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Guidelines for the Monitoring, Evaluation, Reporting, Verification, and Certification of Energy-Efficiency Projects for Climate Change Mitigation

Edward Vine and Jayant Sathaye
**Environmental Energy
Technologies Division**

March 1999

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GUIDELINES FOR THE MONITORING, EVALUATION, REPORTING, VERIFICATION, AND CERTIFICATION OF ENERGY-EFFICIENCY PROJECTS FOR CLIMATE CHANGE MITIGATION

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PREFACE

To combat the growing threat of global climate change from increasing concentrations of greenhouse gases in the atmosphere, the Kyoto Protocol includes project-based mitigation efforts to achieve large-scale and cost-effective emissions reductions. The Protocol requires real and measurable reductions in emissions that are additional to any that would occur in the absence of a certified project activity. Monitoring, evaluation, reporting, verification and certification of these projects are activities that the U.S. Environmental Protection Agency (EPA) sees as important.

EPA has initiated a three-phase process in developing usable guidelines on monitoring, evaluation, reporting, verification and certification (MERVC). In the first phase, an overview of MERVC issues was prepared (E. Vine and J. Sathaye. 1997. *The Monitoring, Evaluation, Reporting, and Verification of Climate Change Mitigation Projects: Discussion of Issues and Methodologies and Review of Existing Protocols and Guidelines*. LBNL-40316. Berkeley, CA: Lawrence Berkeley National Laboratory). The guidelines presented in this report constitute the second phase of work. The third phase will be a procedural handbook that describes the information and requirements for specific measurement and evaluation methods that can be employed for measuring energy savings and carbon emissions.

The intent of these reports is to provide initial methodologies that will support the measurement of greenhouse gas removals from project-level activities. These methodologies will also assist project developers in preparing and implementing monitoring, evaluation, and verification plans that can lead to better estimates of energy savings as well as improve the projects themselves, making them more attractive to investors, the private sector, and local communities.

These guidelines have been reviewed by project developers (working on projects in Eastern Europe, Africa and Latin America) as well as experts in the monitoring and evaluation of energy-efficiency projects. The practitioners reviewed the report for accuracy and assessed whether data were available for completing the forms presented at the end of this report. Based on their feedback, we believe these guidelines and related forms can be used by project developers, evaluators, and verifiers.

These guidelines can also be used by anyone involved with the design and development of joint implementation and Clean Development Mechanism projects, such as: facility energy managers, energy service companies, development banks, finance firms, consultants, government agency employees and contractors, utility executives, city and municipal managers, researchers, and nonprofit organizations. National and international entities can also use these guidelines and forms as a model for developing official MERVC-type guidelines.

Maurice LeFranc
U.S. Environmental Protection Agency

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ABSTRACT

Because of concerns with the growing threat of global climate change from increasing concentrations of greenhouse gases in the atmosphere, the United States and other countries are implementing, by themselves or in cooperation with one or more other nations, climate change mitigation projects. These projects will reduce greenhouse gas (GHG) emissions, and may also result in non-GHG benefits and costs (i.e., other environmental and socioeconomic benefits and costs).

Monitoring, evaluating, reporting, verifying, and certifying (MERVC) guidelines are needed for these projects in order to accurately determine their impact on GHG and other attributes. Implementation of standardized guidelines is also intended to: (1) increase the reliability of data for estimating GHG benefits; (2) provide real-time data so that programs and plans can be revised mid-course; (3) introduce consistency and transparency across project types and reporters; (4) enhance the credibility of the projects with stakeholders; (5) reduce costs by providing an international, industry consensus approach and methodologies; and (6) reduce financing costs, allowing project bundling and pooled project financing.

These guidelines cover the following items: (1) a description of seven methods (engineering methods, basic statistical models, multivariate statistical models, end-use metering, short-term monitoring, and integrative methods) for evaluating energy savings; (2) an explanation of key issues influencing the establishment of a credible baseline (free riders) and the calculation of gross energy savings (positive project spillover and market transformation); (3) a process for verifying and certifying project impacts, based on an interpretation of the Kyoto Protocol; (4) a discussion of the importance and value of including environmental and socioeconomic impacts in the evaluation of energy-efficiency projects; (5) reporting forms for estimation of gross and net energy savings and emission reductions (Appendix A), for monitoring and evaluation of these savings (Appendix B), and for verification (Appendix C); and (6) Quality Assurance Guidelines that require evaluators and verifiers to indicate specifically how key methodological issues are addressed.

The next phase of this work will be to develop a procedural handbook providing information on how one can complete the monitoring, evaluation and verification forms contained in this report. Next, we plan to test the usefulness of these guidelines in the real world.

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1. Introduction

Because of concerns with the growing threat of global climate change from increasing concentrations of greenhouse gases in the atmosphere, more than 176 countries (as of Oct. 7, 1998) have become Parties to the U.N. Framework Convention on Climate Change (FCCC) (UNEP/WMO 1992). The FCCC was entered into force on March 21, 1994, and the Parties to the FCCC adopted the Kyoto Protocol for continuing the implementation of the FCCC in December 1997 (UNFCCC 1997). The Protocol requires developed countries to reduce their aggregate emissions by at least 5.2% below 1990 levels by the 2008-2012 time period.

The Kyoto Protocol requires Annex I (developed) countries to report anthropogenic emissions by sources, and removals by sinks, of greenhouse gases at the national level (Article 5).[1] For example, countries would have to set national systems for estimating emissions accurately, achieving compliance with emissions targets, and ensuring enforcement for meeting emissions targets. Annual reports on measurement, compliance and enforcement efforts at the national level would be required and made available to the public.

The Kyoto Protocol includes two project-based mechanisms for activities across countries. Article 6 of the Protocol allows for joint implementation projects between Annex I countries: i.e., project-level trading of emissions reductions ("transferable emission reduction units") can occur among countries with GHG emission reduction commitments under the Protocol. Article 12 of the Protocol provides for a "Clean Development Mechanism" (CDM) that allows legal entities in the developed world to enter into cooperative projects to reduce emissions in the developing world for the benefit of both parties. Developed countries will be able to use certified emissions reductions from project activities in developing countries to contribute to their compliance with GHG targets. Projects undertaken by developed countries will not only reduce greenhouse gas (GHG) emissions or sequester carbon, but may also result in non-GHG benefits and costs (i.e., other environmental and socioeconomic benefits and costs). The key provisions of the Kyoto Protocol remain to be developed in more detail as negotiations clarify the existing text of the Protocol.[2]

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[1] GHG sources include emissions from fossil fuel combustion, industry, decomposing and oxidized biomass, soil carbon loss, and methane from agricultural activities, livestock, landfills and anaerobic decomposition of phytomass. GHG sinks include storage in the atmosphere, ocean uptake, and uptake by growing vegetation (IPCC 1995; Andrasko et al. 1996).

[2] While the this report focuses on the Kyoto Protocol, it should also be useful for projects undertaken before the Protocol goes into effect: e.g., in the US, the President's Climate Change Proposal contains a program that rewards organizations, by providing credits or incentives (e.g., a credit against a company's emissions or a tax credit), for taking early actions to reduce greenhouse gases before the international agreements from the Kyoto Protocol would take effect. The proposal is now commonly referred to as a "credit for early action" program (USGAO 1998).

1.1. Overview of Project Tasks

Energy-efficiency projects to be undertaken within the Clean Development Mechanism or under joint implementation will likely involve several tasks (Fig. 1.). The guidelines contained in this report are primarily targeted to the tasks that occur during the implementation of a project (see section numbers in Fig. 1). The project design and development phase will incorporate many of the information needs required for completing the later tasks (see Section 3). We expect that there will be different types of arrangements for implementing these projects: e.g., (1) a project developer might implement the project with his/her own money; (2) a developer might borrow money from a financial institution to implement the project; (3) a developer might work with a third party who would be responsible for many project activities; etc. While the flow of funds might change as a result of these different arrangements, the guidelines presented in this report should be relevant to all parties, independent of the arrangement.

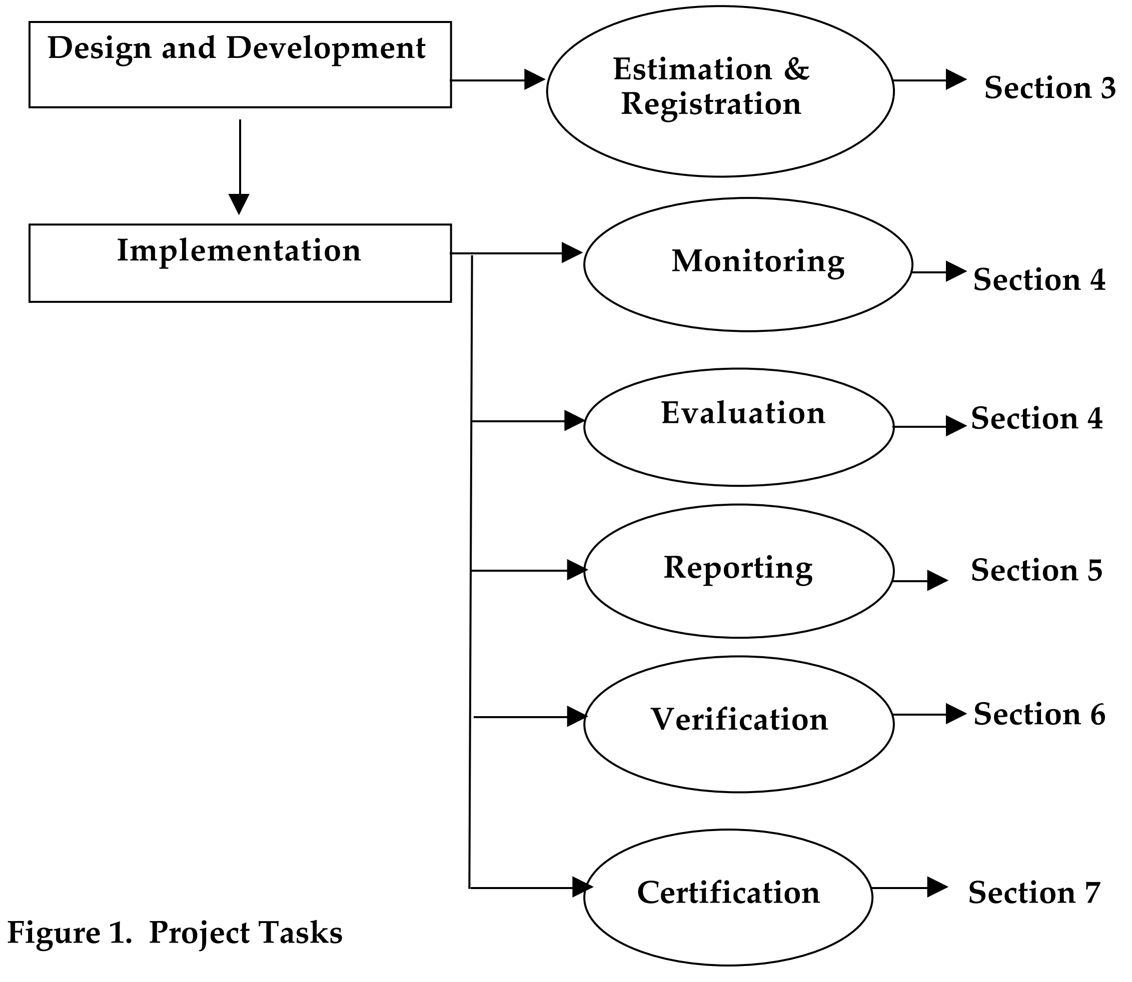

Figure 1. Project Tasks

In Figure 1, we differentiate "registration" from "certification" (see Section 7). Certification refers to certifying whether the measured GHG reductions actually occurred. This definition reflects the language in the Kyoto Protocol regarding the Clean Development Mechanism and "certified emission reductions." In contrast, when a host country approves a project for implementation, the project is "registered" (see UNFCCC 1998b).[1] For a project to be approved, each country will rely on project approval criteria that they developed: e.g., (1) the project funding sources must be additional to traditional project development funding source; (2) the project must be consistent with the host country's national priorities (including sustainable development); (3) confirmation of local stakeholder involvement; (4) confirmation that adequate local capacity exists or will be developed; (5) potential for long-term climate change mitigation; (6) baseline and project scenarios; and (7) the inclusion of a monitoring protocol (see Watt et al. 1995).

A country may also use different administrative or legal requirements for registering projects. For example, the project proposal (containing construction and operation plans, proposed monitoring and evaluation of energy savings and emissions, and estimated energy savings and emissions) might have to be reviewed and assessed by independent reviewers (see Section 3). After this initial review, the project participants would have an opportunity to make adjustments to the project design and make appropriate adjustments to the expected energy savings and emissions. The reviewers would then approve the project, and the project would be registered.[2] Individuals or organizations voicing concerns about the project would have an opportunity to appeal the approval of the project, if desired.

1.2. Conceptual Framework

The analysis of energy use occurs when a project is being designed and during the implementation of an energy-efficiency project. In the design stage, the first step is estimating the baseline (i.e., what would have happened to energy use if the project had not been implemented) (see Section 3.2) and the project impacts. Once these have been estimated, then the net energy savings are simply the difference between the estimated project impacts and the baseline (P-B, in Fig. 2). After a project has started to be implemented, the baseline can be re-estimated and the project impacts will be calculated based on monitoring and evaluation methods (Section 4). The net savings will be the

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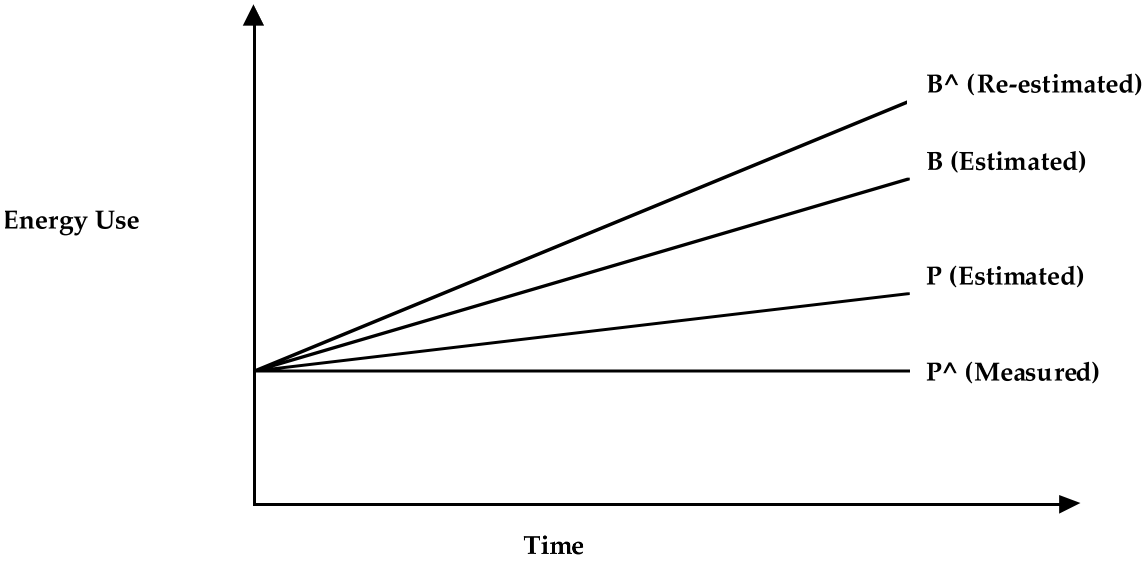
[1] In contrast to our interpretation, others believe certification occurs at the project approval stage, prior to implementation. We disagree, since certification can only occur after energy savings have been measured.

[2] Under this approach, the independent reviewers could be the same people who verify the project during project implementation (personal communication from Johannes Heister, The World Bank, Jan. 12, 1999).

difference between the measured project impacts and the re-estimated baseline (P^-B^, in Fig. 2). The example in Fig. 2 illustrates a case where measured energy use is lower than estimated as a result of an energy-efficiency project. On the other hand, energy use in the re-estimated baseline is higher than what had been estimated at the project design stage. In this case, the calculated net energy savings (P^-B^) is larger than what was first estimated (P-B).



B: Estimated energy use without project (baseline)
P: Estimated energy use with project
P-B: Estimated net (additional) energy savings

B^: Re-estimated energy use without project (baseline) (after monitoring and evaluation)
P^: Measured energy use with project (after monitoring and evaluation)
P^-B^: Measured net (additional) energy savings (after monitoring and evaluation)

Figure 2. Example of Energy Use Over Time

1.3. Purpose of MERVC Guidelines

Monitoring, evaluating, reporting, verifying, and certifying (MERVC) guidelines are needed for joint implementation and CDM projects in order to accurately determine their impact on GHG and other attributes (see Box 1) (Vine and Sathaye 1997). The estimation of project impacts is not the focus of the guidelines in this report; however, these guidelines do discuss many of the issues involved in estimation, since they are of utmost concern in the activities that occur after a project is implemented. Furthermore, the findings based on measurement and evaluation are often compared with the estimated impacts of a project.

Under joint implementation, the reduction in emissions by sources, or an enhancement of removals by sinks, must be “additional” to any that would otherwise occur, entailing project evaluation (Article 6) (see Section 3). And the “emission reduction units” from these projects can be used to meet Annex I Party’s commitment under Article 3 of the Kyoto Protocol, necessitating all MERVC activities to be conducted. Similarly, under the Clean Development Mechanism, emission reductions must not only be additional, but certified, real and measurable, again requiring the performance of all MERVC activities (Article 12).

Implementation of standardized guidelines is also intended to: (1) increase the reliability of data for estimating GHG impacts; (2) provide real-time data so programs and plans can be revised mid-course; (3) introduce consistency and transparency across project types, sectors and reporters; (4) enhance the credibility of the projects with stakeholders; (5) reduce costs by providing an international, industry consensus approach and methodologies; and (6) reduce financing costs, allowing project bundling and pooled project financing.

These guidelines are important management tools for all parties involved in carbon mitigation. There will be different approaches (“models”) in how the monitoring, evaluation, reporting, verification, and certification of energy-efficiency projects will be conducted: e.g., a project developer might decide to conduct monitoring and evaluation, or might decide to contract out one or both of these functions. Verification and certification must be implemented by third parties (Article 12). Similarly, some projects might include a portfolio of projects. Despite the diversity of responsibilities and project types, the Lawrence Berkeley National Laboratory’s (LBNL’s) MERVC guidelines should be seen as relevant for all models and project approaches.

Box 1

Definitions

Estimation: refers to making a judgement on the likely or approximate energy use, GHG emissions, and socioeconomic and environmental benefits and costs in the with- and without-project (baseline) scenarios. Estimation can occur throughout the lifetime of the project, but plays a central role during the project design stage when the project proposal is being developed.

Monitoring: refers to the measurement of energy use, GHG emissions and socioeconomic and environmental benefits and costs that occur as a result of a project. Monitoring does *not* involve the calculation of GHG reductions nor does it involve comparisons with previous baseline measurements. For example, monitoring could involve the number of compact fluorescent lamps installed in a building. The objectives of monitoring are to inform interested parties about the performance of a project, to adjust project development, to identify measures that can improve project quality, to make the project more cost-effective, to improve planning and measuring processes, and to be part of a learning process for all participants (De Jong et al. 1997). Monitoring is often conducted internally, by the project developers.

Evaluation: refers to both impact and process evaluations of a particular project, typically entailing a more in-depth and rigorous analysis of a project compared to monitoring emissions. Project evaluation usually involves comparisons requiring information from outside the project in time, area, or population (De Jong et al. 1997). The calculation of GHG reductions is conducted at this stage. Project evaluation would include GHG impacts and non-GHG impacts (i.e., environmental, economic, and social impacts), and the re-estimation of the baseline, positive project spillover, etc. which were estimated during the project design stage (see Section 3). Evaluation organizes and analyzes the information collected by the monitoring procedures, compares this information with information collected in other ways, and presents the resulting analysis of the overall performance of a project. Project evaluations will be used to determine the official level of GHG emissions reductions that should be assigned to the project. The focus of evaluation is on projects that have been implemented for a period of time, not on proposals (i.e., project development and assessment). While it is true that similar activities may be conducted during the project design stage (e.g., estimating a baseline or positive project spillover), this type of analysis is estimation and not the type of evaluation that is described in this report and which is based on the collection of data.

Reporting refers to *measured* GHG and non-GHG impacts of a project (in some cases, organizations may report on their *estimated* impacts, prior to project implementation, but this is not the focus of this paper). Reporting occurs throughout the MERVC process (e.g., periodic reporting of monitored results and a final report once the project has ended).

Verification refers to establishing whether the measured GHG reductions actually occurred, similar to an accounting audit performed by an objective, certified party. Verification can occur without certification.

Certification refers to certifying whether the measured GHG reductions actually occurred. Certification is expected to be the outcome of a verification process. The value-added function of certification is in the transfer of liability/responsibility to the certifier.

LBNL's MERVC guidelines will help project participants determine how effective their project has been in curbing GHG emissions, and they will help planners and policy makers in determining the potential impacts for different types of projects, and for improvements in project design and implementation. Finally, by providing the basis for more reliable savings and a common approach to the measurement and evaluation of energy-efficiency projects, widespread adoption of the MERVC guidelines will make efficiency improvements more reliable and profitable.

In the longer term, MERVC guidelines will be a necessary element of any international carbon trading system, as proposed in the Kyoto Protocol. A country could generate carbon credits by implementing projects that result in a net reduction in emissions. The validation of such projects will require MERVC guidelines that are acceptable to all parties. These guidelines will lead to verified findings, conducted on an ex-post facto basis (i.e., actual as opposed to predicted project performance).

LBNL's MERVC guidelines have been reviewed by project developers (working on projects in Eastern Europe, Africa and Latin America) as well as experts in the monitoring and evaluation of energy-efficiency projects. The practitioners reviewed the report for accuracy and assessed whether data were available for completing the forms presented at the end of this report. Based on their feedback, we believe LBNL's guidelines can be used by project developers, evaluators, and verifiers. We hope that international entities can also use our guidelines as a model for developing official MERVC-type guidelines.

1.4. Target Audience

These guidelines are primarily for developers, evaluators, verifiers, and certifiers of energy-efficiency projects. This document can also be used by anyone involved with the design and development of joint implementation and Clean Development Mechanism projects, such as: facility energy managers, energy service companies, development banks, finance firms, consultants, government agency employees and contractors, utility executives, city and municipal managers, researchers, and nonprofit organizations.

1.5. Scope

LBNL's MERVC guidelines are targeted to energy-efficiency projects that may reduce the generation of energy from fossil fuel sources, thus reducing GHG emissions.[1] The guidelines can be used for assessing the impacts for a single building, or for a group of buildings (e.g., in a program, where there are many participants). These guidelines occupy an intermediate position between a previous report that provided an overview of MERVC issues (Vine and Sathaye 1997) and a procedural handbook that describes the information and requirements for specific measurement and evaluation methods that may be employed for determining energy savings.

