrated Building Simulation</i> Modeling with potential adjustments for impact of new product standards and or changes in occupancy</p>	<p>For replace on burnout or new construction projects where baseline condition is likely to be chiller system that meets the minimum efficiency standards</p>

All of the methods above require the evaluator to collect data on the condition of the existing equipment (with the exception of new construction) and make an estimate of the remaining useful life of the equipment for use in developing savings estimates using the dual baseline approach. To support use of existing usage conditions for early replacement projects evaluators must present evidence that the program has likely induced an early replacement of the existing chiller equipment. Data sources for condition and remaining useful life of in-situ equipment/systems include interviews with facility managers, equipment logs, inspection of equipment, and manufacturer’s data.

Determining the Length of the Monitoring Period

The frequency and length of the monitoring period (for electricity consumption, cooling loads, etc.) associated with chiller equipment depends on the type of load and frequency of equipment operation. Continuous monitoring for large systems with variable loads (such as chillers service process loads) is

recommended for at least three months, while spot measurements of electricity consumption can be sufficient for systems with constant loads and known hours of operation.

Normalizing Savings to Account for Independent Variables

In many cases, it will be necessary to run regression equations to separate out the impacts of chiller measures from independent variables such as operating temperatures or process throughput. The model's predictive power should be tested using R^2 values or T statistics on the estimated coefficient for the independent variable of interest to ensure accuracy. The Commercial Chiller protocol⁷⁶ from the Uniform Methods Project recommends a model fit thresholds of >0.75 for R^2 and T statistics of greater than 2.0 to determine if savings estimates are statistically significant.

C.7.3. Relevant Protocols and Evaluation Sources for More Information

1. Uniform Methods Project, Chapter 14: Chiller Evaluation Protocol, Chapter reference (Prepared by Alex Tiessen, Posterity Group for the National Renewable Energy Laboratory, September 2014). Reference <http://www.energy.gov/sites/prod/files/2014/10/f18/Chapter%2014--Chiller%20Evaluation%20Protocol.pdf>
2. EVO. (January 2012). International Performance Measurement and Verification Protocol –Concepts and Options for Determining Energy and Water Savings Volume 1. Efficiency Valuation Organization.
3. Fagan, F., Bradley, K., Lutz, A. (2011). Strategies for Improving the Accuracy of Industrial Program Savings Estimates and Increasing Overall Program Influence. Prepared for the International Energy Program Evaluation Conference.
4. Ridge, R., Jacobs, P., Tress, H., Hall, N., Evans, B. (2011). One Solution to Capturing the Benefits of Early Replacement: When Approximately Correct is Good Enough. Prepared for the International Energy Program Evaluation Conference.
5. US DOE FEMP. (April 2008). M&V Guidelines: Measurement and Verification for Federal Energy Projects—Version 3.0. U.S. Department of Energy Federal Energy Management

⁷⁶ Table 6 page 13 in the Chiller Evaluation protocol at:
<http://energy.gov/sites/prod/files/2014/10/f18/Chapter%2014--Chiller%20Evaluation%20Protocol.pdf>