The guidelines focus on end-use energy-efficiency projects (see Section 2). The following energy-efficiency projects are not included in this report: (1) improvements in electric generation (e.g., capacity factor improvements and efficiency improvements); (2) improvements in transmission and distribution (i.e., reducing losses in the delivery of electricity or district heat from the power plant to the end user); and (3) efficiency improvements in the transportation sector.

Interventions targeting production or transmission efficiency typically require different monitoring and evaluation techniques than for distributed end-use interventions. For example, because production efficiency projects generally occur at one or a handful of facilities, sampling strategies for monitoring and evaluation are not required to determine GHG emissions impacts. Measurements must be taken at more than one site in order to monitor a single transmission efficiency project. End-use efficiency projects may target just one or two facilities, but sometimes they target a large number of energy consumers, requiring the use of statistical evaluation methods.

LBNL's MERVC guidelines address several key issues, such as: (1) uncertainty and risk; (2) frequency and duration of monitoring and evaluation; (3) methods for estimating gross and net energy savings and emission reductions; (4) verification and certification of GHG reductions; and (5) the cost of MERVC (Vine and Sathaye 1997). We provide a Monitoring and Evaluation Reporting Form and a Verification Reporting Form at the end of this report to facilitate the review of energy-efficiency projects.

LBNL's MERVC guidelines also:

- Address the needs of participants in energy-efficiency projects, including financiers, investors, developers, and technical consultants.
- Discuss procedures, with varying levels of accuracy and cost, for evaluating and verifying (1) baseline and project installation conditions, and (2) long-term energy savings.

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[1] A similar set of guidelines has been prepared for forestry projects (Vine et al. 1999).

- Apply MERVC procedures to a variety of projects, including residential, commercial, institutional and industrial facilities.
- Provide techniques for calculating "whole-facility" savings and individual technology savings.
- Provide procedures that (1) are consistently applicable to similar projects throughout all geographic regions, and (2) are internationally accepted, impartial and reliable.

These guidelines reflect the following principles: MERVC activities should be consistent, technically sound, readily verifiable, objective, simple, relevant, transparent, and cost-effective. Sometimes, tradeoffs need to be made for some of these criteria: e.g., simplicity versus technical soundness. Because of concerns about high costs in responding to MERVC guidelines, these guidelines are designed to be not too burdensome. Nevertheless, adequate funding and expertise are necessary for carrying out these activities.

While we have provided checklists for evaluating environmental and socioeconomic impacts, we believe that other existing guidelines are better suited for addressing these impacts (Section 8). The checklists are included to remind project developers and evaluators about the importance of these impacts and the need to examine them during the evaluation of energy-efficiency projects.

We assume that the monitoring, evaluation and reporting activities will be undertaken by project implementors, but that verification and certification will be conducted by an outside third party experienced in verification (see Sections 6 and 7). We do not address which organization is the primary recipient of the information collected in MERVC activities: e.g., a national government, the FCCC Secretariat, or the CDM Executive Board. Nor do we address how this information will be used by these entities: e.g., granting full carbon credits, partial credits, or zero credits, based on the evaluation and verification reports. We expect these issues to be addressed by international bodies in the coming years.

Many of the examples described in these guidelines are based on the experience of evaluating energy-efficiency projects and programs in North America. Historically, more resources have been available for conducting MERVC activities in North America than in other countries. Although developing countries, for example, may not presently have the resources to conduct these activities, we believe that all participants implementing and evaluating energy-efficiency projects for climate change mitigation should conduct one or more of the methods proposed in these guidelines. We hope that developed countries will support the use of these methods in developing countries, as part of capacity building and technology transfer. Due to the scarcity of evaluations of energy-efficiency projects in other countries, we hope that resources are made available for preparing these studies so that we can obtain a better understanding of the evaluation experience and capabilities in these countries.

Finally, the Kyoto Protocol contains emission targets, differentiated by country, for an aggregate of six major greenhouse gases (measured in carbon equivalents): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). These guidelines only examine MERVC issues dealing with CO_2.

1.6. Relationship to Other Programs/Documents

In a previous paper, we reviewed existing guidelines and protocols related to GHG reductions (Vine and Sathaye 1997). We concluded that while one or more of these documents addressed many of the issues that need to be covered in MERVC guidelines, none of them provided the type of detailed, standardized guidelines needed for addressing all of the issues in this report. Nevertheless, as noted below, LBNL's MERVC guidelines are indebted to the information and guidance contained in these documents.

1.6.1. International Performance Measurement and Verification Protocol. The U.S. Department of Energy's International Performance Measurement and Verification Protocol (IPMVP) is a consensus document for measuring and verifying energy savings from energy-efficiency projects (Kats et al. 1996 and 1997; Kromer and Schiller 1996; USDOE 1997). For LBNL's MERVC guidelines, the IPMVP is the preferred approach for monitoring and evaluating energy-efficiency projects for climate change mitigation (see Section 3.2.8).

1.6.2. U.S. Federal Energy Management Program. The U.S. Department of Energy's Federal Energy Management Program (FEMP) was established, in part, to reduce energy costs to the U.S. Government from operating Federal facilities. FEMP assists Federal energy managers by identifying and procuring energy-efficiency projects. Part of this assistance included the development of an application of the International Performance Measurement and Verification Protocol (IPMVP), for the U.S. Federal sector, which is called the FEMP Guidelines (USDOE 1996).

1.6.3. U.S. EPA Conservation Protocols. The U.S. Environmental Protection Agency's Conservation Verification Protocols are designed to verify electricity savings from utility demand-side management programs for the purpose of awarding sulfur dioxide allowances under EPA's Acid Rain Program (Meier and Solomon 1995; USEPA 1995 and 1996). LBNL's MERVC guidelines have incorporated aspects of EPA's guidelines.

1.6.4. U.S. ASHRAE GPC 14P. LBNL's MERVC guidelines are complementary to the work of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) GPC 14P Committee that is currently writing guidelines for the measurement of energy and demand savings.

When completed, these guidelines will be used to modify the IPMVP. In contrast to the ASHRAE document, which focuses on the relationship of the measurement to the equipment being verified at a very technical level, LBNL's MERVC guidelines are more general and discuss a variety of topics as they relate to monitoring, evaluation, reporting, verification, and certification.

1.6.5. World Bank's monitoring and evaluation guidelines. The World Bank prepared monitoring and evaluation guidelines for the Global Environment Facility (GEF), a multilateral funding program created to support projects that yield global environmental benefits but would not otherwise be implemented because of inadequate economic or financial returns to project investors (World Bank 1994). The GEF supports four types of projects: biodiversity preservation, pollution reduction of international waters, GHG emission reduction and, to a limited extent, the control of ozone-depleting substances. LBNL's MERVC guidelines have incorporated aspects of the World Bank guidelines.

1.6.6. USIJI's Project Proposal Guidelines. The U.S. Initiative on Joint Implementation (USIJI) prepared project proposal guidelines for organizations seeking funding from investors to reduce GHG emissions (USIJI 1996). The guidelines request information on the proposed project, including the identification of all GHG sources included in the emissions baseline as well as those affected by the proposed project, and net impacts. The guidelines also ask for additional information, such as the estimates of GHG emissions, including methodologies, type of data used, calculations, assumptions, references and key uncertainties affecting the emissions estimates. The estimates include the baseline estimate of emissions of GHG without measures and the estimate of emissions of GHG with measures. LBNL's MERVC guidelines have incorporated many aspects of the USIJI's guidelines.

1.6.7. DOE's Voluntary Reporting of Greenhouse Gases. The U.S. Department of Energy (DOE) prepared guidelines and forms for the voluntary reporting of greenhouse gases (USDOE 1994a and 1994b). The guidelines and forms can be used by corporations, government agencies, households and voluntary organizations to report to the DOE's Energy Information Administration on actions taken that have reduced emissions of greenhouse gases. The documents offer guidance on recording historic and current GHG emissions and emissions reductions. The supporting documents (USDOE 1994b) contain limited examples of project analysis for the following sectors: electricity supply, residential and commercial buildings, industrial, transportation, forestry, and agriculture. Companies are allowed discretion in determining the basis from which their emissions reductions are estimated and can self-certify that their claims are accurate. LBNL's MERVC guidelines have incorporated aspects of DOE's guidelines.

1.6.8. California's Measurement and Evaluation Protocols. Protocols and procedures for the measurement and evaluation of California's utility energy-efficiency programs were developed in response to the shareholder earnings mechanisms established for the four largest investor-owned utilities to acquire demand-side resources (CPUC 1998). The protocols are targeted to the evaluation of programs, rather than an individual building, and have very detailed requirements. LBNL’s MERVC guidelines are more flexible than the California protocols, but have incorporated some components of the protocols (e.g., quality assurance guidelines—see Section 4.2.10).

2. Energy-Efficiency Project Typology

LBNL's MERVC guidelines are targeted to end-use energy-efficiency projects. Table 1 provides a more detailed listing of end-use energy-efficiency projects; this table is not an exhaustive list, but is for illustrative purposes only. In many cases, the proposed projects could be targeted to one or more of the building sectors (residential or commercial) as well as the industrial sector. Most of these projects will target one or a few facilities (in contrast to programs that target many facilities). In all cases, energy-efficiency projects reduce the amount of energy needed to provide given levels of services. If this energy is derived from carbon-based fuel combustion, GHG emissions are reduced.

Table 1. Examples of End-Use Efficiency Measures in Buildings and Industry

Space Conditioning Thermal storage Duct sealing and balancing Improved equipment efficiency Improved building design	**Refrigeration** Defrost control Multi-stage compressors Insulation High efficiency refrigeration cases
Water Heating Insulation blankets Heat pump water heaters Flow restricters High efficiency water heaters	**Lighting** High efficiency ballasts and reflector systems Lighting controls and occupancy sensors Daylight dimmers/switches Compact fluorescents Efficient fluorescent lamps High intensity discharge lamps
Building Envelope Insulating glass Low emissivity glass Insulation Solar shading Highly reflective roofs	**Process Improvements** Drying/curing efficiency Economizers in recovery in steam systems Waste heat recovery Boiler and furnace maintenance Air compressor efficiency Repairing leaks and insulating tanks and pipes
Controls Energy management systems	**Ventilation** Improved efficiency Variable air volume Multi-speed or variable-speed motor
Motors Variable speed drives Improved motor rewinding High efficiency motors	**Operations and Maintenance** Optimization of system operation Proper cleaning and repair Proper operation of systems

The kinds of retrofits for improving energy efficiency can also be characterized by the kind of load and schedule for the load before the retrofit, and the effect that the retrofit has on the load and schedule (personal communication from Steve Kromer, Nov. 20, 1998). The load can be either constant, variable, or variable but predictable, and the schedule can either be known (timed on/off schedule) or unknown/variable (e.g., randomly turned on/off, controlled by occupancy sensor temperature, or a time clock but often manually overridden). The retrofit may change the magnitude of the load and/or change it to/from a constant load from/to a variable load. The retrofit may also change the schedule. During the discussion of monitoring and evaluation in Section 3, we will refer to these different types of loads and schedules.

3. Estimation and Registration of Projects

As part of the project proposal (design) stage, project developers describe the project activities intended to reduce energy use and carbon emissions, establish a project baseline, estimate the project's carbon and monetary returns, and design a monitoring and evaluation plan. In Figure 3, we present an overview of the approach used in this report in estimating gross and net changes in energy use and emissions. In this section, we focus on the issues involved in estimating the baseline and gross changes in energy use and carbon emissions, since the net change is simply the difference between the gross change and the baseline.

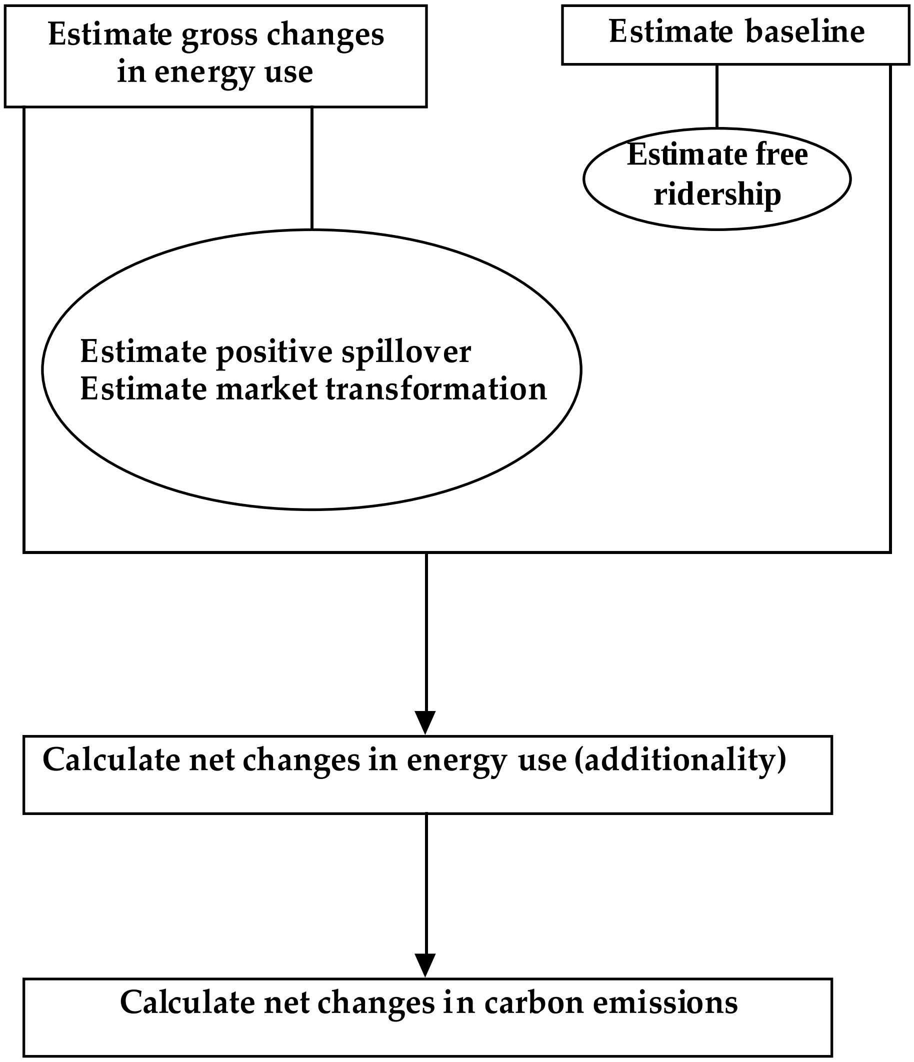

Fig. 3. Estimation Overview

The monitoring and evaluation plan describes the type of data to be collected, the data collection activities (procedures and methods) to be undertaken, and how the data will be evaluated. The plan also specifies the equipment and organizational requirements for monitoring and evaluation. The monitoring and evaluation plan is an integral part of the implementation of the project and should produce more accurate estimates of impacts at a lower cost. The results from the monitoring will later be used to re-estimate the baseline. In Appendix A, we provide an Estimation Reporting Form for project developers to use when designing an energy-efficiency project. The intent of this form is to provide guidance to developers on issues that evaluators and verifiers will examine after a project is implemented.

3.1. Estimating Gross Changes in Energy Use and Carbon Emissions

At the project design stage, changes in energy use and carbon emissions will be estimated by using one or more techniques: (1) modeling, (2) review and analysis of the literature on similar projects (content analysis), (3) review and analysis of data from similar projects recently undertaken; and (4) expert judgement. The estimation methodology can be either simple or complex, depending on the resources available for conducting the estimation and the concern for reliable results (Watt et al. 1995). Since many assumptions need to be made, project estimates are later compared with measured data to determine the accuracy and precision of the estimated changes in energy use and carbon emissions. The key issues that need to be addressed in estimating gross changes are: (1) determining the appropriate monitoring domain, and (2) accounting for positive project spillover and market transformation.

3.1.1. Monitoring domain

The domain that needs to be monitored (i.e., the monitoring domain, see Andrasko 1997 and MacDicken 1997) is typically viewed as larger than the geographic and temporal boundaries of the project. In order to compare GHG reductions across projects, a monitoring domain needs to be defined. Consideration of the domain needs to address the following issues: (1) the temporal and geographic extent of a project's direct impacts; and (2) coverage of positive project spillover and market transformation.

The first monitoring domain issue concerns the appropriate geographic boundary for evaluating and reporting impacts. For example, an energy project might have local (project-specific) impacts that are directly related to the project in question, or the project might have more widespread (e.g., regional) impacts (leading to positive project spillover and market transformation, see Sections 3.1.2

and 3.1.3). Thus, one must decide the appropriate geographic boundary for evaluating and reporting impacts. Also, energy projects may impact energy supply and demand at the point of production, transmission, or end use. The MERVC of such impacts will become more complex and difficult as one attempts to monitor how emission reductions are linked between energy end users and energy producers (e.g., tracking the emissions impact of 1,000 kWh saved by a household in a utility's generation system).

The second issue concerns coverage of positive project spillover, as discussed in the next section. It is important to note that not all secondary impacts can be predicted. In fact, many secondary impacts occur unexpectedly and cannot be foreseen. And when secondary impacts are recognized, a commitment needs to be made to ensure that resources are available to evaluate these impacts.

One could broaden the monitoring domain to include off-site baseline changes (which are normally perceived as occurring outside the monitoring domain). Widening the system boundary, however, will most likely entail greater MERVC costs (see Section 9) and could bring in tertiary and even less direct effects that could overwhelm any attempt at project-specific calculations (Trexler and Kosloff 1998). Consequently, project developers should devote most of their resources to the immediate monitoring domain. During the monitoring and evaluation stage, the monitoring domain can be expanded if warranted.

3.1.2. Positive project spillover

For most projects, the number of eligible nonparticipants is far greater than the number of participants. Thus, when measuring energy savings, it is possible that the actual reductions in energy use are greater than measured because of changes in participant behavior not directly related to the project, as well as to changes in the behavior of other individuals not participating in the project (i.e., nonparticipants). These secondary impacts stemming from an energy-efficiency project are commonly referred to as "positive project spillover." Positive project spillover may be regarded as an unintended consequence of an energy-efficiency project; however, as noted below, increasing positive project spillover may also be perceived as a strategic mechanism for reducing GHG emissions.

Spillover effects can occur through a variety of channels including: (1) an individual hearing about a project measure from a participant and deciding to pursue it on his or her own ("free drivers"); (2) project participants that undertake additional, but unaided, energy-efficiency actions based on positive experience with the project; (3) manufacturers changing the efficiency of their products, or retailers and wholesalers changing the composition of their inventories to reflect the demand for more efficient goods created through the project; (4) governments adopting new building codes or appliance standards because of improvements to appliances resulting from one or more energy efficiency projects; or, (5) technology transfer efforts by project participants which help reduce market barriers throughout a region or country.

Because of the multiple actors that may be involved in causing positive project spillover, it is unclear on how much of these changes should be attributed to the project developer. Since spillover is an unintended consequence, and the project developer is a passive recipient of the benefits of spillover, it should not be his responsibility for expending resources for an assessment of project spillover. Project spillover still needs to be evaluated, but not assessed in the estimation stage.

3.1.3. Market transformation

Project spillover is related to the more general concept of "market transformation," defined as: "the reduction in market barriers due to a market intervention, as evidenced by a set of market effects, that lasts after the intervention has been withdrawn, reduced or changed" (Eto et al. 1996). In contrast to project spillover, increasing market transformation is expected to be a strategic mechanism (i.e., an intended consequence) for reducing GHG emissions for the following reasons:

- To increase the effectiveness of energy-efficiency projects: e.g., by examining market structures more closely, looking for ways to intervene in markets more broadly, and investigating alternative points of intervention.
- To reduce reliance on incentive mechanisms: e.g., by strategic interventions in the market place with other market actors.
- To take advantage of regional and national efforts and markets.
- To increase focus on key market barriers other than cost.
- To create permanent changes in the market.

Market transformation has emerged as a central policy objective for future publicly funded energy-efficiency projects in the United States, but the evaluation of such projects is still in its infancy. Furthermore, regulatory authorities have little experience in accepting savings from market transformation. Nevertheless, because of its importance, we encourage project developers to consider savings from market transformation, particularly since other countries are starting to implement market transformation programs (see Box 2).

Box 2

Market Transformation Programs Outside North America

Market transformation programs are being implemented outside of North America, particularly in Sweden, Brazil, Thailand, India, Philippines, Sri Lanka, Poland, and China (Martinot 1998; Meyers 1998). We provide information on market transformation programs for the first three countries.

The ten-year old Swedish program for energy efficiency has produced 25 procurements within the residential, commercial and industrial sectors (Suvilehto and Öfverholm 1998). Examples in the residential sector include refrigerators and freezers, washing machines and dryers; in the commercial sector, lighting and ventilation; and in the industrial sector: factory doors and fans. This program aims at establishing market transformation and consists of technology procurement and projects supporting market penetration. There is a wide variety of methods in use; each of them are designed according to the market barriers, its actors, decision makers, their interplay, and specific market needs, expectations and conditions.

Since 1995, Brazil's national electricity conservation program, PROCEL, has been involved in market transformation, including cooperative efforts with equipment manufacturers (Geller 1997). PROCEL has had considerable success in transforming the efficiency of refrigerators and freezers, lighting, motors, and meters. PROCEL conducts or co-funds several other programs in the areas of research and development, consumer education, training, promotion and ESCO support. These programs are designed to introduce new technologies, increase awareness, change behavior, and stimulate investment in energy efficiency in Brazil.

The Thailand Promotion of Electricity Efficiency project is a comprehensive five-year utility DSM program that created a DSM office within the national electric utility (EGAT) (Martinot 1998). The DSM office is developing and implementing a number of market intervention strategies in the residential, commercial and industrial sectors. The project provides for financing mechanisms, energy-efficiency codes and standards, appliance labeling, testing laboratories, monitoring and evaluation protocols and systems, development and training of energy service companies, integrated supply-side and demand-side planning, and load management programs. EGAT has tried to rely on voluntary agreements, market mechanisms, and intensive publicity and public education campaigns (including appliance energy labels).

Sources: (1) Suvilehto, H. and E. Öfverholm. 1998. "Swedish Procurement and Market Activities — Different Design Solutions on Different Markets," in the *Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings*. Vol. 7, pp. 311-322. Washington, D.C.: American Society for an Energy-Efficient Economy. (2) Geller, H. 1997. *Market Transformation through PROCEL: Brazil's National Electricity Conservation Program*. Washington, D.C.: American Council for an Energy-Efficient Economy. (3) Martinot, E. 1998. *Monitoring and Evaluation of Market Development in World Bank-GEF Climate Change Projects*. Washington, D.C.: The World Bank. (4) Meyers, S. 1998. *Improving Energy Efficiency: Strategies for Supporting Sustained Market Evolution in Developing and Transitioning Countries*. LBNL-41460. Berkeley, CA: Lawrence Berkeley National Laboratory.

In the case of market transformation, the project developer is one of the responsible parties for engendering energy-use changes and, therefore, should be responsible for estimating the amount of market transformation. However, because of the multiple actors involved in causing market transformation, the developer should not be solely responsible for assessing and later monitoring and evaluating market transformation.[1] The amount of resources devoted to assessing market transformation, therefore, will depend on how much energy savings can be attributed to this project, which may be reflected in contracts among parties involved in transforming markets.

3.2. Estimating a Baseline

For joint implementation (Article 6) and Clean Development Mechanism (Article 12) projects implemented under the Kyoto Protocol, the emissions reductions from each project activity must be "additional to any that would otherwise occur," also referred to as "additionality criteria" (Articles 6.1b and 12.5c).[2] Determining additionality requires a baseline for the calculation of energy saved, i.e., a description of what would have happened to energy use had the project not been implemented (see Violette et al. 1998). Additionality and baselines are inextricably linked and are a major source of debate (Trexler and Kosloff 1998). Determining additionality is inherently problematic because it requires resolving a counter-factual question: What would have happened in the absence of the specific project?

Because investors and hosts of energy-efficiency projects have the same interest in an energy-efficiency project (i.e., they want to get maximum energy savings from the project), they are likely to overstate and over-report the amount of energy saved by the project (e.g., by overstating business-as-usual energy use). Cheating may be widespread if there is no strong monitoring and verification of the projects. Even if projects are well monitored, it is still possible that the real amount of energy saved is less than estimated values. Hence, there is a critical need for the establishment of realistic and credible baselines.

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[1] Other challenges in proving attribution include the following: (1) multiple interventions occur (e.g., changes in standards, products offerings and prices and activities of other market actors (e.g., regulators and regulatory intervenors)); (2) programs and underlying change factors interact with one another; (3) the effects of different programs are likely to have different lag times; (4) changes in different technologies are likely to proceed along different time paths; (5) changes are likely to differ among different target segments; (6) the lack of an effective external comparison group; (7) data availability; and (8) large, complex interconnected sociotechnical systems are involved, with different sectors changing at different rates and under different influences.

[2] In this report, the criterion of additionality refers only to carbon emissions. The related criterion of "financial additionality" is not described in LBNL's MERVC guidelines. Financial additionality refers to the financial flows of a project (Andrasko et al. 1996): would the expenditures involved been made without the energy-efficiency project? This question addresses: (1) the sources of funding for the project, (2) the alternative uses of that funding, and (3) the motivation for choosing the energy-efficiency projects (Swisher 1998). We expect financial additionality to be addressed when the proposed project is registered (see Section 1.1).

Future changes in energy use may differ from past levels, even in the absence of the project, due to growth, technological changes, input and product prices, policy or regulatory shifts, social and population pressure, market barriers, and other exogenous factors. Consequently, the calculation of the baseline needs to account for likely changes in relevant regulations and laws, changes in key variables (e.g., population growth or decline, and economic growth or decline) (Andrasko et al. 1996; Michaelowa 1998).

Ideally, when first establishing the baseline, energy use should be measured for at least a full year before the date of the initiation of the project. The baseline will be re-estimated based on monitoring and evaluation data collected during project implementation. Finally, in order to be credible, project-specific baselines need to account for free riders.

3.2.1. Free riders

In energy-efficiency projects, it is possible that the reductions in energy use are undertaken by participants who would have installed the same measures if there had been no project. These participants are called "free riders." The savings associated with free riders are not truly "additional" to what would occur otherwise (Vine 1994). Although free riders may be regarded as an unintended consequence of an energy-efficiency project, free ridership should still be estimated, if possible, during the estimation of the baseline (Section 4.3). Although many studies have been able to estimate the number of free riders, some studies have not been able to find any free riders: e.g., in Texas, an independent evaluation of all state agencies participating in the Texas LoanSTAR program[1] showed virtually no free ridership (personal communication from Jeff Haberl, Texas A&M University, Jan. 13, 1999). While free riders can also cause positive project spillover, this impact is typically considered to be insignificant compared to the impacts from other participants.

For projects installing energy-efficient technologies in developing countries where the efficiency of these technologies would be regarded as "conventional" in developed countries, all project participants could be regarded as free riders. As a result, there would be few projects implemented. A possible solution to this problem would be the establishment of performance benchmarks (standards) that would indicate to project developers the type of energy-efficient equipment that would be allowed to be installed and that would pass the "free rider test" (Section 3.2.2).

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[1] The Texas LoanSTAR program is a $98.6 million revolving loan program that was created to provide public funds for energy-efficiency retrofits to state, local government, and school district buildings within Texas (Verdict et al. 1990; Claridge et al. 1991; Haberl et al. 1996).

3.2.2. Performance benchmarks

Concerned about an arduous project-by-project review that might impose prohibitive costs, some researchers have proposed an alternate approach, based on a combination of performance benchmarks and procedural guidelines that are tied to appropriate measures of output (e.g., Lashof 1998; Michaelowa 1998; Swisher 1998; Trexler and Kosloff 1998). In all cases, measurement and verification of the actual performance of the project is required. The performance benchmarks for new projects could be chosen to represent the high performance end of the spectrum of current commercial practice (e.g., representing roughly the top 25th percentile of best performance). In this case, the benchmark serves as a goal to be achieved. In contrast, others might want to use benchmarks as a reference or default baseline: an extension of existing technology, and not representing the best technology or process.

A panel of experts could determine a baseline for a number of project types, which could serve as a benchmark for the UNFCCC. This project categorization could be expanded to a categorization by regions or countries, resulting in a region-by-project matrix. Project developers could check the relevant element in the matrix to determine the baseline of their project. Most of the costs in this approach relate to the establishment of the matrix and its periodical update. Before moving forward with this approach, analysis is needed to consider the costs in developing the matrix and its update, the potential for projects to qualify, and the potential for free riders. The U.S. EPA is assessing the feasibility and desirability of implementing a benchmark approach for evaluating additionality (e.g., see Hagler Bailly 1998).

3.3. Estimating Net GHG Emissions

Once the net energy savings have been calculated (i.e., estimated gross energy use minus baseline energy use), net GHG emissions reductions can be estimated in one of two ways: (1) if emissions reductions are based on fuel-use or electricity-use data, then default emissions factors can be used, based on utility or nonutility estimates (e.g., see Appendix B in USDOE 1994b); or (2) emissions factors can be based on generation data specific to the situation of the project (see Section 4.14). In both methods, emissions factors translate consumption of energy into GHG emission levels (e.g., tons of a particular GHG per kWh saved). At the project design stage, we expect most project developers to use default emission factors (method #1); a more detailed discussion of using calculated factors (method #2) is found in Section 4.14.

4. Monitoring and Evaluation of Energy Use and GHG Emissions

In Figure 4, we present an overview of the approach used in LBNL's MERVC guidelines for evaluating changes in energy use and emissions. During the monitoring and evaluation stage, gross energy savings are first measured, using one of the options provided in the U.S. Department of Energy's (DOE) International Performance Measurement and Verification Protocol (IPMVP) (Section 4.2.9). The baseline is also re-estimated, accounting for free riders (Section 4.13.1). The net change in energy use is equal to the gross change in energy use minus the re-estimated baseline. Net emissions are then calculated, using either default emission factors or emissions based on generation data (as mentioned in Section 1.4, we are only examining CO_2 impacts).

During the implementation of the project, monitoring of project activities is conducted periodically to ensure the project is performing as designed. We expect most, if not all, of the monitoring and evaluation activities to be performed by project developers and their contractors.[1] While the project is being implemented, however, we expect periodic (e.g., annual) reviews by third-party verifiers (to avoid conflicts of interest), leading to certification (see Sections 6 and 7). These verifiers might be the same independent reviewers who assessed the project proposal at the registration stage (personal communication from Johannes Heister, The World Bank, Jan. 12, 1999). As noted in Section 6, verification of energy savings and carbon emissions would be performed at certain intervals during the time the project is scheduled to save energy.

This section introduces some of the basic data collection and analysis methods used to estimate changes in energy use and associated impacts. The methods vary in cost, accuracy, simplicity and technical expertise required. Tradeoffs will need to be made for choosing the appropriate methods: e.g., level of accuracy and cost of data collection.

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[1] An alternative approach is to require only certified professionals to conduct the monitoring and evaluation, as required when institutions of higher education enter into energy performance-based contracts in Texas (Texas Higher Education Coordinating Board et al. 1998). Moreover, a "professional engineer stamp" is required: (1) to certify that the monitoring and evaluation plan complies with the Texas guidelines, (2) by the person that creates the plan, (3) by the person that does the audit and cost engineering, and (4) for the person that does an independent review of the project (personal communication from Jeff Haberl, Texas A&M University, Dec. 30, 1998).

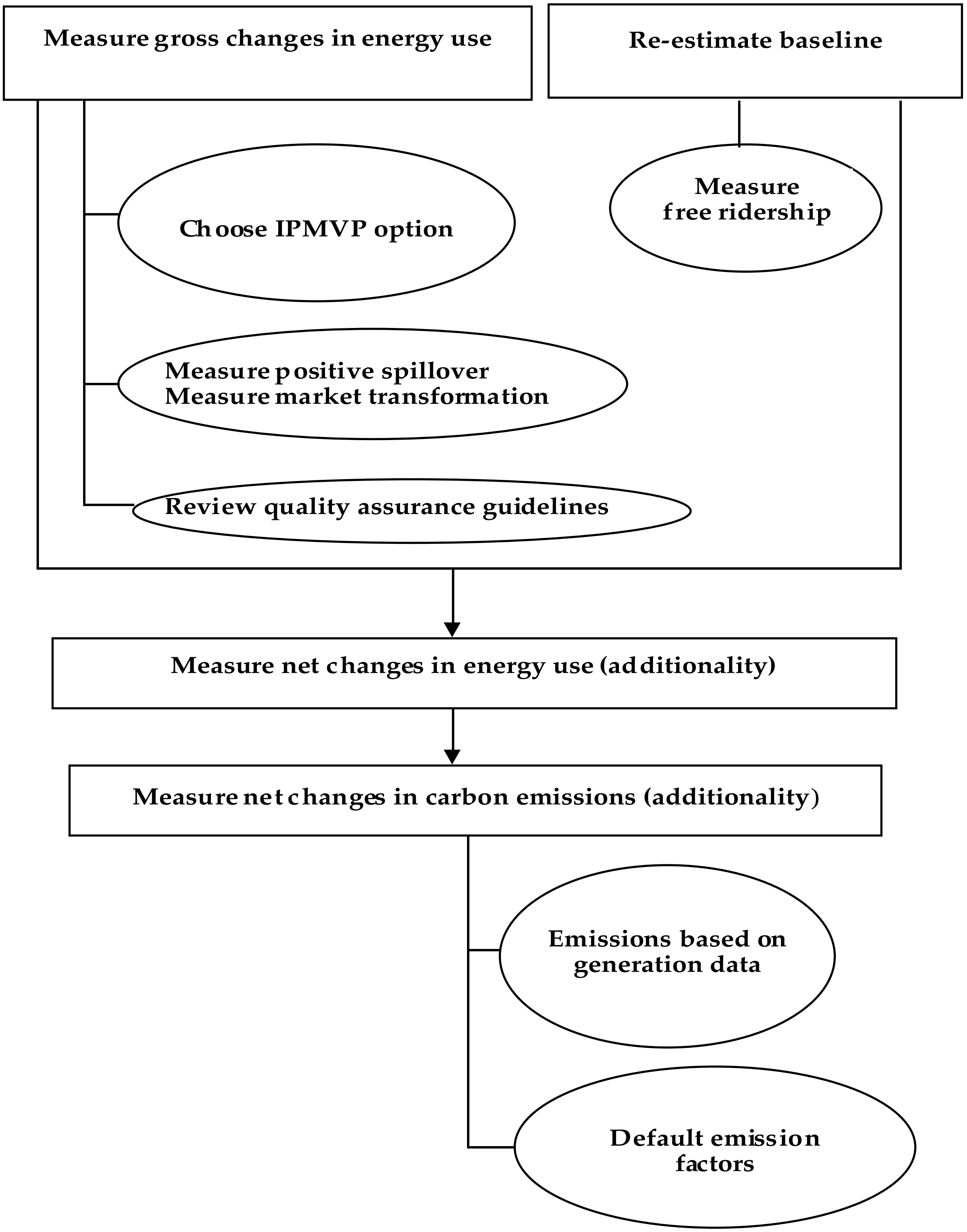

Fig. 4. Evaluation Overview

This section introduces some of the basic data collection and analysis methods used to produce energy-saving estimates (see USDOE 1994b; Raab and Violette 1994). As noted in Section 1.4, these methods have been used extensively in the evaluation of energy-efficiency programs in North America (particularly in California, the Pacific Northwest, Wisconsin, New England, and the mid-Atlantic states) (see Box 3). These methods have also been used in the evaluation of energy-efficiency programs in other countries (Hebb and Kofod 1998; Vreuls and Kofod 1997; Vine 1996a). Finally, some of the methods may be more applicable to the monitoring and evaluation of a particular project (e.g., a retrofit of a large commercial building), rather than the monitoring and evaluation of a program that involves many projects at multiple facilities (sites). If the focus is on one building, then some of the methods contained in this report will not be utilized (e.g., basic statistical models, multivariate statistical models, and some integrative methods). In the text, we indicate where these methods are appropriate for only groups of buildings; otherwise, the methods are appropriate for all situations.

Energy service companies (ESCOs) are currently using these methods in energy performance contracting. An ESCO is a company that is engaged in developing, installing and financing comprehensive, performance-based projects, typically 5-10 years in duration, centered around improving the energy efficiency or load reduction of facilities owned or operated by customers (Cudahy and Dreessen 1996; Fraser 1996). Projects are performance-based when the ESCO's compensation, and often the project's financing, are meaningfully tied to the amount of energy actually saved, and the ESCO assumes the risk in linking their compensation directly to results. Monitoring, evaluation and verification are built into the contract between the ESCO and the customer. Until recently, energy performance contracting has typically been implemented at one facility (e.g., a large commercial or industrial facility), in contrast to demand-side management projects which often promote the installation of energy-efficiency measures in many buildings (e.g., efficient lighting among residential households, chillers among hospitals, etc.). In the last few years, utilities in New Jersey and California have offered "standard performance contract" programs (pay-for-performance energy-efficiency incentive programs), resulting in energy performance contracting being conducted at multiple facilities (Goldman et al. 1998; Rubinstein et al. 1998).

Box 3

The Evaluation of Energy-Efficiency Programs in California

California is widely recognized as the state having the most experience in evaluating utility energy-efficiency programs in the U.S. as well as having rigorous measurement and evaluation protocols (CPUC 1998). The protocols and procedures were developed in response to the shareholder earnings mechanisms established for the four largest investor-owned utilities to acquire demand-side resources. Since 1994, the California utilities have completed hundreds of evaluation studies; earnings claims for 1994 programs and beyond have been based on adopted ex-post agreements identified in the protocols. These utilities, along with eight additional organizations, comprise the California Demand Side Management Measurement Advisory Committee which was established by the California Public Utilities Commission (CPUC) to oversee the demand-side management measurement and evaluation activities of these utilities.

The utility program evaluations have been conducted by utility staff or contractors to the utilities. The results from these evaluations are then filed with the CPUC. The CPUC's Office of Ratepayer Advocates (ORA) reviews these studies, the claimed shareholder earnings, and proposed changes or additions to the protocols. Two types of review are conducted by ORA: (1) verification of participation: a review of the utility's files to make sure all participants are in the utility's data base, and a review of the files for a random sample of participants (in some cases, onsite visits are conducted on a small sample of nonresidential customers); (2) for the larger programs, ORA prepares "review memos" that are based on a review of the evaluation studies: if problems are encountered, utility data files are requested for conducting a "replicate analysis". If ORA cannot replicate the utility analysis, then ORA will challenge the utility's results. If ORA can replicate the utility's analysis but there are problems, then more information is requested and more analyses are conducted. If ORA can replicate the utility's analysis and it is reasonable, then there is no basis for challenging the utility's results. At the end of each year, ORA files a report with the CPUC which contains recommendations on the utility evaluation studies and findings. A case management process is then conducted to see if the differences between the ORA and the utilities can be resolved. If not, then hearings are held at the CPUC to resolve the differences. At the end of the process, the Administrative Law Judge at the CPUC issues a decision on the utilities' earning claims and associated evaluation studies (where appropriate).

The California experience in measurement and evaluation is regarded by many observers to be an experience that other states (or countries) should not replicate because of the extended regulatory processes and the level of resources needed to participate in the process. However, for States (or countries) that choose to rely on utilities to promote energy efficiency as a least-cost resource with the combined set of regulations associated with Integrated Resource Planning (shareholder incentives, program cost recovery, lost revenue protection, etc.), something like the California experience is probably necessary. While the final evaluation methods and findings are clearly the best standard for the industry, nobody has made a systematic and comprehensive assessment of the costs and benefits of conducting this type of evaluation process compared to a less rigorous evaluation process. The costs are probably relatively high, but may decrease over time as the methods and their use become better known. Also, the costs are necessary to ensure that utility claims of avoided supply-side additions and shareholder incentives are reasonable.

4.1. Methodological Issues

Prior to reviewing the data collection and analysis methods used for measuring gross and net energy savings and GHG emissions, we first discuss two key methodological issues: measurement uncertainty, and the frequency and duration of monitoring and evaluation. These issues are not only addressed in the monitoring and evaluation stage but should also be examined in the project design stage.

4.1.1. Measurement uncertainty

While there are several types of uncertainty that can affect the actual realization of GHG reductions, uncertainty in the measurement of GHG reductions needs to be taken into account when presenting monitoring and evaluation findings.[1] Measurement uncertainties include the following: (1) the use of simplified representations with averaged values (especially emission factors); (2) the uncertainty in the scientific understanding of the basic processes leading to emissions and removals for non-CO_2 GHG; and (3) the uncertainty in measuring items that cannot be directly measured (e.g., project baselines). Some of these uncertainties vary widely by type of project (depending on approach, level of detail, use of default data or project specific data, etc.), and length of project (e.g., short-term versus long-term). It is important to provide as thorough an understanding as possible of the uncertainties involved when monitoring and evaluating the impacts of energy-efficiency projects.

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[1] Other types of uncertainty include the following: (1) project development and construction uncertainty, i.e., the project won't be implemented on time or at all, even though funds have been spent on project development; (2) operations and performance uncertainty (e.g., if the energy-consuming equipment is not used as projected, then carbon savings will change); and (3) environmental uncertainty (IPCC 1995; USAID 1996; UNFCCC 1998b). Project developers should provide a description of the project developer's experience, existing warranties, the reputation of equipment manufacturers, the performance history of previous projects, and engineering due diligence. The political and social conditions that exist that could potentially affect the credibility of the implementing organizations (e.g., political context, stability of parties involved and their interests, and potential barriers) also need to be described.

Because of the difficulties and uncertainties in estimating energy savings and reduced emissions, the level of precision and confidence levels associated with the measurement of savings need to be identified.[1] Project developers and evaluators should report the precision of their measurements and results in one of two ways: (1) quantitatively, by specifying the standard deviation around the mean for a bell-shaped distribution, or providing confidence intervals around mean estimates; or (2) qualitatively, by indicating the general level of precision of the measurement (e.g., low, medium or high).

It is unclear at this time on how uncertainty will be treated in the calculation and crediting of energy savings and reduced emissions. At a minimum, the most conservative figures should be used at every stage of calculation (e.g., the lower boundary of a confidence interval). The qualitative assessment of uncertainty is more problematic, however, some type of discounting or debiting could be used to adjust energy savings and reduced emissions in situations where there is a great deal of uncertainty. Where there is substantial uncertainty, project developers need to design higher quality energy-efficiency projects so that impacts are more certain.

In conclusion, the evaluation of energy-efficiency projects should: (1) evaluate the project's contingency plan, where available, that identifies potential project uncertainties and discusses the measures provided within the project to manage the uncertainties; (2) identify and discuss key uncertainties affecting all emission estimates; (3) assess the possibility of local or regional political and economic instability and how this may affect project performance; and (4) provide confidence intervals around mean estimates.

4.1.2. Frequency and duration of monitoring and evaluation

The frequency of monitoring and evaluation will most likely be linked to the schedule of transfer of carbon credits.[2] It is possible that these credits could be issued on an annual basis. The frequency of monitoring and evaluation will also depend on the variables being examined and methods used: e.g., hourly end-use monitoring conducted for a two-week period, or short-term monitoring of lighting energy use for five-minute periods. The monitoring period may last longer than the project

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[1] Unless otherwise noted, we assume normal distributions, represented by a normal, bell-shaped curve in which the mean, median and mode all coincide.

[2] Other models are possible (e.g., up-front lump-sum payment), but unlikely since the issuance of certified emission reduction units occurs after a verification process.

implementation period: for example, a project to install compact fluorescent lamps may last 3 years, but electricity savings from those lamps will continue beyond the three years.

The **persistence** of the energy savings from energy-efficiency projects is a critical issue in the monitoring and evaluation of energy savings, as well as in the design and implementation of the projects. The institutional, community, technical and contractual conditions likely to encourage persistence are of utmost concern. In some cases, encouraging the participation of community members in the development and implementation of energy-efficiency projects will help to ensure the longevity of a project, although the design and implementation process may take longer and costs will increase. Project persistence will also increase by encouraging operations and maintenance, providing spare parts and equipment, and making sure technical expertise is available. Finally, contracts can incorporate provisions that lead to debiting of emission reduction units (for the host and/or investor country) if a project does not last as long as expected.

The issue of persistence is directly linked to the concept of market transformation (Section 3.1.3). Markets are transformed as market barriers are reduced due to market intervention. The reduction in market barriers is reflected in a set of market effects that last after the market intervention has been withdrawn, reduced or changed. For example, an energy-efficiency project may reduce awareness barriers by providing information to a targeted audience (e.g., building owners and managers). The key question for market transformation (and persistence) is whether the targeted audience remains informed once the project has ended: if there is no persistence, then there is no market transformation; if there is some persistence, then market transformation is possible.

As mentioned at the beginning of this section, energy service companies conduct energy performance contracting in one or more buildings, and their compensation, and often the project's financing, are tied to the amount of energy actually saved. Because the persistence of energy savings is of paramount interest for all concerned, periodic (if not continuous) monitoring and evaluation is built into the contract between the ESCO and the customer. For example, when institutions of higher education in Texas enter into energy performance-based contracts, they require periodic monitoring to guarantee the energy savings in their contract (Texas Higher Education Coordinating Board et al. 1998).

In California, investor-owned utilities must periodically conduct two types of persistence studies on energy-efficiency measures: retention studies and performance studies (CPUC 1998). The retention studies assess the fraction of measures installed in the first program year which are still in place and operable at the time of the study. The data are collected by telephone, on-site or mail surveys from program participants. In the performance studies, the performance/efficiency of the equipment is measured on site; the studies are conducted every four or five years.

The U.S. Environmental Protection Agency's (EPA) Conservation Verification Protocols (CVP) contains disincentives to encourage monitoring over the life of the measure (see Section 1.6.3). Three options are available for evaluating subsequent-year energy savings (Table 2): monitoring, inspection and a default (Meier and Solomon 1995; USEPA 1995 and 1996). The estimated impacts of the energy-efficiency measures eligible for emissions credits are those that can be demonstrated with at least a 75% level of confidence. This means that there must be a 75% likelihood that the true level of impacts is equal to or greater than the value calculated in the evaluation (i.e., there can be no more than a 25% likelihood that actual impacts are less than those reported by the evaluation). The evaluation must be designed to produce this level of confidence in the final evaluation estimates.

Table 2. Options for Obtaining Credit for Energy Savings Over Time

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

Source: Derived from USEPA (1995 and 1996)

Finally, where more than one project is being implemented, evaluators should evaluate a project by its persistence or lack of persistence — this will be reflected in "project lifetime," which may be different than an expected lifetime of a project as initially proposed by developers. For example, if a project area is likely to undergo serious changes in 10 years, then the carbon emission reductions for that project are limited to that 10-year lifetime. The value of those reduced emissions may be less than for emissions from similar projects that are expected to last longer (e.g., 20 years). Accompanying the evaluation, the evaluator should provide a list of indices that demonstrate the potential for persistence: e.g., type and number of income groups targeted by project, potential socioeconomic impacts addressed (see Section 8.2), local manufacturing capability, potential sources of uncertainty and risk addressed (see Section 4.1.1), etc.

4.2. Measurement of Gross Energy Savings

As described at the beginning of this section, the first step in measuring emission reductions is the measurement of gross energy savings[1]: comparing the observed energy use of project participants with pre-project energy consumption.[2] Several data collection and analysis methods are available which vary in cost, precision, and uncertainty. The data collection methods include engineering calculations, surveys, modeling, end-use metering, on-site audits and inspections, and collection of utility bill data. Most monitoring and evaluation activities focus on the collection of measured data; if measured data are not collected, then one may rely on engineering calculations and "stipulated" (or default) savings (as described in EPA's Conservation Verification Protocols and in DOE's International Performance Measurement and Verification Protocol (Section 4.2.9)).[3] Data analysis methods include engineering methods, basic statistical models, multivariate statistical models (including multiple regression models and conditional demand models), and integrative methods. As mentioned at the beginning of this section, the use of these methods will vary by how many buildings are being evaluated.

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[1] LBNL's MERVC guidelines focus on energy use (e.g., kWh and fuel use), and not demand (e.g., kW) because CO_2 emissions depend on the amount of kWh that must be supplied, not the power capacity saved.

[2] Takeback (or snapback or rebound) is a price effect where program participants increase their demand for energy services when efficiency measures decrease the price of services. We do not discuss takeback in this report because most researchers believe that takeback of energy savings is minimal, with the possible exception of low-income programs that affect customers who are consuming energy services below their comfort level (Violette et al. 1998).

[3] Stipulated savings refer to two different types of stipulated savings methods: (1) algorithms for calculating energy savings for specific measures; and (2) a set of criteria for using best-engineering practices (USEPA 1995). The rationale for the use of stipulated savings is that the performance of some energy-efficiency measures is well understood and may not be cost effective to monitor; stipulated savings should only be used for certain retrofits and conditions.

In this section, we provide a brief review of methods to provide guidance to evaluators. For each method, we provide examples of applications of these methods; the examples are for illustrative purposes. The methods used for data collection and the evaluation of non-electric end-use efficiency projects are similar to those used for electric end-use efficiency projects; there will, however, often be greater reliance on engineering methods and surveys because centralized billing information will generally not exist.

4.2.1. Establishing the monitoring domain

During the project design stage, the project developer needs to determine who will be monitored: just program participants, or nonparticipants, too. In the beginning stages of a project, the indirect impacts of a project are likely to be modest as the project gets underway, so that the MERVC of such impacts may not be a priority. These effects are also likely to be insignificant or small for small projects. Under these circumstances, it may be justified to disregard these impacts and simply focus on energy savings from the project. This would help reduce MERVC costs. As the projects become larger or are more targeted to market transformation, these impacts should be evaluated.

Currently, there are weak linkages in assessing multiple monitoring domains (e.g., local, regional and national) (Andrasko 1997). One potential solution to strengthening these linkages is the use of "nested monitoring systems" where an individual project's monitoring domain is defined to capture the most significant energy savings and where provisions are made for monitoring energy use and carbon emissions outside of the project area by regional or national monitoring systems (Andrasko 1997).

4.2.2. Engineering methods

Engineering methods are used to develop estimates of energy savings based on technical information from manufacturers on equipment in conjunction with assumed operating characteristics of the equipment. The two basic approaches to developing engineering estimates are engineering algorithms and engineering simulation methods (Violette et al. 1991).

<u>Engineering algorithms</u> are typically straightforward equations showing how energy (or peak) is expected to change due to the installation of an energy efficiency measure. They are generally quick and easy to apply but are limited to certain types of retrofits (e.g., motor replacement on constant use motor). The accuracy of the engineering estimate, however, depends upon the accuracy of the

inputs, and the quality of data that enters an engineering algorithm can vary dramatically. Hence, calibration to measured data is often necessary for using algorithms.

Engineering building simulations are computer programs that model the performance of energy-using systems in residential and commercial buildings.[1] These models use information on building occupancy patterns, building shell and building orientation (e.g., window area, building shape and shading) and information on all of the energy-using equipment. The input data requirements for the more complex simulation models are extensive and require detailed onsite data collection as well as building blueprints (e.g., see Box 4).

Building simulation models are best suited for space heating/cooling analyses and for predicting interactive effects of multiple measure packages where one of the measures influences space conditioning.[2] Measures best addressed by simulation models include heating, ventilation, and air-conditioning (HVAC) measures, building shell measures, HVAC interactions with other measures, and daylighting measures. Equipment measures such as lighting, office equipment, and appliance use are typically calibrated outside the simulation, except for their interactive impacts.

Building simulation models are tools, and their usefulness is a function of the skill of the modeler, the accuracy of the input information, and the level of detail in the simulation algorithms. A key component of building energy simulation methods is the appropriate calibration of these models to actual consumption data. The calibration could involve monthly energy consumption data from bills (at a minimum), kW demand meters, run-time meters, and short-term end-use metering (e.g., two to six weeks of metering). One advantage of simulation models is that they take into account such factors as weather data and interactions between the HVAC system and other end uses. A primary disadvantage of building simulation tools is that they are very time consuming and usually require specialized technical expertise, making them costly in the long run. In addition, because they simplify processes, they may work well on average but may not necessarily work well for a particular building (or vice versa). Finally, the behavior-driven inputs (e.g., hours of operation) are often subject to self-report bias.

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[1] Building energy simulations have been carried out in many countries outside of North America including: Australia (Yune 1998), Brazil (Lamberts et al. 1998), China, Hong Kong, Mexico, New Zealand, Pakistan, Saudi Arabia, Singapore, South Africa, South Korea, Sweden, and Switzerland (personal communications from Joe Huang and Fred Winkelmann, Lawrence Berkeley National Laboratory, Nov. 12, 1998).

[2] The simulation results can be produced in kWh, therms, or Btus. Given the fuel efficiency of the heating system, the amount of fuel required to meet the heating demand of the building can be calculated.

Box 4

Engineering Building Simulation Example

The Pacific Gas and Electric Company and Southern California Edison contracted with a consulting firm to perform a comprehensive evaluation of their 1994 nonresidential new construction programs. These programs offered incentives for building envelope, lighting, HVAC and refrigeration measures, with the aim of encouraging the construction of buildings more energy efficient than mandated by statewide building codes.

Evaluation methods: The gross impact analysis was conducted using the DOE-2 building energy simulation program. DOE-2 is a very flexible modeling tool that allows the calculation of energy and demand savings for lighting, lighting controls, shell measures, HVAC efficiency improvements, many HVAC control measures, and grocery store refrigeration systems. An automated process that integrated on-site data collection and DOE-2 modeling conducted DOE-2 simulations of 347 sites under multiple baseline scenarios. A DOE-2 model was constructed for each surveyed building, and the engineering analysis used Typical Meteorological Year weather data representative of the building's location.

Model calibration to billing data was used to provide a check on the model results. Calibration procedures focused on high influence parameters, such as outside air fraction, economizer operation, fan schedules, etc. that may be difficult to observe during an on-site survey. Models were calibrated to ±10% agreement on monthly whole-building energy consumption, where possible.

A second round of calibrations was performed on a sub-sample of 30 sites where short-term monitored data were collected. The short-term monitoring was used to improve the end-use consumption estimates in all building models, thus improving estimates of energy savings for the entire sample. Data gathered from short-term monitoring was used to define key simulation model inputs, thus limiting the key variables available for adjustment during calibration. This ensured that building systems were modeled as they actually operated.

Evaluation concerns: (1) in collecting extensive billing data, the study was delayed and may have done more harm than good: only a fraction of the billing data proved to be useful and had a relatively small impact on the results, while the delay made surveying decision makers and obtaining permission for on-site audits more difficult; (2) the use of a commercial database as a sample frame led to ambiguities in the identity and location of program participants; and (3) the collection of building standard documentation was frustrating as many companies viewed this documentation as proprietary and refused to release it: as a result, very little documentation was collected.

Findings: The PG&E program resulted in a gross summer on-peak demand savings of 19.7 MW and an annual energy savings of 81,350 MWH. The SCE program resulted in a gross summer on-peak demand savings of 10.3 MW and an annual energy savings of 67,850 MWH.

Source: Pacific Gas and Electric. 1997. *Impact Evaluation of Pacific Gas and Electric Company and Southern California Edison 1994 Nonresidential New Construction Programs*. March 1. San Francisco, CA: Pacific Gas and Electric.

Engineering estimates (in algorithms and building simulations) are often developed as part of an ongoing project tracking database. Because of changes during project implementation, the engineering assumptions used at the design stage of a project need to be changed as evaluation data are collected (e.g., number of operating hours and specific measures installed). Engineering methods for use in assessing the impacts of energy-efficiency projects are improving as experience points out their strengths and weaknesses. Their value for impact evaluation also is increasing as actual field data is used to adjust or recalculate savings estimates. Engineering methods are often used as a complement to other evaluation methods rather than serving as stand-alone estimates of project impacts (see below).

Although engineering approaches are improving and increasing in sophistication, engineering estimates generally produce estimates of baseline energy use and project impacts that do not account for free riders (Section 3.2.1) and positive project spillover (Section 3.1.2). It is possible to incorporate free rider and spillover factors from surveys and other evaluation sources in order to calculate more accurately baseline energy use and project impacts. Engineering analyses may be most appropriate for: (1) the initial year of project implementation where monitoring will rely on engineering estimates and where data have not been collected; (2) projects where small savings are expected (making less expensive methods preferable); (3) large industrial customers (making it difficult to find a representative comparison group of customers); (4) new construction projects (where pre-project energy use does not exist); and (5) certain types of retrofits (e.g., motor replacement for a constant use motor).

In sum, the advantages of engineering methods are that engineering algorithms are relatively quick and inexpensive to use (in contrast to building simulations that are typically more resource intensive) and are probably most useful when integrated with other data collection and analysis methods. The primary disadvantage is that the data used in the calculations rely on assumptions that may vary in their level of accuracy. Accordingly, engineering analyses need to be “calibrated” with onsite data (e.g., operating hours and occupancy). Thus, as project information is collected, engineering estimates can be improved.

Table 3. References to Engineering Methods

Examples	References
Residential new construction	Mahone et al. (1996)
Commercial heating, ventilation & air-conditioning	Baker et al. (1996)
Commercial lighting	Caulfield and Galawish (1996)
Commercial new construction	Sebold and Wang (1996)
Commercial new construction	Carlson et al. (1997b)
Commercial retrofit	Katipamula and Claridge (1993)
Commercial retrofit	Lui and Claridge (1998)
Commercial retrofit	Haberl and Claridge (1985)
Commercial energy management systems	Wortman et al. (1996)
Commercial chillers	Carlson et al. (1997a)
Industrial process, refrigeration, and miscellaneous measures	Clarke et al. (1996)
Industrial heating, ventilation & air-conditioning	Mowris et al. (1996)
	General References
	Claridge (1998) Jacobs et al. (1992) Knebel (1983) Ridge et al. (1997) USDOE (1997) Violette et al. (1991)

4.2.3. Basic statistical models for evaluation (for groups of buildings)

Statistical models that compare energy consumption before and after the installation of energy efficiency measures have been used as an evaluation method for many years (Violette et al. 1991). The most basic statistical models simply look at monthly billing data before and after measure installation using weather normalized consumption data (this is particularly important where weather-dependent measures are involved—e.g., heating and cooling equipment, refrigerators, etc.). If the energy savings are expected to be a reasonably large fraction of the customer's bill (e.g., 10% or more), then this change should be observable in the project's bills. Smaller changes (e.g., 4%) might also be observed in billing data, but more sophisticated billing analysis procedures are often required. This method can be used for comparing changes in energy use for project participants and a comparison group (e.g., see Box 5). Statistical models are most useful where many projects (or one project with many participants) are being implemented (e.g., in the residential sector).

These simple statistical comparison estimates rely on the assumption that the comparison group is, in fact, a good proxy for what project participants would have done in the absence of the project. However, there are reasons to expect systematic differences between project participants and a comparison group (e.g., participants may already be more inclined to adopt a measure than nonparticipants do). Consequently, evaluators may start with a basic statistical approach because it is relatively inexpensive and easy to explain, but they should consider augmenting this method with survey data and other measurements to test the underlying assumptions of the model. Additional modeling and verification methods may be needed before the results of these basic comparisons can be accepted as accurately representing the actual impacts of an energy-efficiency project.

Box 5

Basic Statistical Model Example
(for groups of buildings)

The Ohio Department of Development's Office of Energy Efficiency contracted with a consulting firm to perform a comprehensive evaluation of the Ohio Low-income Home Weatherization Assistance Program. The program evaluation compared the energy use of participants and a comparison group, using a software model called the Princeton Scorekeeping Method, or PRISM (see Box 4). Approximately 95% of the utility participants were served by one of eight local utilities owned by 6 utility companies. A key task in the study was to collect and clean the needed data for assessing energy usage.

Evaluation methods: The data collection process began in early 1996 with the gathering of statewide weatherization databases for program years 1994 and 1995. The participant utility account numbers, recorded by local weatherization agencies, were checked and cross-referenced to other databases to create the most accurate and complete participant account lists. Energy usage was formally requested from utilities in June of 1996. The data requested included approximately 3 years of usage data.

PRISM was used to analyze the gas usage data for the 1994 low-income weatherization assistance program participants and a comparison group drawn from the 1995 participants. PRISM provides weather-adjusted annual energy consumption estimates based on monthly usage data. Savings for each house were calculated as the difference in the normalized annual consumption rates between the pre- and post-treatment periods. For the comparison group, the pre-period was defined as the period two years prior to actual treatment, and the post-period was the year immediately preceding actual treatment.

Evaluation concerns: (1) cleaning the utility usage and payment data was a major task; (2) sample attrition (usage data were acquired for just 70% of participants); and (3) usage anomalies and/or incomplete data, which led to the exclusion of 23% of the PRISM savings estimates due to unreliable or physically impossible PRISM results in either the pre or post periods.

Findings: Preliminary results indicated that the program produced impressive gas savings of more than 300 ccf/year, and 400 ccf/year for high-use households. The savings enabled low-income customers to better afford their utility service, avoiding collection actions and service disconnections.

Sources: (1) Blasnik, M. 1997. "A Comprehensive Evaluation of Ohio's Low-Income HWAP: Big Benefits for Clients and Ratepayers," in the *Proceedings of the 1997 International Energy Program Evaluation Conference*. pp. 301-308. Chicago, IL: National Energy Program Evaluation Conference. (2) Fels, M. 1986. "PRISM: An Introduction," *Energy and Buildings* 9(1-2): 5-18.

The advantages of basic statistical models are that comparing the billing data is inexpensive, and the results are easy to understand and communicate. The disadvantages include limited applicability (because of the need for stable building operations or lack of prior billing records (e.g., new construction)), participant samples of significant size are required for validity, and peak impacts cannot be evaluated.

Table 4. References to Basic Statistical Models
(for groups of buildings)

Examples	References
Residential weatherization	Bohac et al. (1996)
Low-income weatherization	Blasnik (1997)
Commercial heating, ventilation & air-conditioning	Baker et al. (1996)
	General References
	Fels (1986) Ridge et al. (1997) Violette et al. (1991)

4.2.4. Multivariate statistical models for evaluation (for groups of buildings)

In project evaluation, more detailed statistical models may need to be developed to better isolate the impacts of an energy-efficiency project from other factors that also influence energy use. Typically, these more detailed approaches use multivariate regression analysis as a basic tool (Box 6) (Violette et al. 1991). Regression methods are simply another way of comparing kWh or kW usage across dwelling units or facilities and comparison groups, holding other factors constant. Regression methods can help correct for problems in data collection and sampling. If the sampling procedure over- or under-represents specific types of projects (e.g., large-scale energy intensive projects) among either project participants or the comparison group, the regression equations can capture these differences through explanatory variables. Two commonly applied regression methods are conditional demand analysis (CDA) and statistically adjusted engineering models (Violette et al. 1991).

Some define CDA strictly as a very specific and complex regression-based approach that should include, among other independent variables, a complete inventory of all major energy-using equipment (see Ridge et al. 1994). Others define CDA less restrictively as a collection of regression-based approaches that specify energy consumption as conditional on any number of measured variables, but not a complete inventory of equipment. Statistically adjusted engineering models would fall into this category. Most impact evaluations of energy-efficiency programs fall into the general category of non-classic, less restrictive CDA. Because of its greater data requirements, the classic, restrictive CDA model experiences greater measurement error, sample error and non-response error than a model that has less demanding data requirements. However, these same data requirements also mean that it will be less likely to omit a relevant variable. Similarly, CDA models that have much less demanding data requirements than the more restrictive CDA models will experience less measurement error, sample error and non-response error. However, these same data requirements mean that there is a greater likelihood that a relevant variable will be omitted.

Box 6

Multivariate Statistical Model Example
(for groups of buildings)

In 1982, Southern California Edison contracted with a consulting firm to conduct an impact evaluation of its commercial and industrial conservation program in which commercial and industrial customers received cash rebates for installing energy-saving devices.

Evaluation methods: In addition to an engineering analysis of energy savings, a multivariate statistical analysis of energy savings was conducted to account for variations in weather patterns and customer characteristics that affect energy consumption and realized savings. The savings estimates were based on a statistical analysis of customers' bills for a period spanning at least 1 year before and 1 year after the equipment was installed. A separate analysis was performed for each type of equipment, using only the bills for customers who installed that type of equipment. The equations included variables that were used to account for three components of consumption: baseload, weather-sensitive consumption, and the conservation effect. The variables explaining base, non-weather-sensitive load were hours of operation per month, square footage, average price of electricity, time trend indicators for the demand group of each customer, and an indicator for whether the customer was commercial or industrial. Weather sensitivity was captured by a cooling degree days variable. The effect of installing equipment under the program was captured with a dummy variable indicating that the customer had installed the equipment.

Findings: The amount of variability (adjusted R-squared) explained by these models varied by type of equipment: 0.21 for time clocks, 0.75 for photocells, 0.75 for load controllers, 0.60 for HVAC economy cycle, 0.56 for lighting system changes, and 0.74 for low wattage fluorescent lamps.

Source: Train, K., P. Ignelzi, and M. Kumm. 1985. "Evaluation of a Conservation Program for Commercial and Industrial Customers," *Energy* 10(10):1079-1088.

Table 5. References to Multivariate Statistical Models
(for groups of buildings)

Examples	References
Residential new construction	Mahone et al. (1996)
Residential new construction	Gunel et al. (1995)
Commercial retrofit	Katipamula et al. (1994)
Commercial retrofit	Coito and Barnes (1996)
Commercial and industrial retrofit	Fagan et al. (1995)
Commercial new construction	Heitfield et al. (1996)
Commercial heating, ventilation & air-conditioning	Randazzo et al. (1996)
	General References
	Claridge (1998) Reddy et al. (1998) Ridge et al. (1997) Violette et al. (1991)

4.2.5. End-use metering

Energy savings can be measured for specific equipment for specific end uses through end-use metering (Box 7) (Violette et al. 1991). This type of metering is conducted before and after a retrofit to characterize the performance of the equipment under a variety of load conditions. The data are often standardized (normalized) for variations in operations, weather, etc. The advantage of end-use metering is that it provides a greater degree of accuracy than engineering estimates or short-term monitoring for measuring energy use (Box 7) (see Section 3.3.5). End-use meters calculate the energy change on an individual piece of equipment in isolation from the other end-use loads (as opposed to billing analysis, which captures the effect at the whole building level). Hence, end-use metering reduces measurement error (assuming the metering equipment is reliable) and reduces the number of control variables required in models.

The disadvantages of end-use metering are: (1) it requires specialized equipment and expertise, typically more costly than the other methods, and therefore most samples need to be small; (2) the small samples may lead to biases in sample selection and problems in representativeness; (3) end-use metering of post-participation energy consumption alone does not, in and of itself, improve estimates of project impacts; (4) end-use metering experiments to measure both pre-and post-installation consumption are difficult to construct, especially in identifying project participants before their becoming participants to allow the pre-measure end-use metering; and (5) it cannot by itself be used to estimate free riders and positive project spillover. Accordingly, end-use metering is more often seen as a data collection method (rather than a data analysis method) that can provide useful information for integrative methods (see Section 4.2.7).

Box 7

End-use Metering Example

The Central Maine Power Company contracted with a consulting firm to conduct an impact evaluation of it residential new construction program. The program was designed to improve the energy efficiency of new homes being built in the area.

Evaluation methods: Space heating electricity use was metered. As part of the evaluation, the consultants constructed a conditional demand model using billing data for space heating only as the dependent variable. The regression model only controlled for variables that influenced space heating: e.g., use of wood heating, square footage, thermostat setback usage, presence of heated basement, R-value of ceiling and wall insulation, etc.

Findings: The amount of variability (adjusted R-squared) explained by this model was 0.72, a large R-squared given the small sample size (22 observations).

Source: Central Maine Power Company. 1990. *Evaluation of the Energy Savings Resulting from Central Maine Power Company's Good Cents Home Program*. Augusta, ME: Central Maine Power Company.

Table 6. References to End-use Metering

Examples	References
Residential new construction	Central Maine Power (1990)
Commercial chillers	Carlson et al. (1997a)
Commercial chillers and motors	Quackenbush et al. (1997)
Commercial lighting	Amalfi et al. (1996)
Thermal energy storage	Michelman et al. (1995)
Commercial heating, ventilation & air-conditioning	Dohrmann et al. (1995)
	General Reference
	Violette et al. (1991)

4.2.6. Short-term monitoring

Short-term monitoring refers to data collection conducted to measure specific physical or energy consumption characteristics either instantaneously or over a short time period. This type of monitoring is conducted to support evaluation activities such as engineering studies, building simulation and statistical analyses (Violette et al. 1991). Examples of the type of monitoring that can take place are spot watt measurements of efficiency measures, run-time measurements of lights or motors, temperature measurements, or demand monitoring (e.g., see Box 8). Short-term monitoring is gaining increasing attention as evaluators realize that for certain energy-efficiency measures with relatively stable and predictable operating characteristics (e.g., commercial lighting and some motor applications), short-term measurements will produce gains in accuracy nearly equivalent to that of long-term metering at a fraction of the cost.

Box 8

Short-term Monitoring Example

In this example, short-term monitoring of lighting systems was undertaken in the context of an EPRI Tailored Collaboration aimed at developing short-term monitoring techniques for evaluating commercial building lighting and HVAC systems. High-quality, long-term lighting and end-use metered data were obtained for six commercial buildings.

Evaluation methods: Long-term end-use metered data were assembled for each building in the study. A data logger collected true electric power measurements. The data records were averaged over a 15-minute period. A continuous annual time-series data file was assembled for each building. The time-series data records were processed into average daily values for each day of the year. Annual consumption was calculated from the sum of the daily values. Once the actual annual lighting energy consumption was tabulated, the data were segmented into continuous two, three and four week periods. Thus, a series of short-term lighting tests were simulated from the annual time series data. The average daily consumption for weekdays and weekends was calculated for each of the simulated short-term periods, and the annual energy consumption was extrapolated from the daily values for each period. The extrapolated annual consumption was compared to the actual measured annual consumption, thus providing a comparison between the value calculated from a simulated short-term test to the actual value. This exercise was repeated over all possible two, three, and four-week periods throughout the year.

Findings: The extrapolation errors associated with short-term monitoring were found to be reasonable. With the exception of one building, the error is generally in the range of 2-8% and the maximum error is in the range of 5-20%. These errors are generally lower than the sampling errors associated with making measurements on a subset of the total lighting fixtures or circuits in a building.

Source: Amalfi, J., P. Jacobs, and R. Wright. 1996. “Short-Term Monitoring of Commercial Lighting Systems - Extrapolation from the Measurement Period to Annual Consumption, ” in the *Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings*. Vol. 6, pp. 1-7. Washington, D.C.: American Society for an Energy-Efficient Economy.

Short-term monitoring is a useful tool for estimating energy savings when the efficiency of the equipment is enhanced, but the operating hours remains fixed (e.g., constant-load and constant-use equipment, such as hallway lighting and exit signs). Spot metering of the connected load before and after the activity quantifies this change in efficiency with a high degree of accuracy. For activities where the hours of operation are variable, the actual operating (run-time) hours of the activity should be measured before and after the installation using a run-time meter. Thus, the advantage of the spot meter is that it is simple and easy to apply. This method is more accurate than using engineering calculations, since the parameters are measured instead of being assumed. The primary disadvantage is its limited applicability (i.e., where operating hours are the same before and after treatment). Similar to end-use metering, short-term monitoring is more often seen as a data collection method (rather than a data analysis method) that can provide useful information for integrative methods (see Section 4.2.7).

Table 7. References to Short-term Monitoring

Examples	References
Residential weatherization	Bohac et al. (1996)
Commercial lighting	Jacobs et al. (1994)
Industrial process, refrigeration, and miscellaneous measures	Clarke et al. (1996)
Paper manufacturing	Englander et al. (1996)
	General Reference
	Violette et al. (1991)

4.2.7. Integrative methods (for groups of buildings)

Integrative methods combine one or more of the above methods to create an even stronger analytical tool. These approaches are rapidly becoming the state of the practice in the evaluation field (Raab and Violette 1994). The most common integrative approach is to combine engineering and statistical models where the outputs of engineering models are used as inputs to statistical models (Box 9). These methods are often called Statistically Adjusted Engineering (SAE) methods or Engineering Calibration Approaches (ECA). Although they can provide more accurate results, integrative methods typically increase the complexity and expense. To reduce these costs while maintaining a high level of accuracy, a related set of procedures has been developed to leverage high cost data with less expensive data. These leveraging approaches typically utilize a statistical estimation approach termed ratio estimation that allows data sets on different sample sizes to be leveraged to produce estimates of impacts (see Violette and Hanser 1991). Done properly, ratio estimation will decrease costs because the data needs are less.

Box 9

Integrative Methods Example
(for groups of buildings)

The Pacific Gas and Electric (PG&E) Company contracted with a consulting firm to conduct an integrated and comprehensive evaluation of its Commercial Lighting Program. Two types of data sources were used for the evaluation: Existing data and newly gathered evaluation data. The existing data included PG&E's historical billing data, program participation data, other program-related data, and industry standards information. The new data came from evaluation surveys and metered data. The impact analysis was based on a nested sample design, with a core of lighting-loggered sites supplying calibration for the on-site sample, and the on-site audit sample being leveraged with a larger, less expensive, telephone survey. The lighting logger data supplied the most accurate source of data for calibration of engineering estimates. A relatively small on-site auditing sample supported the telephone sample for the largest participation segments. This sample contributed equipment details that were site-specific, and better estimates of operating hours, operating factors, equipment efficiency, lamp burnout rates, etc. The telephone survey supplied information on participant decision-making, energy-related changes at each site for the billing period covered by the billing analysis, etc

Evaluation methods: Demand estimates were based upon engineering models calibrated to on-site data, metered data, and industry standards. The energy impact estimates are derived from a combination of engineering estimates and statistically adjusted engineering (SAE) estimates. In the SAE analysis, engineering estimates are compared to billing data using regression analysis, in order to adjust for behavioral factors of occupants and other unaccounted for effects.

Findings: Gross savings were approximately 300,000 MWh and 63,200 kW. The net savings were approximately 270,000 MWh and 57.000 kW (includes free ridership and participant spillover).

Source: Caulfield, T., and E. Galawish. 1996. "Enlightened Lighting Evaluation: Tightening Up the Process," in the *Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings*. Vol. 6, pp. 19-26. Washington, D.C.: American Society for an Energy-Efficient Economy.

Table 8. References to Integrative Methods
(for groups of buildings)

Examples	References
Residential new construction	Mahone et al. (1996)
Residential heating, ventilation & air-conditioning	Samiullah et al. (1996)
Commercial heating, ventilation & air-conditioning	Baker et al. (1996)
Commercial lighting	Caulfield and Galawish (1996)
Commercial new construction	Sebold and Wang (1996)
Commercial and industrial`	Caulfield and Boertman (1995)
Industrial process, refrigeration, and miscellaneous measures	Clarke et al. (1996)
	General Reference
	Violette et al. (1991)

4.2.8. Application of estimation methods

Several methods are available for collecting data on energy-efficiency projects: e.g., engineering calculations, surveys, modeling, end-use metering, on-site audits and inspections, and collection of utility bill data. Similarly, several methods are available for evaluating these kinds of projects: e.g., engineering methods, basic statistical models, multivariate statistical models (including multiple regression models and conditional demand models), and integrative methods. If the focus of the monitoring and evaluation is an individual building, then some methods will not be utilized (e.g., basic statistical models, multivariate statistical models, and some integrative methods), since they are more appropriate for a group of buildings.

There is no one approach that is "best" in all circumstances (either for all project types, evaluation issues, or all stages of a particular project). The costs of alternative approaches will vary and the selection of evaluation methods should take into account project characteristics and the kind of load and schedule for the load before the retrofit. As mentioned previously, the load can be constant, variable, or variable but predictable, and the schedule can either be known (timed on/off schedule) or unknown/variable. The monitoring approach can be selected according to the type of load and schedule.

In addition to project characteristics, the appropriate approach depends on the type of information sought, the value of information, the cost of the approach, and the stage and circumstances of project implementation. The applications of these methods are not mutually exclusive; each approach has different advantages and disadvantages (Table 9), and there are few instances where an evaluation method is not amenable to most energy-efficiency measures. Using more than one method can be informative. Employing multiple approaches, perhaps even conducting different analyses in parallel, and integrating the results, will lead to a robust evaluation. Such an approach builds upon the strengths and overcomes the weaknesses of individual approaches. Also, each approach may be best used at different stages of the project life cycle and for different measures or projects. An evaluation plan should specify the use of various analytical methods throughout the life of the project and account for the financial constraints, staffing needs, and availability of data sources.

Finally, in developing countries, some of these methods may be difficult to implement. For example, in Eastern European countries, metering of energy use at the building level is the most common type of energy metering available and not all buildings are metered (Vine and Kazakevicius 1998). And where people live in apartments, metering of individual apartments is almost nonexistent. Utility bill analysis, therefore, would be impractical; field-calibrated engineering analysis would have to be conducted.

Table 9. Advantages and Disadvantages of Data Collection and Analysis Methods

Methods	Application	Advantages	Disadvantages
Engineering Methods	Individual buildings and groups of buildings	Relatively quick and inexpensive for simple engineering methods. Most useful as a complement to other methods. Methods are improving. Useful for baseline development.	Relatively expensive for more sophisticated engineering models. Need to be calibrated with onsite data. By themselves, not good for evaluation of spillover.
Basic Statistical Models	Primarily for groups of buildings	Relatively inexpensive and easy to explain.	Assumptions need to be confirmed with survey data and other measured data. Limited applicability. Cannot evaluate peak impacts. Large sample sizes needed.
Multivariate Statistical Models	Primarily for groups of buildings	Can isolate project impacts better than basic statistical models.	Same disadvantages as for basic statistical models. Relatively more complex, expensive, and harder to explain than basic statistical models.
End-use Metering	Individual buildings and groups of buildings	Most accurate method for measuring energy use. Most useful for data collection, not analysis.	Can be very costly. Small samples only. Requires specialized equipment and expertise. Possible sample biases. Difficult to generalize to other projects. Does not, by itself, calculate energy savings. Difficult to obtain pre-installation consumption.
Short-term Monitoring	Individual buildings and groups of buildings	Useful for measures with relatively stable and predictable operating characteristics. Relatively accurate method. Most useful for data collection, not analysis.	Limited applicability. Using this method alone, energy savings cannot be calculated.
Integrative Methods	Primarily for groups of buildings	Relatively accurate.	Relatively more complex, expensive, and harder to explain than some of the other models.

4.2.9. Application of IPMVP approach

In an earlier report, we reviewed several protocols and guidelines that were developed for the MERVC of GHG emissions in the energy sectors by governments, nongovernmental organizations, and international agencies (Vine and Sathaye 1997). Although not targeted to carbon emissions, we believe that the U.S. Department of Energy's (DOE) International Performance Measurement and Verification Protocol (IPMVP) is the preferred approach for monitoring and evaluating energy-efficiency projects for individual buildings and for groups of buildings, since the IPMVP covers many of the issues discussed in these guidelines as well as offering several measurement and verification methods for user flexibility (Kats et al. 1996 and 1997; Kromer and Schiller 1996; USDOE 1997).[1] North America's energy service companies have adopted the IPMVP as the industry standard approach to measurement and verification. States ranging from Texas to New York now require the use of the IPMVP for state-level energy efficiency retrofits. The U.S. Federal Government, through the Department of Energy's Federal Energy Management Program (FEMP), uses the IPMVP approach for energy retrofits in Federal buildings. Finally, countries ranging from Brazil to the Ukraine have adopted the IPMVP, and the Protocol is being translated into Bulgarian, Chinese, Czech, Hungarian, Polish, Portuguese, Russian, Spanish, Ukrainian and other languages. When completed, ASHRAE's GPC 14P guidelines will be used to modify the IPMVP (see Section 1.6).

A key element of the IPMVP is the definition of two measurement and verification (M&V) components: (1) verifying proper installation and the measure's potential to generate savings; and (2) measuring (or estimating) actual savings. The first component involves the following: (a) the baseline conditions were accurately defined and (b) the proper equipment/systems were installed, were performing to specification, and had the potential to generate the predicted savings. The general approach to verifying baseline and post-installation conditions involves inspections, spot measurement tests, or commissioning activities.[2]

The IPMVP was built around a common structure of four M&V options (Options A, B, C, and D) (Table 10). These four options were based on the two components to M&V defined above. The purpose of providing several M&V options is to allow the user flexibility in the cost and method of assessing savings. A particular option is chosen based on the expectations for risk and risk sharing

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[1] The IPMVP is primarily targeted to the monitoring and evaluation of an individual building, in contrast to other protocols (e.g., CPUC 1998) that are aimed at the monitoring and evaluation of programs (involving multiple sites). The protocol can be downloaded via the World Wide Web: http://www.ipmvp.org.

[2] Commissioning is the process of documenting and verifying the performance of energy systems so that the systems operate in conformity with the design intent.

between the buyer and seller and onsite and energy-efficiency project specific features. The options differ in their approach to the level and duration of the verification measurements. None of the options are necessarily more expensive or more accurate than the others. Each has advantages and disadvantages based on site specific factors and the needs and expectations of the customer. Project evaluators should use one of these options for reporting on measured energy savings.

DOE is currently revising the IPMVP and is examining how each of the options can be related to the constancy or variations in load and schedule for the load, and the confidence levels of the energy savings associated with each of these options (personal communication from Steve Kromer, Nov. 20, 1998). For example, simple engineering algorithms could be used for projects with constant loads, multivariate statistical models could be used for predictable loads, and more sophisticated engineering models could be used for random (hard to predict) loads. The level of uncertainty in savings will increase as the loads become harder to predict.

Table 10. Overview of IPMVP's M&V Options

M&V Options[1]	How Savings Are Calculated [reference to LBNL's MERVC methods]	Initial Cost[2, 3]	Annual Operating Cost[4]
Option A: ▪ Focuses on physical inspection of equipment to determine whether installation and operation are to specification. Performance factors are either stipulated (based on standards or nameplate data) or measured. ▪ Key performance factors (e.g., lighting wattage or "motor" efficiency) are measured on a snapshot or short-term basis. ▪ Operational factors (e.g., Lighting operating hours or motor runtime) are stipulated based on analysis of historical data or spot/short-term measurements.	Engineering calculations or computer simulations based on metered data and stipulated operational data. [Engineering methods (4.2.2)] [Short-term monitoring (4.2.6)]	0.5 to 3%	0.1 to 0.5%
Option B: ▪ Intended for individual energy conservation measures (ECMs) (retrofit isolation) with a variable load profile. ▪ Both performance and operational factors are measured on a short-term continuous basis taken throughout the term of the contract at the equipment or system level.	Engineering calculations after performing a statistical analysis of metered data. [Engineering methods (4.2.2)] [End-use metering (4.2.5)]	2 to 8%	0.5 to 3%
Option C: ▪ Intended for whole-building M&V where energy systems are interactive (e.g. efficient lighting system reduces cooling loads) rendering measurement of individual ECMs inaccurate. ▪ Performance factors are determined at the whole-building or facility level with continuous measurements. ▪ Operational factors are derived from hourly measurements and/or historical utility meter (electricity or gas) or sub-metered data.	Engineering calculations based on a statistical analysis of whole-building data using techniques from simple comparison to multivariate (hourly or monthly) regression analysis. [Basic statistical models (4.2.3)] [Multivariate statistical models (4.2.4)]	0.5 to 3% (utility bill analysis) 2 to 8% (hourly data)	0.5 to 3%
Option D: ▪ Typically employed for verification of saving in new construction and in comprehensive retrofits involving multiple measures at a single facility where pre-retrofit data may not exist. ▪ In new construction, performance and operational factors are modeled based on design specification of new, existing and/or code complying components and/or systems. ▪ Measurements should be used to confirm simulation inputs and calibrate the models.	Calibrated energy simulation/ modeling of facility components and/or the whole facility; calibrated with utility bills and/or end-use metering data collected after project completion. [Engineering methods (4.2.2)] [Integrative methods (4.2.7)]	2 to 8%	0.5 to 3%

Source: Adapted from USDOE (1997) and based on personal communication from Greg Katz, USDOE, Dec. 18, 1998.

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[1] It is assumed that the cost of minimum M&V, in projects not following IPMVP, involves an initial cost of 0.5%, and an annual operating cost of 0.1% to 0.2%, of the project cost. The costs in this table are uncertain and should be used for general guidance; developers need to estimate costs based on real projects.

[2] The initial M&V cost includes installation and commissioning of meters.

[3] In new construction, this is the % of the difference in cost between baseline equipment and upgraded/more efficient equipment

[4] Annual operating cost includes reporting, data logger and meter maintenance cost over the period of the contract

4.2.10. Quality assurance guidelines

Implementing data collection and analysis methods is both an art and a science, and there is known problems associated with these methods. Thus, simply adhering to minimal standards contained in guidelines is no guarantee that an evaluator is doing a professional job. Accordingly, we have included Quality Assurance Guidelines (QAG) that require evaluators and verifiers to indicate specifically how basic methodological issues and potentially difficult issues were addressed (see Appendices B and C).[1] The guidelines cover key methodological issues associated with each data collection and analysis method.

The QAG should be seen as practice and reporting standards, rather than highly prescriptive methodological standards: the QAG require evaluators to describe how certain key issues were addressed rather than to require them to address these issues in a specific way. Adherence to such guidelines still allows the methods to be shaped by the interaction of the situation, the data, and the evaluator.

The QAG are to be used in three ways. First, they are included in the Monitoring and Evaluation Reporting Form (Appendix B), so that evaluators will know that they will be held accountable for conducting a sound analysis. Second, they are included in the Verification Reporting Form (Appendix B), so that policymakers and other stakeholders could review a verification report and quickly assess whether the evaluator addressed the most basic methodological issues. This is especially important since most stakeholders do not have the time nor the personnel to carefully scrutinize every written evaluation report, let alone attempt to replicate the results of all of these studies. The details of how evaluators addressed these methodological issues should be contained in the very detailed documentation that would be in the technical appendix of any evaluation report, or in working papers. Finally, the QAG can be used to create a common language to facilitate communication among project developers, evaluators, verifiers, policymakers, and other stakeholders.

Evaluators and verifiers should consider the issues involved in conducting these methods, some of which have been described previously, and which are listed in Table 11 and described in more detail in Appendices B and C. The column headings refer to the data collection and analysis methods described in Section 4.2. The rows refer to the types of issues to be considered when addressing each method. Examples of each of these issues are mentioned below:

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[1] These guidelines are primarily based on the QAG that were developed for the California Demand-Side Management Advisory Committee (CADMAC) (Ridge et al. 1997). In theory, the QAG could be used in the estimation stage, but are not included in the Estimation Reporting Form.

For individual buildings and groups of buildings:

- **Calibration**: e.g., were the input assumptions and calculated results of engineering models compared and adjusted to actual data?

- **Data type and sources**: e.g., what was the source of the data and the methods used in collecting data?

- **Outliers**: e.g., how were outliers and influential observations identified and handled?

- **Missing data**: e.g., how were missing data handled?

- **Triangulation**: e.g., if more than one estimate of savings was calculated, how were the results combined to form one estimate?

- **Weather**: e.g., what was the source of weather data used for the analysis?

- **Engineering priors**: e.g., what was the source of prior engineering estimates of savings?

- **Interactions**: e.g., how was the interaction between heating and lighting addressed?

- **Measurement duration**: e.g., what was the duration and interval of metering?

For groups of buildings:

- **Sample and sampling**: e.g., what kind of sampling design was used?

- **Collinearity**: e.g., if two or more variables were highly correlated, how were they treated?

- **Specification and error**: e.g., what kind of errors were encountered in measuring variables and how were these errors minimized?

- **Comparison group**: e.g., how was a comparison group defined for estimating net savings?

Table 11. Quality Assurance Issues for Data Collection and Analysis Methods[1]

(✔ = applicable; blank = not applicable)

	Engineering Methods	Basic Statistical Models (2)	Multivariate Statistical Models (3)	End-use Metering	Short-term Monitoring	Integrative Methods (4)
Calibration	✔					✔
Data type and sources	✔	✔	✔	✔	✔	✔
Outliers		✔	✔			✔
Missing data		✔	✔	✔	✔	✔
Triangulation			✔			✔
Weather		✔	✔			✔
Engineering priors			✔			✔
Interactions	✔	✔	✔			✔
Measurement duration				✔	✔	✔
Sample and sampling		✔	✔	✔	✔	✔
Specification and error			✔			✔
Collinearity			✔			✔
Comparison group		✔	✔			✔

[1] Quality assurance issues (rows) are described in Appendices B and C, and the data collection and analysis methods are described in Section 4.2

[2] Primarily for analysis of groups of buildings; includes statistical comparison methods

[3] Primarily for analysis of groups of buildings; includes conditional demand analysis models

[4] Primarily for analysis of groups of buildings; includes engineering calibration approaches

4.11. Positive Project Spillover

The methods for estimating positive project spillover are similar to those used for free ridership (Section 4.13.1) (Goldberg and Schlegel 1997; Weisbrod et al. 1994). Explicit estimates can be obtained by asking participants and nonparticipants survey questions, and discrete choice models can be used (e.g., the effect on implementation of program awareness, rather than program participation, is estimated). Participant and nonparticipant spillover effects can be included in savings estimates in billing analyses, similar to how gross savings are calculated (see Box 10).

Box 10

Project Spillover Example

A group of utilities in the New England area (New England Electric System, Inc., Boston Edison, Northeast Utilities, Eastern Utilities Associates and Commonwealth Electric System) contracted with a consulting firm to assess the effect of DSM programs on the residential market for compact fluorescent lamps technology and quantify the spillover effects of their residential DSM programs.

Evaluation methods: The study included telephone surveys of participants, nonparticipants and interviews with representatives of major manufacturers of compact fluorescents and retailers, as well as a review of statistical and secondary sources on shipments, sales, and residential saturation of compact fluorescent lamps (CFLs). Three methods were used to estimate spillover: (1) comparison of saturation of CFLs between households in the sponsors' territories and those in nonprogram areas (in the Midwest and South), (2) spillover estimates based on analysis of customer self-reports within the program areas, and (3) discrete choice modeling (which yields estimates of net program savings including spillover and of spillover savings alone).

Evaluation findings: The three methods yielded similar (all within 7% points) net-to-gross ratios. The discrete choice modeling was chosen as the superior methodology, compared to the other two methodologies. The model estimated spillover savings at 27% of gross program savings. The researchers also identified: (1) changes in the behavior of manufacturers which accelerated the market penetration of CFLs; (2) indicators that these changes were likely to persist in the face of the current decline in utility DSM activity; and (3) evidence that the above changes were attributable to utility DSM efforts and, in some cases, to the efforts of the sponsors in particular.

Source: Xenergy, Inc. 1995. *Final Report: Residential Lighting Spillover Study*. Burlington, MA: Xenergy, Inc.

4.12. Market Transformation

Most evaluations of market transformation projects focus on market effects (e.g., Eto et al. 1996; Schlegel et al. 1997): the effects of energy-efficiency projects on the structure of the market or the behavior of market actors that lead to increases in the adoption of energy-efficient products, services, or practices. In order to claim that a market has been transformed, project evaluators need to demonstrate the following (Schlegel et al. 1997):

- There has been a change in the market that resulted in increases in the adoption and penetration of energy-efficient technologies or practices.
- That this change was due at least partially to a project (or program or initiative), based both on data and a logical explanation of the program's strategic intervention and influence.
- That this change is lasting, or at least that it will last after the project is scaled back or discontinued.

The first two conditions are needed to demonstrate market effects, while all three are needed to demonstrate market transformation. The third condition is related to the discussion on persistence

(Section 4.1.2): if the changes are not lasting (i.e., they do not persist), then market transformation has not occurred. Because fundamental changes in the structure and functioning of markets may occur only slowly, evaluators should focus their efforts on the first two conditions, rather than waiting to prove that the effects will last.

To implement an evaluation system focused on market effects, one needs to carefully describe the scope of the market, the indicators of success, the intended indices of market effects and reductions in market barriers, and the methods used to evaluate market effects and reductions in market barriers (Schlegel et al. 1997) (see Box 11).

Box 11

Market Transformation Example

The Pacific Gas and Electric (PG&E) Company contracted with a consulting firm to determine the extent to which the current state of the supermarket industry in PG&E's territory reflected the effects of past market interventions by PG&E.

Evaluation methods: Preliminary data collection and analysis activities included a review of PG&E data sources and existing literature; interviews with PG&E program staff; two focus groups within PG&E's service territory and one in the comparison territory served by Commonwealth Edison; a series of open-ended interviews with vendors at the Food Marketing Institute show in Chicago; and an interview with a supermarket specialist. Other primary data collection activities included interviews with PG&E staff, supermarket decision-makers, architects, designers and technical specification managers, and vendors/manufacturers. These primary data collection activities helped to determine how market actions and attitudes were or were not influenced by PG&E's programs. Interviews were designed to elicit both qualitative and quantitative data, and included both open-ended and structured responses.

Evaluation findings: The overall trend in supermarket energy intensity had been downward until 1995, but energy use has been increasing since then. Refrigeration equipment accounts for the largest share (50%) of energy use in this sector. Three manufacturers dominate the refrigeration system industry, while the market for design services is concentrated in a few specialized architects and designers who serve the national market. Local refrigeration contractors supplement in-house supermarket maintenance organizations, playing a critical role in the installation and operation of energy-using equipment. The most fundamental barrier to energy efficiency in the supermarket industry, both now and in the past, is the overwhelming emphasis placed on increasing sales—to the exclusion of energy efficiency and most other operational concerns. In the past several years, barriers to energy efficiency in supermarkets have grown as the result of a number of external forces: marketing, business considerations, regulatory issues, and technology-related concerns. On balance, the PG&E programs appear to have heightened awareness of and interest in energy efficiency; however, supermarkets have become conditioned to expect rebates as a precondition for undertaking energy-efficiency actions. One of the strategies that may help address many of the fundamental barriers to energy efficiency in this industry is to emphasize non-energy benefits in promoting these measures or technologies.

Source: Quantum Consulting, Inc. 1998. *Study of Market Effects on the Supermarket Industry*. Berkeley, CA: Quantum Consulting, Inc.

Evaluation activities will include one or more of the following: (1) measuring the market baseline; (2) tracking attitudes and values; (3) tracking sales; (4) modeling of market processes; and (5) assessing the persistence of market changes (Prahl and Schlegel 1993). As one can see, these evaluation activities will rely on a large and diverse group of data collection and analysis methods, such as: (1) surveys of customers, manufacturers, contractors, vendors, retailers, government organizations, energy providers, etc.; (2) analytical and econometric studies of measure cost data, stocking patterns, sales data, and billing data; and (3) process evaluations.

4.3. Re-estimating the Baseline

During project implementation, the baseline needs to be re-estimated, based on monitoring and evaluation data collected during this period. The re-estimated baseline should describe the existing technology or practices at the facility or site. Ideally, energy use should be measured for at least a full year before the date of the initiation of the retrofit project and for each year after the initiation of the project during the lifetime of the project. However, some types of projects may not require a full year of monitoring prior to the retrofit: e.g., if the loads and operating conditions are constant over time, one-time spot measurement may be sufficient to estimate equipment performance and efficiency.

The monitoring and evaluation of new buildings differs fundamentally from retrofit projects in that existing performance baselines are hypothetical rather than materially existent and are, therefore, generally not physically measurable or verifiable. The implications of this increase with the complexity of measures and strategies to be monitored and verified. The basic steps in the new building monitoring and evaluation do not vary significantly in concept from retrofit monitoring and evaluation.[1]

For new facilities, evaluators often consider the current state or national building code as the baseline.[2] For those states or countries without a building code, standard building practices, usually obtained from builder surveys, are sometimes used as the baseline. However, evaluators should recognize the problems associated with these options (Vine 1996b). The problem with relying on building standards is that builders both exceed and fall below codes. The problem with focusing on builder practices is that the surveys used to characterize building practices may be inaccurate because they are not conducted on a regular basis and rapidly become outdated. Some analysts also

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[1] The IPMVP has a separate section (Section 6.0) on measurement and verification for new buildings (USDOE 1997).

[2] A few developing countries have building codes (see Janda and Busch 1994).

use the American Society of Heating, Refrigeration and Air-Conditioning Engineers' guidelines, ASHRAE 90.1, as a baseline: ASHRAE 90.1 guides designers in conducting hourly simulations using the specifications in the ASHRAE document. Results obtained from running a simulation on actual buildings is used to determine the level of savings. Simulation results need to be calibrated with actual data to calculate energy savings.

4.3.1. Free riders

Free ridership can be evaluated either explicitly or implicitly (see Box 12) (Goldberg and Schlegel 1997; Saxonis 1991). The most common method of developing explicit estimates of free ridership is to ask participants what they would have done in the absence of the project (also referred to as "but for the project" discussions). Based on answers to carefully designed survey questions, participants are classified as free riders (yes or no) or assigned a free ridership score. Project free ridership is then estimated as the proportion of participants who are classed as free riders. Two problems arise in using this approach: (1) very inaccurate levels of free ridership may be estimated, due to questionnaire wording;[1] and (2) there is no estimate of the level of inaccuracy, for adjusting confidence levels.

Another method of developing explicit estimates of free ridership is to use discrete choice models to estimate the effect of the program on customers' tendency to implement measures. The discrete choice is the customer's yes/no decision whether to implement a measure. The discrete choice model is estimated to determine the effect of various characteristics, including project participation, on the tendency to implement the measures.

A method for calculating implicit estimates of free ridership is to develop an estimate of savings using billing analysis (as described above) that may capture this effect, but does not isolate it from other impacts. Rather than taking simple differences between participants and a comparison group, however, regression models are used to control for factors that contribute to differences between the two groups (assuming that customers who choose to participate in projects are different from those who do not participate). The savings determined from the regression represent the savings

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[1] For example, in an analysis of free ridership in a high-efficiency refrigerator program, estimates of free ridership varied from 37% to 89%, depending on questionnaire wording (Boutwell et al. 1992).

associated with participation, over and above the change that would be expected for these customers due to other factors, including free ridership.[1]

Box 12

Free Riders Example

The New England Power Service Company contracted with a consulting firm to estimate free ridership in their commercial/industrial new construction program.

Evaluation method: The study used an extensive survey to probe into what actions participants were likely to have installed in the absence of the program. The survey was administered on-site in 31 facilities to architects, engineers, and designers who had specified 51 different measure installations. An additional 94 such professionals were surveyed by telephone, bringing the total to 125 respondents responsible for 223 measure installations. There was no sampling: attempts were made to reach everyone in the population. Fifty-one nonparticipants were also surveyed. The study used nine general categories: lighting, lighting controls, HVAC equipment, HVAC controls, motors, variable speed drives, refrigeration, building shell, and custom measures. Many survey questions were developed, and the responses to the questions were weighted by the estimated savings accounted for by each project. The purpose of the weighting was to give the larger projects more significance in the calculation of overall free-ridership rates for each measure category.

Evaluation concerns: It was not possible to locate the appropriate respondents for a significant number of installations: e.g., the individual who had worked on a particular project had left the firm or was otherwise not available.

Evaluation findings: Free ridership estimates were: 28-45% for lighting, 62% for lighting controls, 3-9% for HVAC equipment, 16-22% for HVAC controls, 19-80% for motors, 10% for variable speed drives, 0-2% for refrigeration, 90-100% for building shell, and 2-24% for custom measures. Some measure categories (refrigeration, variable speed drives, customer measures, and building shell) had very few respondents and, therefore, provided less confidence in the free-ridership estimates than for other measures. The midpoints of the ranges were used to modify program savings for assessing cost-effectiveness. Significant changes to the program were made as a result of these findings, including the disqualification of building shell measures for financial incentives.

Source: Tokin, B. and G. Reed. 1993. “Free-Ridership Estimation in the New Construction DSM Market,” in the *Proceedings of the 1993 Energy Program Evaluation Conference*, pp. 787-791. Chicago, IL: National Energy Program Evaluation Conference.

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[1] This approach assumes: (1) nonparticipants would naturally buy the energy-efficiency measure as much as participants would, (2) savings from the measures have a significant impact on the bills of nonparticipants, and (3) a sizeable proportion of nonparticipants buy/install the measure. These assumptions are not always valid (personal communication from Adrienne Kandel, California Energy Commission, Jan. 4, 1999).

The U.S. Environmental Protection Agency's Conservation Verification Protocols (Section 1.6.3) reward more rigorous methods of verifying free riders by allowing a higher share of the savings to qualify for tradable SO_2 allowances. Three options are available for verifying free riders: (1) default "net-to-gross" factors for converting calculated "gross energy savings" to "net energy savings;"[1] (2) project-estimated net-to-gross factors, based on measurement and evaluation activities (e.g., market research, surveys, and inspections of nonparticipants) (see Box 13); or (3) if a developer does not do any monitoring nor provide documentation and the default net-to-gross factors are not used, then the net energy savings of a measure will be 50% of the first-year savings, based on one of the methods described in Section 4.2 (Meier and Solomon 1995; U.S. USEPA 1995 and 1996).

4.3.2. Comparison groups

For many projects, comparison groups can be used for evaluating the impacts of energy efficiency projects. Acting as a baseline, comparison groups can capture time trends in consumption that are unrelated to project participation. For example, if the comparison groups' utility bills show an average reduction in energy use of 5% between the pre- and post-periods, and the participants' bills show a reduction of 15%, then it may be reasonable to assume that the estimated project impacts will be 15% minus the 5% general trend for an estimated 10% reduction in use being attributed to the project.

4.4. Calculating Net GHG Emissions

Once the net energy savings have been calculated (i.e., measured energy use minus re-estimated baseline energy use), net GHG emissions reductions can be calculated in one of two ways: (1) if emissions reductions are based on fuel-use or electricity-use data, then default emissions factors can be used, based on utility or nonutility estimates (e.g., see Appendix B in USDOE 1994b)[2]; or (2) emissions factors can be based on generation data specific to the situation of the project (e.g., linking a particular project on an hourly or daily basis to the marginal unit it is affecting). In both methods,

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[1] The "net-to-gross" factor is defined as net savings divided by gross savings. The gross savings are the savings directly attributed to the project and include the savings from all measures and from all participants; net savings are gross savings that are "adjusted" for free riders and positive project spillover. Multiplying the gross savings by the net-to-gross factor yields net savings.

[2] The emission factors represent the basic conversion between energy consumption and generation of greenhouse gases. These factors are usually expressed in mass of emitted gas per unit of energy input (g/GJ) or sometimes in mass of gas per mass of fuel (g/kg or g/t).

emissions factors translate consumption of energy into GHG emission levels (e.g., tons of a particular GHG per kWh saved). In contrast to default emission factors (method #1), the advantage of using the calculated factors (method #2) is that they can be specifically tailored to match the energy efficiency characteristics of the activities being implemented by time of day or season of the year. For example, if an energy-efficiency project affects energy demand at night, then baseload plants and emissions will probably be affected. Since different fuels are typically used for baseload and peak capacity plants, then emission reductions will also differ.

Box 13

Net-to-Gross Energy Savings Example

The Pacific Gas and Electric (PG&E) Company contracted with a consulting firm to conduct an impact evaluation of its 1994 Industrial Program, specifically industrial process measures (e.g., modifications to food processing systems, oil pumping systems, process boilers, compressors, pumps, dryers, and pollution control equipment). The evaluation was PG&E's largest evaluation to date to employ a "project-specific" engineering approach.

<u>Evaluation methods</u>: To determine gross impacts, projects were categorized into evaluation strata based on measure type, measure impact, and project-specific evaluation cost. Large impact projects typically received extensive project-specific engineering approach to determine gross impacts, and smaller impact projects received simple verifications of installation. In general, the evaluation approach consisted of the following steps: (1) verify installation; (2) review and improve on PG&E's impact methodologies; (3) collect post-retrofit data (e.g., actual operating conditions and equipment usage patterns); and (4) measure/monitor key operating parameters.

The net-to-gross analysis was project specific as well, with each project in the evaluation sample receiving a project-specific net-to-gross analysis based on a series of customer interviews (onsite and telephone). For this evaluation, spillover effects were assumed to be small relative to the primary program impacts, and the net-to-gross analysis focused on measuring the impacts of free ridership (four net-to-gross classifications were created).

<u>Evaluation concerns</u>: Self-reported data are prone to subjectivity and ambiguity: in practice, the distinction between a free rider and a program-induced participant can frequently be obscure. In many cases, there are elements of both program-induced participation and free ridership in a customer's decision to implement a single energy-efficiency project.

<u>Evaluation findings</u>: The net-to-gross analyses showed a high level of free ridership (about 50%). Larger projects had a greater tendency toward free ridership because customers were inclined to identify and implement these projects (for monetary savings and other strategic reasons) independent of motivation from PG&E.

<u>Source</u>: Clarke, L., F. Coito, and F. Powell. 1996. "Impact Evaluation of Pacific Gas & Electric's Industrial Process, Refrigeration, and Miscellaneous Measures Programs," in the *Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings*. Vol. 6, pp. 27-34. Washington, D.C.: American Society for an Energy-Efficient Economy.

The calculations become more complex (but more realistic) if one decides to use the emission rate of the marginal generating plant (multiplied by the energy saved) for each hour of the year, rather than the average emission rate for the entire system (i.e., total emissions divided by total sales) (Swisher 1997). For the more detailed analysis, one must analyze the utility's existing expansion plan to determine the generating resources that would be replaced by saved electricity, and the emissions from these electricity-supply resources. Thus, one would establish a baseline (current power expansion plan, power dispatch, peak load/base load, etc.), select a monitoring domain, conduct monitoring option, measure direct emission reductions (e.g., reductions occurring at the neighboring power plant to lower demand), measure indirect emissions (e.g., modification in the power system due to lower output at the neighboring plant), and calculate net carbon reductions.

One would have to determine if the planned energy-efficiency measures would reduce peak demand sufficiently and with enough reliability to defer or obviate planned capacity expansion. If so, the deferred or replaced source would be the marginal expansion resource to be used as a baseline. This type of analysis may result in more accurate estimates of GHG reductions, but this method will be more costly and require expertise in utility system modeling. In addition, this type of analysis is becoming more difficult in those regions where the utility industry is being restructured: e.g., the supply of energy may come from multiple energy suppliers, either within or outside the utility service area.

The decision on which methodology to use will depend on project size (e.g., kWh, kW, carbon credits requested, project expenditures) or relative project size (e.g., MW/utility service MW). It is up to the evaluator to decide on the best method for the project. Certain thresholds may need to be developed. If a project is of a certain relative magnitude (e.g., a project is 50 MW and the utility's service area is 400 MW), the evaluator should probably select the second method above.

5. Reporting of GHG Reductions

Reporting occurs throughout the MERVC process and refers to *measured* GHG and non-GHG benefits and costs of a project (in some cases, organizations may report on their *estimated* impacts, prior to project implementation, but this is not the focus of these guidelines).[1] Reporting guidelines for each of the Kyoto Protocol's flexibility mechanisms (e.g., joint implementation (Article 6), Clean Development Mechanism (Article 12), and emissions trading (Article 17)) are to be developed by the Conference of Parties.

The Framework Convention on Climate Change's (FCCC) Subsidiary Body for Scientific and Technological Advice (SBSTA) developed a Uniform Reporting Format (URF) for activities implemented jointly under a pilot program; the format was approved by the SBSTA as part of the implementation of the FCCC (SBSTA 1997). In completing the URF, the project proposers need to estimate the projected emissions for their project baseline scenario and project activity scenario. They must estimate cumulative effects for carbon dioxide, methane, nitrous oxide, and other greenhouse gases. This format contains a section on benefits (environmental and socioeconomic) which requires quantitative information; qualitative information is acceptable when quantitative information is not available. Project developers need to describe how their project is compatible with, and supportive of, national economic development and socioeconomic and environmental priorities and strategies. Furthermore, the URF requests information on the "practical experience gained or technical difficulties, effects, impacts or other obstacles encountered" (either quantitatively or qualitatively). The impacts include environmental or socioeconomic impacts. This type of information will continue to be necessary, since sustainable development is one of the principal goals of the Clean Development Mechanism (Section 8)

We have developed a Monitoring and Evaluation Reporting Form (MERF) that we recommend that evaluators use when reporting energy use and carbon emissions (Appendix B). It is expected that the MERF will be distributed to project participants, the host country, the investor country, the FCCC Secretariat, and the CDM Executive Board. Project developers and evaluators may modify this form based on their past experience in using similar forms. The MERF complements, but does not substitute for, the SBSTA's URF. In completing the MERF, in addition to providing basic contact information and a description of the project, evaluators need to present the estimated and measured electricity and fuel use for the project baseline and the project activity cases, net energy savings, and the carbon

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[1] Appendix A contains an Estimation Reporting Form that provides some guidance to project developers at the design stage; however, we expect that additional information will need to be provided for registering a project.

emissions from energy consumption. Evaluators also need to provide information on the precision of the results, the data collection and analysis methods used in calculating energy use and carbon emissions, and the IPMVP options used in measuring energy savings; in particular, how estimates of free ridership, positive project spillover, and market transformation were estimated (where calculated). Evaluators must describe the methods used to calculate emissions and provide information on key uncertainties affecting all energy and emission estimates. At the end of the MERF, evaluators are asked to provide information on environmental and socioeconomic impacts and indicate whether there is consistency between environmental laws, environmental impact statements and expected environmental impacts.

5.1. Multiple reporting

Several types of reporting might occur in energy-efficiency projects: (1) impacts of a particular project could be reported at the project level and at the program level (where a program consists of two or more projects); (2) impacts of a particular project could be reported at the project level and at the entity level (e.g., a utility company reports on the impacts of all of its projects); and (3) impacts of a particular project could be reported by two or more organizations as part of a joint venture (partnership) or two or more countries. The MERF reports project results, although these results could be combined with other project results for reporting at the program or entity level. To mitigate the problem of multiple reporting, project-level reporters should indicate whether other entities might be reporting on the same activity and, if so, who. If there exists a clearinghouse with an inventory of stakeholders and projects, multiple reporting might not constitute a problem. For example, in their comments on an international emissions trading regime, Canada (on behalf of Australia, Iceland, Japan, New Zealand, Norway, Russian Federation, Ukraine and the United States) proposed a national recording system to record ownership and transfers of assigned amount units (i.e., carbon offsets) at the national level (UNFCCC 1998a). A synthesis report could confirm, at an aggregate level, that bookkeeping was correct, reducing the possibility of discrepancies among Parties' reports on emissions trading activity.

6. Verification of GHG Reductions

Verification refers to establishing whether the GHG reductions assessed by the evaluators actually occurred, similar to an accounting audit performed by an objective, certified party. If carbon credits become an internationally traded commodity, then verifying the amount of carbon reduced or fixed by projects will become a critical component of any trading system. Investors and host countries may have an incentive to overstate the GHG emission reductions from a given project, because it will increase their earnings when excessive credits are granted. For example, these parties may overstate baseline emissions or understate the project's emissions. To resolve this problem, there is a need for external (third party) verification.

The verifier is expected to conduct an overall assessment of the quality and completeness of each of the GHG impact estimates. To this end, the verifier will request information in a Verification Reporting Form (VRF) (Appendix C), similar to the Monitoring and Evaluation Reporting Form (Appendix B). It is expected that the VRF will be distributed to project participants, the host country, the investor country, the FCCC Secretariat, and the CDM Executive Board. Verifiers may modify this form based on their past experience in using similar forms. Verifiers will use additional material and data for evaluating the performance of energy-efficiency projects. For example, verifying baseline and post-project conditions may involve inspections, spot measurement tests, or assessments, as well as requesting documentation on key aspects of the project (similar to what is done as part of the IPMVP). In addition, the following general questions regarding quality and validity need to be asked: (1) have the monitoring and evaluation methods been well documented and reproducible? (2) have the results been checked against other methods? (3) have results (e.g., monitored data and emissions) been compared for reasonableness with outside or independently published estimates? (4) have the sources of emission factors been well documented? and (5) have the sources of emission factors been compared with other sources? (IPCC 1995). Verification can occur without certification.

Verifiers could be active from the beginning of the project's operations, but in our mind, verification occurs after the project begins regular operations. After the project's first operational interval (e.g., one year), and periodically thereafter (e.g., annually), the verifier would verify the project's energy savings and carbon emissions in the preceding period. This may include the following tasks (personal communications from Johannes Heister, The World Bank, Jan. 12, 1999 and Bill Stanley, The Nature Conservancy, Jan. 13, 1999):

- Review continued compliance of the project operator with the agreed procedures for project maintenance and monitoring.
- Audit the relevant physical measurements and statistical data collected at the project site and, if so required by the monitoring and evaluation plan, also outside of the project boundaries (especially if positive project spillover and market transformation are expected).
- Check whether energy savings and carbon emissions have been calculated correctly (including a check of the data used in the calculation of the baseline).
- Examine the comparison of the actual, verified energy savings and carbon emissions with the estimated energy savings and carbon emissions.
- Assess whether significant environmental and socioeconomic impacts have been identified, quantified, and addressed.
- Alert the project participants of any developments that could lead to increased risks and that could jeopardize the success of the project.

The verifier would issue a report for each verification period. The report would cover the above tasks in a transparent manner and in such a way that the quantification of energy savings and carbon emissions achieved during the verification period could, in principle, be reproduced by other interested parties. Based on the verification report and other lessons learned, the project participants may want to amend their monitoring and evaluation plan or other procedures.

7. Certification of GHG Reductions

Certification refers to certifying whether the measured GHG reductions actually occurred. This definition reflects the language in the Kyoto Protocol regarding the Clean Development Mechanism and "certified emission reductions." However, as noted in Section 1.1, some argue that "certification" could be done ex-ante, to certify a proposed offset, assuming that it is carried out as planned. Similarly, some propose CDM projects to be "certified" when they are approved by a host country; however, in this situation, "registered" or "validated" appears to be a more accurate descriptor (see UNFCCC 1998b).

At this time, certification is expected to simply be the outcome of a verification process: i.e., no other measurement and evaluation activities are expected to be conducted. Each of the Kyoto Protocol's flexibility mechanisms (e.g., joint implementation (Article 6), Clean Development Mechanism (Article 12), and emissions trading (Article 17)) requires some form of "government approval" either at the point of transfer, or under Article 3, at the point that the part of the assigned amount or emissions reduction unit is added to or deducted from Annex I Parties' assigned amount. However, only Article 12 provides for a process of auditing and certification that would provide for an objective assessment of whether the transfer was likely to result in net emissions reduction. Hence, part of the discussions in implementing the Kyoto Protocol will focus on the establishment of certification procedures for emissions reduction units generated and traded through these mechanisms.

The value-added function of certification is in the transfer of liability/responsibility to the certifier (personal communication from Marc Stuart, EcoSecurities, Ltd., Jan. 21, 1999). The amount of liability will be negotiated for each specific contract. Ultimately, sellers of emissions reduction units (credits) are responsible for the quality of the credits they deliver. The sellers would, therefore, need to provide the appropriate documentation before they could transfer the credits. This is what certification provides. In the case of CDM credits, there is a great responsibility on the part of the certifiers, since non-Annex I countries are unlikely to have UNFCCC-level penalties in place. A private entity that comes under liability due to credit delivery failure would have some recourse against the certifier of the failed emission credit.

Certification companies need to be accredited by some higher body: e.g., an international accreditation board, established under the auspices of the UNFCCC.[1] This board would certify

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[1] An alternative accreditation option is to place all accreditation procedures into the International Standards Organization (ISO) process. The ISO is the standard keeper for a variety of process evaluations and quality standards and, for many industries, certification under the ISO guidelines

companies and make sure these companies are abiding by certain standards (e.g., via spot auditing). For instance, SGS (see Section 1.6.3), Rainforest Alliance, and the Soil Association are certification companies that are accredited by the Forest Stewardship Council to certify that forests meet the standards of the Forest Stewardship Council as set forth in their "Principles and Criteria for Forest Management" (see Section 1.6.7) (personal communication from Pedro Moura-Costa, EcoSecurities, Ltd., Jan. 28, 1999).

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has become a *de facto* international performance standard. However, ISO is a non-governmental process and has not been involved in the type of certification activities which result in quantitative output (e.g., varying levels of emission reductions), rather than passing a series of qualitative evaluations (personal communication from Marc Stuart, EcoSecurities, Ltd. Jan. 21, 1999). The involvement of the ISO would require that this organization work closely with the UNFCCC and governments.

8. Environmental and Socioeconomic Impacts

The Kyoto Protocol exhorts Annex B parties, in fulfilling their obligations, to minimize negative social, environmental and economic impacts, particularly on developing countries (Articles 2.3 and 3.14).[1] Furthermore, one of the primary goals of the Clean Development Mechanism is sustainable development.[2] At this time, it is unclear on what indicators of sustainable development need to be addressed in the evaluation of energy-efficiency projects. Once there is an understanding of this, then MERVC guidelines for those indicators will need to be designed. At a minimum, energy-efficiency projects should meet current country guidelines for non-Clean Development Mechanism projects.

LBNL's MERVC guidelines for energy-efficiency projects include environmental and socioeconomic impacts for two additional reasons. First, the persistence of GHG reductions and the sustainability of energy-efficiency projects depend on individuals and local organizations that help support a project during its lifetime. Both direct and indirect project benefits will influence the motivation and commitment of project participants. Hence, focusing only on GHG impacts would present a misleading picture of what is needed in making a project successful or making its GHG benefits sustainable. Second, a diverse group of stakeholders (e.g., government officials, project managers, non-profit organizations, community groups, project participants, and international policymakers) are interested in, or involved in, energy-efficiency projects and are concerned about their multiple impacts. In the monitoring and verification forms (Appendices B and C), checklists are provided for developers, evaluators, and verifiers to qualitatively assess the impacts described in this section. These checklists are not exhaustive but are included to indicate areas that need to be assessed. Other existing guidelines are better suited for addressing these impacts: e.g., the World Bank has developed guidance documents for World Bank-supported projects (World Bank 1989). LBNL's checklists should help to improve the credibility of the project (by showing stakeholders that these impacts have, at least, been considered) as well as to facilitate the review of energy-efficiency projects.

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[1] As defined in the Kyoto Protocol, Annex B countries are OECD countries and countries undergoing the process of economic transition to a market economy (UNFCCC 1997).

[2] In one definition, development is sustainable when it "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). In order to translate this general definition to specific applicable policies, a variety of definitions have appeared, sometimes serving different objectives and interest groups (see Makundi 1997; Michael 1992; O'Riordan 1988).

8.1. Environmental Impacts.

Energy-efficiency projects have widespread and diverse environmental impacts that go beyond GHG impacts. The environmental benefits associated with energy-efficiency projects can be just as important as the global warming benefits. Potential environmental impacts that need to be considered are presented in Table 12 (see also Box 14). Direct and indirect project impacts need to be examined, as well as "avoided negative environmental impacts" (e.g., the deferral of the construction of a new power plant). Both gross and net impacts need to be evaluated.

Table 12. Potential Environmental Impacts

Impact Category	Comments
Dams and reservoirs	Implementation and operation
Effluents from power plants	Air, water and solid effluents from power plants (e.g., City of Decin's fuel switching for district heating project and Honduras' bio-gen biomass power generation project; USIJI 1998)
Hazardous and toxic materials	Manufacture, use, transport, storage and disposal
Indoor air quality	Measures to maintain and/or improve indoor air quality (Community of Guguletu et al. 1998; Chen and Vine 1998)
Industrial hazards	Prevention and management
Insurance claims	Reduced losses in personal and commercial lines of coverage (Vine et al. 1998)
Occupational health and safety	Plans
Water quality	Protection and enhancement
Wildlife and habitat protection or enhancement	Protection and management

Source: Adapted from World Bank (1989).

At a minimum, developers need to describe the environmental impacts associated with the project.[1] In addition, the developer needs to identify any proposed mitigation activities to address the negative impacts. The filing of an environmental impact statement (EIS) is likely to help ensure the persistence of energy savings from energy-efficiency projects. Where applicable, developers need to indicate whether an EIS has been filed and that their response to the checklist in Table 12 is consistent with the EIS. In addition, developers need to indicate if any existing laws require these impacts to be examined.

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[1] An issue that still needs to be resolved: does an investor abide by its country's environmental laws, or must it abide, at a minimum, by the host country's laws?

Box 14

Energy Efficiency and the Indoor Environment

In developing countries, fuels are often burned in inefficient stoves, with inadequate, or in many cases, non-existent chimneys. The resulting indoor air pollution exposes families to particulates, carbon monoxide and other products of combustion. The costs of the failure to recognize the energy-development linkage is evident in the nations' health statistics. For example, one study found that black South African children are 270 times more likely to die from acute respiratory infection than west European children. In a more recent study, respiratory diseases across all age groups cost the South African Department of Health US $75 million in treatment costs alone. In addition to these costs, there are productivity and quality of life losses which are more difficult to quantify, but could conceivably add up to tens of millions of dollars equivalent per year.

To address these problems, South Africa launched the Reconstruction and Development Program (RDP) which intends to provide the following services to South Africa's historically disadvantaged population: electricity, clean water, health services, education, economic advancement, and improved housing. Monitoring of the housing will include the collection of the following data: comfort levels in home (temperature measurements); indoor air quality (e.g., particulate matter, sulfur dioxide and carbon monoxide), health indicators for both children and adults (e.g., incidence of lung disease, mortality and morbidity rates, and health related expenditures per family), and safety indicators (e.g., incidence of fires, burn, and poisoning from kerosene usage; and economic costs of fires and burns).

Source: Community of Guguletu, PEER Consultants, P.C., and International Institute for Energy Conservation. 1998. "Housing for a Sustainable South Africa: The Guguletu Eco-Homes Project," USIJI Project Proposal. Washington, D.C.: International Institute for Energy Conservation.

At a minimum, evaluators need to review the checklist of environmental impacts and the EIS, if available. Evaluators need to collect some minimal information on potential impacts via surveys or interviews with key stakeholders. The evaluator should also check to see: (1) whether any existing laws require these impacts to be examined, (2) if any proposed mitigation efforts were implemented, and (3) whether expected positive benefits ever materialized. Evaluators may want to conduct some short-term monitoring to provide conservative estimates of environmental impacts. The extent and quality of available data, key data gaps, and uncertainties associated with estimates should be identified and estimated.

The information collected and analyzed by evaluators will be useful for better describing the stream of environmental services and benefits of a project, in order to attract additional investment and to characterize the project's chances of maintaining reduced GHG emissions over time. This information will, hopefully, also help in mitigating any potentially negative environmental impacts and encouraging positive environmental benefits.

8.2. Socioeconomic Impacts

A project's survival is dependent on whether it is economically sound: i.e., the benefits (including the value of carbon) outweigh the costs and are equitably distributed. Developers could use one or more economic indicators for assessing the economics of energy-efficiency projects: e.g., cost-benefit ratio, net present value, payback period, rate of return on investment, or dollars per ton of carbon emissions reduced. These indicators could be calculated from different perspectives (e.g., government, investor, and consumer), and all assumptions (e.g., lifetime, discount rate, project costs) should be identified. In addition, the distribution of project benefits and costs needs to be evaluated to make sure one population group is not being unduly affected (equity impacts).

In constructing these indicators, the developer should also consider possible macro-economic impacts from the project: e.g., gross domestic product, jobs created or lost, effects on inflation or interest rates, implications for long-term development, foreign exchange and trade, other economic benefits or drawbacks, and displacement of present uses.

In examining socioeconomic impacts, developers and evaluators need to ask the following questions: who the key stakeholders are, what project impacts are likely and upon what groups, what key social issues are likely to affect project performance, what the relevant social boundaries and project delivery mechanisms are, and what social conflicts exist and how they can be resolved (World Bank 1994). To address these questions, developers and evaluators could conduct informal sessions with representatives of affected groups and relevant non-governmental organizations.

The need to analyze social factors that influence a project continues throughout the entire life of a project. The evaluation of the social dimensions of a project is called a social analysis or social impact assessment (Asian Development Bank 1994). The social analysis typically includes an assessment of the benefits to the clientele participating in the project (e.g., does the project meet their needs), their capability to implement the project (e.g., level of knowledge and skill and capabilities of community organizations), and any potential adverse impacts on population groups affected by the project (e.g., involuntary resettlement, loss of livelihood, and price changes).

During the project development stage, projects are approved if they are consistent with the general development objectives of the host country, in terms of social and economic effects (Table 13). Both gross and net impacts need to be evaluated.

Table 13. Socioeconomic Impacts

Impacts
Cultural properties (archeological sites, historic monuments, and historic settlements)
Distribution of income and wealth
Employment rights
Gender equity
Induced development and other sociocultural aspects (secondary growth of settlements and infrastructure)
Long-term income opportunities for local populations plants (jobs) (e.g., City of Decin's fuel switching for district heating project plants (e.g., City of Decin's fuel switching for district heating project and Honduras' bio-gen biomass power generation project; USIJI 1998); USIJI 1998)
Public participation and capacity building
Quality of life (local and regional)

Source: Adapted from World Bank (1989) and EcoSecurities (1998).

After a project has been implemented, MERVC activities should assess whether the project led to any impacts and whether any mitigation was done. Direct and indirect project impacts need to be examined, as well as "avoided negative socioeconomic impacts" (e.g., the preservation of an archaeological site as a result of the deferral of the construction of a new power plant).

Developers need to indicate whether their project will have one or more of these socioeconomic impacts and, where appropriate, describe the type of impact. In addition, the developer should identify any proposed mitigation activities to address the negative impacts and that may lead to positive impacts.

Evaluators need to review the checklist of socioeconomic impacts and should collect some minimal information on potential impacts via surveys or interviews with key stakeholders. The evaluator should also check to see if any proposed mitigation efforts were implemented and whether expected positive benefits ever materialized. The extent and quality of available data, key data gaps, and uncertainties associated with estimates may need to be identified and estimated.

9. MERVC Costs

Monitoring and evaluation costs will depend on what information is needed, what information and resources are already available, the size of the project area, the monitoring methods to be used, and frequency of monitoring. Furthermore, some methods require high initial costs: e.g., in metering, start-up costs in terms of equipment and personnel training may make the installation of meters very expensive, while making continuous metering over time exceedingly cost effective. Based on the experience of U.S. utilities and energy service companies, monitoring and evaluation activities can easily account for 5-10% of a project's budget (see Meier and Solomon 1995; Raab and Violette 1994).

Due to the availability of funding, we realize that some project developers and evaluators will not be able to conduct the most data intensive methods proposed in this report; however, we expect each project to undergo some evaluation and verification in order to receive carbon credits (especially, certified emission reduction units). Moreover, we believe that monitored projects will save more energy and carbon and offset the cost of the monitoring because: (1) installations following a monitoring and evaluation protocol should come in near or even above the projected level of energy savings; and (2) installations with some measurement of energy savings should tend to have higher levels of energy savings initially and experience energy-saving levels that remain high during the lifetime of the measure (e.g., see Kats et al. 1996). In the end, the cost of monitoring and evaluation will be partially determined by its value in reducing the uncertainty of carbon credits: e.g., will one be able to receive carbon credits with a value greater than 10% of project costs that are spent on monitoring and evaluation?

Because of concerns about high costs, MERVC activities cannot be too burdensome: in general, the higher the costs, the less likely organizations and countries will try to develop and implement energy-efficiency projects. However, in some cases, due to the enormous cost differential between the carbon reduction options of UNFCCC Parties, fairly high costs can be accommodated before these costs become prohibitive. Nevertheless, MERVC costs should be as low as possible. In sum, actual (as well as perceived) MERVC costs may discourage some transactions from occurring. Tradeoffs are inevitable, and a balance needs to be made between project implementation and the level of detail (and costs) of MERVC reporting guidelines.

Project estimates of impacts could be adjusted, based on the amount of uncertainty associated with the estimates, without conducting project-specific analyses. Projects with less accurate or less precisely quantified benefit estimates would have their estimates adjusted and therefore have their benefits rendered policy-equivalent to credits from projects that can be more accurately quantified. As noted previously (Section 4.13.1), the U.S. Environmental Protection Agency's Conservation Verification Protocol reward more rigorous methods of verifying energy savings by allowing a higher share of the savings to qualify for tradable SO_2 allowances. Thus, utilities could use a simpler evaluation method at a lower cost and receive fewer credits, or they could use a more sophisticated method and receive more credits.

10. Concluding Remarks

MERVC guidelines are needed for energy-efficiency projects in order to accurately determine the net GHG, and other, benefits and costs, and to ensure that the global climate is protected and that country obligations are met. The MERVC guidelines may be used for transferring GHG reductions into credible, internationally acceptable GHG credits that could be traded at a high degree of confidence in commodity markets.

The strictness of MERVC guidelines needs to be carefully considered. Strict guidelines may easily lead to burdensome and complex procedures, thereby increasing the costs and reducing the cost-effectiveness of a project. If the guidelines for international verification are "loose", however, then project sponsors might be more able to manipulate the "measured" emission reductions, e.g., inflating the net emission reductions from the project. Because of concerns about high costs in responding to MERVC guidelines, the guidelines for energy-efficiency projects are designed to be not too burdensome.

The energy guidelines presented in this document are based on existing work that has been in use for several years (e.g., EPA's Conservation and Verification Protocols and DOE's International Performance Measurement and Verification Protocol). In order to follow the guidance provided in this report, we have developed common reporting forms: project developers and evaluators will need to complete a monitoring and evaluation form (Appendix B) and verifiers will need to complete a verification form (Appendix C). As part of these forms, we have included Quality Assurance Guidelines that require analysts to indicate specifically how they addressed basic methodological issues.

The next phase of this work will be to develop a procedural handbook providing information on how one can complete the monitoring, evaluation and verification forms contained in this report. Next, we plan to test the usefulness of these guidelines in the real world. When necessary, these guidelines will be revised in order to correct for systematic errors in the guidelines.

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APPENDIX A

ESTIMATION REPORTING FORM:
ENERGY-EFFICIENCY PROJECTS

The purpose of the Estimation Reporting Form is to ensure the standardized collection of data on estimated impacts from energy-efficiency projects. There are four main sections in this form.

In **Section A** (Project Description), the reporter provides the following information: the title of the project, contact information on the principal project developer, and a brief description of the project. If multiple participants are involved in the project, then these people should be listed.

In **Section B** (Energy Use and Carbon Emissions), the reporter first provides information on the estimated baseline, estimated gross energy use due to the project, and estimated net energy use and carbon emissions. The reporter describes how free riders, positive project spillover and market transformation were estimated. In the last part of Section B, the reporter provides information on the measurement and operational uncertainties affecting the project (including a description of a contingency plan).

In **Section C** (Environmental Impacts), the reporter indicates, via a checklist, the types of environmental impacts that could be affected by the project, the types of mitigation activities that could be conducted, and consistency of the project with environmental laws and, if applicable, environmental impact statements.

In **Section D** (Socioeconomic Impacts), the reporter indicates, via a checklist, the types of socioeconomic impacts that could be affected by the project, and the types of mitigation activities that could be conducted.

A. PROJECT DESCRIPTION

A1. Title of project:

A2. Principal project developer and contact:

Item	Please fill in if applicable
Name of principal project developer[1]:	
Name of project developer (English):	
Mailing address:	
Telephone:	
Fax:	
Contact person for this project:	
Mailing address:	
Telephone:	
Fax:	
Email:	

[1] If multiple participants are involved in the project, then they need to assign one of the participants as the "principal project developer" to complete this form. Other participants are not allowed to report on the impacts of this specific project, to avoid multiple reporting.

A3. Other participants

List other participants:

A4. Project Description

Briefly describe the project:

B. ENERGY USE AND CARBON EMISSIONS

B1. Estimated Energy Use and Carbon Emissions in Baseline [At Time of Project Registration]

Estimate annual energy use and carbon emissions (1) for the unadjusted baseline (without free riders), (2) free riders, and (3) for the baseline (adjusted for free riders). Indicate the level of precision for each value.

Estimated	Unadjusted Baseline (1)	Level of Precision[a]	Free Riders (2)	Level of Precision[a]	Without - Project Baseline (3=1-2)	Level of Precision[a]
On-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] Type of fuel:						
Carbon emissions (tC/yr.)						
On-site electricity use (MWh/yr.)						
Carbon emissions factor [b] Type of fuel:						
Carbon emissions (tC/yr.)						
Off-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] Type of fuel:						
Carbon emissions (tC/yr.) [c]						
Off-site electricity use (MWh/yr.)						
Carbon emissions factor [b] Type of fuel:						
Carbon emissions (tC/yr.) [c]						
TOTAL Carbon emissions (tC/yr.)						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B2. Estimated Gross Changes in Energy Use and Carbon Emissions from Project [At Time of Project Registration]

Estimate annual energy use and carbon emissions (1) for the unadjusted project, (2) from positive project spillover, (3) from market transformation, and (4) for the "with-project" scenario. Indicate the level of precision for each value.

Estimated	Unadjusted With Project (1)	Positive Project Spillover (2)	Market Transformation (3)	With-Project (4=1+2+3)
On-site fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
On-site electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
Off-site fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
Off-site electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
TOTAL **Carbon emissions (tC/yr.)**				

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B3. Estimated Net Changes in Energy Use and Carbon Emissions from Project [At Time of Project Registration

Calculate the net change in annual energy use and carbon emissions by subtracting "with-project" values (taken from Table B2) from "without-project baseline" values (taken from Table B1). Indicate the level of precision for each value.

Estimated	Without-Project Baseline (1)	Level of Precision[a]	With-Project (2)	Level of Precision[a]	Net Change in Energy Use and Emissions (3=1-2)	Level of Precision[a]
<u>On-site</u> fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
<u>On-site</u> electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
<u>Off-site</u> fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
<u>Off-site</u> electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
TOTAL **Carbon emissions (tC/yr.)**						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B4. Free Riders

B4.1. Describe how free ridership was estimated:

B5. Positive Project Spillover

B5.1. Describe how positive project spillover was identified and estimated, and discuss options within the project to account for spillover:

B6. Market Transformation

B6.1. Describe how market transformation was estimated:

B7. Uncertainty

B7.1. Identify and discuss key measurement and operational uncertainties affecting all energy and emission estimates:

Measurement Uncertainties:

Operational Uncertainties:

B7.2. Describe the project's contingency plan that identifies potential project uncertainties and discusses the contingencies provided within the project estimates to manage the uncertainties.

Contingency plan:

B7.3. Assess the possibility of local or regional political and economic instability in the short-term (5 years or less) and how this may affect project performance.

Political and economic instabilities:

C. ENVIRONMENTAL IMPACTS

C1. Indicate whether the project will have one or more environmental impacts and, where appropriate, describe the type of impact.

	Potential Environmental Impacts	
	Impact Category	**Comments**
☐	Dams and reservoirs*	Implementation and operation
☐	Effluents from power plants	Air, water and solid effluents from power plants
☐	Hazardous and toxic materials	Manufacture, use, transport, storage and disposal
☐	Indoor air quality	Measures to maintain and/or improve indoor air quality
☐	Industrial hazards	Prevention and management
☐	Insurance claims	Reduced losses in personal and commercial lines of coverage
☐	Occupational health and safety	Plans
☐	Water quality	Protection and enhancement
☐	Wildlife and habitat protection or enhancement	Protection and management

*Without project

C2. Identify any proposed mitigation activities.

Mitigation activities:

C3. Indicate whether an environmental impact statement (EIS) has been filed and that the response to the checklist of environmental impacts is consistent with the EIS.

☐	EIS filed
☐	EIS not filed
☐	Checklist consistent with EIS
☐	Checklist not consistent with EIS. Explain reasons:

C4. Indicate whether any environmental laws apply to these impacts and that the response to the checklist of environmental impacts is consistent with the environmental laws.

☐	Applicable environmental laws
☐	Checklist consistent with environmental laws
☐	Checklist not consistent with environmental laws. Explain reasons:

D. SOCIOECONOMIC IMPACTS

D1. Indicate whether the project will have one or more socioeconomic impacts and, where appropriate, describe the type of impact.

☐	Cultural properties (archeological sites, historic monuments, and historic settlements)
☐	Distribution of income and wealth
☐	Employment rights
☐	Gender equity
☐	Induced development and other sociocultural aspects (secondary growth of settlements and infrastructure)
☐	Long-term income opportunities for local populations (e.g., jobs)
☐	Public participation and capacity building
☐	Quality of life (local and regional)

D2. Identify any proposed mitigation activities.

Mitigation activities:

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APPENDIX B

MONITORING AND EVALUATION REPORTING FORM:

ENERGY-EFFICIENCY PROJECTS

The purpose of the Monitoring and Evaluation Reporting Form is to ensure the standardized collection of data on measured impacts from energy-efficiency projects. There are four main sections in this form.

In **Section A** (Project Description), the reporter provides the following information: the title of the project, contact information on the principal project developer, and a brief description of the project. If multiple participants are involved in the project, then these people should be listed. Much of this information will be identical to the information contained in the Estimation Reporting Form (Appendix A) and, therefore, the relevant fields are shaded to indicate to the evaluator that this information may not need to be collected again.

In **Section B** (Energy Use and Carbon Emissions), the reporter first provides information on the estimated baseline, estimated gross energy use due to the project, and estimated net energy use and carbon emissions (primarily drawn from the project proposal, or the impacts of the project (primarily drawn from project proposal, or the Estimation Reporting Form in Appendix A; these sections are shaded). The reporter then provides information on a re-estimated baseline, measured gross energy use due to the project, and measured net energy use and carbon emissions. A comparison of the estimated and measured impacts provides information on the performance and effectiveness of the project. The reporter provides information on the data collection and analysis methods used for calculating gross energy use and carbon emissions. The reporter also shows how methodological issues were addressed for each method by responding to quality assurance guidelines. The reporter describes how free riders, positive project spillover and market transformation were measured, and compares these calculations with those estimated at the start of the project. If there are differences or discrepancies, the reporter needs to explain the inconsistencies. In the last part of Section B, the reporter provides information on the measurement and operational uncertainties affecting the project (including a description of a contingency plan).

In **Section C** (Environmental Impacts), the reporter indicates, via a checklist, the types of environmental impacts affected by the project, the types of mitigation activities conducted, and consistency of the project with environmental laws and, if applicable, environmental impact statements.

In **Section D** (Socioeconomic Impacts), the reporter indicates, via a checklist, the types of socioeconomic impacts affected by the project, and the types of mitigation activities conducted.

A. PROJECT DESCRIPTION

A1. Title of project:

A2. Principal project developer and contact:

Item	Please fill in if applicable
Name of principal project developer1:	
Name of project developer (English):	
Mailing address:	
Telephone:	
Fax:	
Contact person for this project:	
Mailing address:	
Telephone:	
Fax:	
Email:	

[1] If multiple participants are involved in the project, then they need to assign one of the participants as the "principal project developer" to complete this form. Other participants are not allowed to report on the impacts of this specific project, to avoid multiple reporting.

A3. Other participants

List other participants:

A4. Project Description

Briefly describe the project:

B. ENERGY USE AND CARBON EMISSIONS

B1. Estimated Energy Use and Carbon Emissions in Baseline [At Time of Project Registration]

Estimate annual energy use and carbon emissions (1) for the unadjusted baseline (without free riders), (2) free riders, and (3) for the baseline (adjusted for free riders). Indicate the level of precision for each value.

Estimated	Unadjusted Baseline (1)	Level of Precision[a]	Free Riders (2)	Level of Precision[a]	Without - Project Baseline (3=1-2)	Level of Precision[a]
On-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
On-site electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
Off-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
Off-site electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
TOTAL **Carbon emissions (tC/yr.)**						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B2. Estimated Gross Changes in Energy Use and Carbon Emissions from Project [At Time of Project Registration]

Estimate annual energy use and carbon emissions (1) for the unadjusted project, (2) from positive project spillover, (3) from market transformation, and (4) for the "with-project" scenario. Indicate the level of precision for each value.

Estimated	Unadjusted With Project (1)	Positive Project Spillover (2)	Market Transformation (3)	With - Project (4=1+2+3)
On-site fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
On-site electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
Off-site fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
Off-site electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
TOTAL **Carbon emissions (tC/yr.)**				

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B3. Estimated Net Changes in Energy Use and Carbon Emissions from Project [At Time of Project Registration

Calculate the net change in annual energy use and carbon emissions by subtracting "with-project" values (taken from Table B2) from "without-project baseline" values (taken from Table B1). Indicate the level of precision for each value.

Estimated	Without-Project Baseline (1)	Level of Precision[a]	With-Project (2)	Level of Precision[a]	Net Change in Energy Use and Emissions (3=1-2)	Level of Precision[a]
<u>On-site</u> fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
<u>On-site</u> electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
<u>Off-site</u> fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
<u>Off-site</u> electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
TOTAL **Carbon emissions (tC/yr.)**						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B4. Re-estimated Energy Use and Carbon Emissions in Baseline [During Project Implementation]

Re-estimate annual energy use and carbon emissions (1) for the unadjusted baseline (without free riders), (2) free riders, and (3) for the baseline (adjusted for free riders). Indicate the level of precision for each value.

Re-estimated	Unadjusted Baseline (1)	Level of Precision[a]	Free Riders (2)	Level of Precision[a]	Without - Project Baseline (3=1-2)	Level of Precision[a]
On-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
On-site electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
Off-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
Off-site electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
TOTAL **Carbon emissions (tC/yr.)**						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B5. Measured Gross Changes in Energy Use and Carbon Emissions from Project [During Project Implementation]

Measure annual energy use and carbon emissions (1) for the unadjusted project, (2) from positive project spillover, (3) from market transformation, and (4) for the "with-project" scenario. Indicate the level of precision for each value.

Measured	Unadjusted With Project (1)	Positive Project Spillover (2)	Market Transformation (3)	With - Project (4=1+2+3)
On-site fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
On-site electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
Off-site fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
Off-site electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
TOTAL **Carbon emissions (tC/yr.)**				

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B6. Measured Net Changes in Energy Use and Carbon Emissions from Project [During Project Implementation]

Calculate the net change in annual energy use and carbon emissions by subtracting "with-project" values (taken from Table B5) from "without-project baseline" values (taken from Table B4). Indicate the level of precision for each value.

Measured	Without-Project Baseline (1)	Level of Precision[a]	With-Project (2)	Level of Precision[a]	Net Change in Energy Use and Emissions (3=1-2)	Level of Precision[a]
On-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
On-site electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
Off-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
On-site electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
TOTAL **Carbon emissions (tC/yr.)**						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B7. Data Collection and Analysis Methods

B7.1. Check one or more of the following data collection and analysis methods used for calculating energy savings:

☐	Engineering methods
☐	Basic statistical models
☐	Multivariate statistical models
☐	End-use metering
☐	Short-term monitoring
☐	Integrative methods

B8. Quality Assurance Guidelines

The Quality Assurance Guidelines (QAG) are contained in six tables, one table for each data collection and analysis method. Provide a separate sheet for each table.

Table QAG-1	Quality assurance guidelines for engineering methods
Data	1. Describe the data that were collected to support the analysis. 2. Describe the source(s) and method(s) of collecting these data. 3. Describe which data were collected from site inspection, building plans, default values, or other sources of data 4. Describe how the loads, systems, and plants components of the model were specified.
Calibration	1. Describe how the models were calibrated to observed data on usage levels. 2. Describe the criteria used to judge whether the model was appropriately calibrated. 3. Describe the input values that were changed to bring the simulation into calibration and give the reasons why a value was changed.
Weather	Describe how the weather data was chosen for the simulation and how the weather data corresponded to the geographic location and climate conditions of the building.

Table QAG-2	**Quality assurance guidelines for basic statistical models**
Sampling	1. If a sample was used, describe the sample design (e.g., was a random sample used? proportional sample? cluster sample? stratified sample?). 2. Describe the size of the expected sample and achieved sample (e.g., how many questionnaires were mailed out and how many completed ones were returned?). 3. Describe the response rate for each of the major data collection efforts. 4. Describe any efforts to estimate the extent of non-response bias. 5. Describe any efforts to correct for non-response bias. 6. Describe any procedures used to determine the size of the samples in order to achieve a specific level of precision at a given level of confidence. 7. Describe any tests or comparisons made to examine whether the sample was representative of the population of participants (or comparison population). 8. If a stratified sample was used, describe how the strata were defined and how the allocation to strata was determined. 9. If the sample was weighted for analysis, describe the basis for the weighting.
Data	1. Describe the data that were collected to support the analysis. 2. Describe the source(s) and method(s) of collecting these data. 3. Describe the screens used to eliminate customers from the analysis and the number of customers eliminated as the result of each screen (where applicable). 4. Describe where data collection instruments can be found.
Outliers	If outliers were identified, describe how they were identified, how many there were, and how they were handled.
Missing data	Describe how missing data were handled.
Weather	1. Describe the weather normalization model used. 2. Describe the source of the weather data used for analysis. 3. Describe how weather normalization adjusted for heating degree-days only, cooling degree-days only, or both. 4. Describe the degree-day base used for heating and for cooling.
Comparison group	1. If a comparison group was not used to estimate gross savings, describe what was done to control for the effects of background variables (e.g., economic and political activity) that may account for any increase or decrease in consumption in addition to the project itself. 2. If a comparison group was used to estimate gross or net savings, describe how the group was defined and what, if anything, was done to control for differences between the comparison and participant groups and any suspected self-selection bias.

Table QAG-3	Quality assurance guidelines for multivariate statistical models
Sampling	See Table QAG-2.
Data	1. Describe the data that were collected to support the analysis. 2. Describe the source(s) and method(s) of collecting these data.
Specification and error	1. Describe any substantial errors in measuring important independent variables and how these errors were minimized. 2. If autocorrelation was a problem, describe the diagnosis carried out, the solutions attempted, and their effects. If left untreated, explain why. 3. If heteroskedasticity was a problem, describe the diagnosis carried out, the solutions attempted, and their effects. If left untreated, explain why.
Collinearity	If collinearity was a problem, describe the diagnosis carried out, the solutions attempted, and their effects. If left untreated, explain why.
Outliers	See Table QAG-2.
Missing data	See Table QAG-2.
Triangulation	If more than one estimate of impact is calculated, describe how the results have been combined to form a single estimate.
Weather	See Table QAG-2.
Engineering priors	If prior engineering estimates of usage or savings were used in the models, describe the source(s) of the priors.
Comparison group	See Table QAG-2.
Interactions	Describe how interaction effects (e.g., between heating and lighting) were addressed.

Table QAG-4	Quality assurance guidelines for end-use metering
Sampling	See Table QAG-2.
Data	See Table QAG-3.
Outliers	See Table QAG-2.
Missing data	See Table QAG-2.
Weather	See Table QAG-2.
Comparison group	See Table QAG-2.
Interactions	See Table QAG-3.
Measurement duration	Describe the duration and interval of the metering.

Table QAG-5	Quality assurance guidelines for short-term monitoring
Sampling	See Table QAG-2.
Data	See Table QAG-3.
Outliers	See Table QAG-2.
Missing data	See Table QAG-2.
Weather	See Table QAG-2.
Comparison group	See Table QAG-2.
Interactions	See Table QAG-3.
Measurement duration	Describe the duration and interval of the monitoring.

Table QAG-6	Quality assurance guidelines for integrative methods
Sampling	See Table QAG-2.
Data	See Table QAG-3.
Specification and error	See Table QAG-3
Collinearity	See Table QAG-3
Outliers	See Table QAG-2.
Missing data	See Table QAG-2.
Triangulation	See Table QAG-2.
Weather	See Tables QAG-1 and QAG-2.
Engineering priors	See Table QAG-2.
Comparison group	See Table QAG-2.
Calibration	See Table QAG-1.
Measurement duration	See Tables QAG-4 and QAG-5.
Interactions	See Table QAG-3.

B9. IPMVP Options

B9.1. Describe which of the following options from the International Performance Measurement and Verification Protocol (IPMVP) were used (see Section 4.2.9 of report):

☐	Option A
☐	Option B
☐	Option C
☐	Option D

B10. Data Collection and Analysis Methods

B10.1. Describe which of the following methods were used for calculating net energy savings:

☐	Default “net-to-gross” factors
☐	Project-estimated net-to-gross factors
☐	50% deduction of first-year savings

B11. Free Riders

B11.1. Describe how free ridership was evaluated, compare to estimated free ridership, and explain inconsistencies:

B11.2. What methods were used to evaluate free ridership:

☐	Surveys
☐	Discrete choice modeling
☐	Multivariate statistical models

B12. Positive Project Spillover

B12.1. Describe how positive project spillover was evaluated, compare to estimated spillover, and explain inconsistencies. Where applicable, assess how effective options have been to account for spillover.

B12.2. What methods were used to evaluate positive project spillover:

☐	Surveys
☐	Discrete choice modeling
☐	Multivariate statistical models

B13. Market Transformation

B13.1. Which of the following indicators were used to describe how the market has been transformed, or that the savings from the project are expected to persist? [Check all that may apply]

☐	Changes in government standards or regulations
☐	Physical changes in production or distribution practices that are not easily undone
☐	Institutional changes in standard practice
☐	New market entrants
☐	Profitable market entities continue the market transformation
☐	Key market barriers removed or reduced
☐	Market saturation of equipment

B13.2. Which of the following methods were used to evaluate market transformation? [Check all that may apply]

☐	Surveys
☐	Sales tracking
☐	Multivariate statistical models
☐	Modeling of market processes
☐	Econometric studies
☐	Process evaluations

B13.3. Compare measured changes from market transformation to estimated changes from market transformation, and explain inconsistencies:

B14. Emissions

B14.1. Which of the following methods were used for calculating carbon emissions:

☐	Default emissions factors
☐	Project-estimated emissions factors

B15. Uncertainty

B15.1. Identify and discuss key measurement and operational uncertainties affecting all energy and emission estimates:

Measurement Uncertainties:

Operational Uncertainties:

B15.2. Describe the project's contingency plan that identifies potential project uncertainties and discusses the contingencies provided within the project estimates to manage the uncertainties.

Contingency plan:

B15.3. Assess the possibility of local or regional political and economic instability in the short-term (5 years or less) and how this may affect project performance.

Political and economic instabilities:

C. ENVIRONMENTAL IMPACTS

C1. Indicate whether the project will have one or more environmental impacts and, where appropriate, describe the type of impact. If there are differences or discrepancies with the information in the Estimation Reporting Form, explain the inconsistencies.

	Potential Environmental Impacts	
	Impact Category	**Comments**
☐	Dams and reservoirs*	Implementation and operation
☐	Effluents from power plants	Air, water and solid effluents from power plants
☐	Hazardous and toxic materials	Manufacture, use, transport, storage and disposal
☐	Indoor air quality	Measures to maintain and/or improve indoor air quality
☐	Industrial hazards	Prevention and management
☐	Insurance claims	Reduced losses in personal and commercial lines of coverage
☐	Occupational health and safety	Plans
☐	Water quality	Protection and enhancement
☐	Wildlife and habitat protection or enhancement	Protection and management

*Without project

C2. Identify any proposed mitigation activities.

Mitigation activities:

D. SOCIOECONOMIC IMPACTS

D1. Indicate whether the project will have one or more socioeconomic impacts and, where appropriate, describe the type of impact.

☐	Cultural properties (archeological sites, historic monuments, and historic settlements)
☐	Distribution of income and wealth
☐	Employment rights
☐	Gender equity
☐	Induced development and other sociocultural aspects (secondary growth of settlements and infrastructure)
☐	Long-term income opportunities for local populations (e.g., jobs)
☐	Public participation and capacity building
☐	Quality of life (local and regional)

D2. Identify any proposed mitigation activities.

Mitigation activities:

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APPENDIX C

VERIFICATION REPORTING FORM:
ENERGY-EFFICIENCY PROJECTS

The Verification Reporting Form is to be used for verifying the measured impacts of energy-efficiency projects as reported in the Monitoring and Evaluation Form (Appendix B). There are four main sections in this form.

Verification refers to establishing whether the measured GHG reductions actually occurred, similar to an accounting audit performed by an objective, certified party. External (third-party) verification processes need to be put in place and not rely on internal verification or audits. As part of the verification exercise, an overall assessment of the quality and completeness of each of the GHG impact estimates needs to be made by completing the Verification Reporting Form, similar to the Monitoring and Evaluation Reporting Form. For energy-efficiency projects, verifying baseline and post-project conditions may involve research studies, surveys, or other assessments (see Section 4.2), as well as requesting documentation on key aspects of the project. At a minimum, the verifier should ask the following general questions:

☐	Are the monitoring and evaluation methods well documented and reproducible?
☐	Have the results been checked against other methods?
☐	Have the results been compared for reasonableness with outside or independently published estimates?
☐	Are the sources of emission factors well documented?
☐	Have the sources of emission factors been compared with other sources?
☐	Are there any environmental or socioeconomic impacts that need to be evaluated in more detail?

In **Section A** (Project Description), the verifier provides the following information: the title of the project, contact information on the principal project developer, and a brief description of the project. If multiple participants are involved in the project, then these people should be listed. Much of this information will be identical to the information contained in the Monitoring and Evaluation Reporting Form (Appendix B) and, therefore, the relevant fields are shaded.

In **Section B** (Energy Use and Carbon Emissions), the verifier first provides information on the re-estimated baseline, measured gross energy use due to the project, and measured net energy use and carbon emissions (primarily drawn from the Monitoring and Evaluation Reporting Form in Appendix B; these sections are shaded). The verifier then provides information on a verified baseline, verified gross energy use due to the project, and verified net energy use and carbon emissions. A comparison of the measured and verified impacts provides information on the performance and effectiveness of the project. If additional data collection and analysis was conducted, the verifier provides information on the data collection and analysis methods used for verifying changes in energy use and carbon emissions.

The verifier also needs to indicate whether key methodological issues were addressed for each method by responding to quality assurance guidelines. After indicating which monitoring and evaluation option of the International Performance Measurement and Verification Protocol was used, the verifier provide information on the data collection and analysis methods used for calculating net energy use and carbon emissions. The verifier describes how free riders, positive project spillover, and market transformation were verified, and compares these calculations with those measured during project implementation. If there are differences or discrepancies, the verifier needs to explain the inconsistencies. In the last part of Section B, the verifier provides information on the measurement and operational uncertainties affecting the project (including a description of a contingency plan). If there are differences or discrepancies with the information in the Monitoring and Evaluation Reporting Form, the verifier needs to explain the inconsistencies.

In **Section C** (Environmental Impacts), the verifier indicates, via a checklist, the types of environmental impacts affected by the project, the types of mitigation activities conducted, and consistency of the project with environmental laws and, if applicable, environmental impact statements. If there are differences or discrepancies with the information in the Monitoring and Evaluation Reporting Form, the verifier needs to explain the inconsistencies.

In **Section D** (Socioeconomic Impacts), the verifier indicates, via a checklist, the types of socioeconomic impacts affected by the project, and the types of mitigation activities conducted. If there are differences or discrepancies with the information in the Monitoring and Evaluation Reporting Form, the verifier needs to explain the inconsistencies.

A. PROJECT DESCRIPTION

[*Same as Reported in Monitoring and Evaluation Reporting Form*]

A1. Title of project:

A2. Principal project developer and contact:

Item	Please fill in if applicable
Name of principal project developer[1]:	
Name of project developer (English):	
Mailing address:	
Telephone:	
Fax:	
Contact person for this project:	
Mailing address:	
Telephone:	
Fax:	
Email:	

[1] If multiple participants are involved in the project, then they need to assign one of the participants as the "principal project developer" to complete this form. Other participants are not allowed to report on the impacts of this specific project, to avoid multiple reporting.

A3. Other participants

List other participants:

A4. Project Description

Briefly describe the project:

B. ENERGY USE AND CARBON EMISSIONS

B1. Re-estimated Energy Use and Carbon Emissions in Baseline Emissions [Same as Reported in Section B4 in Monitoring and Evaluation Reporting Form]

Re-estimate annual energy use and carbon emissions (1) for the unadjusted baseline (without free riders), (2) free riders, and (3) for the baseline (adjusted for free riders). Indicate the level of precision for each value.

Re-estimated	Unadjusted Baseline (1)	Level of Precision[a]	Free Riders (2)	Level of Precision[a]	Without - Project Baseline (3=1-2)	Level of Precision[a]
On-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] Type of fuel:						
Carbon emissions (tC/yr.)						
On-site electricity use (MWh/yr.)						
Carbon emissions factor [b] Type of fuel:						
Carbon emissions (tC/yr.)						
Off-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] Type of fuel:						
Carbon emissions (tC/yr.) [c]						
On-site electricity use (MWh/yr.)						
Carbon emissions factor [b] Type of fuel:						
Carbon emissions (tC/yr.) [c]						
TOTAL Carbon emissions (tC/yr.)						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B2. Measured Gross Changes in Energy Use and Carbon Emissions from Project [Emissions [*Same as Reported in Section B5 in Monitoring and Evaluation Reporting Form*]

Measure annual energy use and carbon emissions (1) for the unadjusted project, (2) from positive project spillover, (3) from market transformation, and (4) for the "with-project" scenario. Indicate the level of precision for each value.

Measured	Unadjusted With Project (1)	Positive Project Spillover (2)	Market Transformation (3)	With-Project (4=1+2+3)
On-site fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
On-site electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
Off-site fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
Off-site electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
TOTAL **Carbon emissions (tC/yr.)**				

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B3. Measured Net Changes in Energy Use and Carbon Emissions from Project [*Same as Reported in Section B6 in Monitoring and Evaluation Reporting Form*]

Calculate the net change in annual energy use and carbon emissions by subtracting "with-project" values (taken from Table B2) from "without-project baseline" values (taken from Table B1). Indicate the level of precision for each value.

Measured	Without-Project Baseline (1)	Level of Precision[a]	With-Project (2)	Level of Precision[a]	Net Change in Energy Use and Emissions (3=1-2)	Level of Precision[a]
<u>On-site</u> fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
<u>On-site</u> electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
<u>Off-site</u> fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
<u>Off-site</u> electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
TOTAL **Carbon emissions (tC/yr.)**						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B4. Verified Energy Use and Carbon Emissions in Baseline Emissions [*to be completed by verifier*]

Verify annual energy use and carbon emissions (1) for the unadjusted baseline (without free riders), (2) free riders, and (3) for the baseline (adjusted for free riders). Indicate the level of precision for each value.

Verified	Unadjusted Baseline (1)	Level of Precision[a]	Free Riders (2)	Level of Precision[a]	Without - Project Baseline (3=1-2)	Level of Precision[a]
<u>On-site</u> fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
<u>On-site</u> electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
<u>Off-site</u> fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
<u>Off-site</u> electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
TOTAL **Carbon emissions (tC/yr.)**						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B5. Verified Gross Changes in Energy Use and Carbon Emissions from Project [*to be completed by verifier*]

Verify annual energy use and carbon emissions (1) for the unadjusted project, (2) from positive project spillover, (3) from market transformation, and (4) for the "with-project" scenario. Indicate the level of precision for each value.

Verified	Unadjusted With Project (1)	Positive Project Spillover (2)	Market Transformation (3)	With-Project (4=1+2+3)
<u>On-site</u> fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
<u>On-site</u> electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.)				
<u>Off-site</u> fuel use (Terajoules = 10^{12} joules/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
<u>Off-site</u> Electricity use (MWh/yr.)				
Carbon emissions factor [b] **Type of fuel:**				
Carbon emissions (tC/yr.) [c]				
TOTAL **Carbon emissions (tC/yr.)**				

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B6. Verified Net Changes in Energy Use and Carbon Emissions from Project [t*o be completed by verifier*]

Calculate the net change in annual energy use and carbon emissions by subtracting "with-project" values (taken from Table B5) from "without-project baseline" values (taken from Table B4). Indicate the level of precision for each value.

Measured	Without-Project Baseline (1)	Level of Precision[a]	With-Project (2)	Level of Precision[a]	Net Change in Energy Use and Emissions (3=1-2)	Level of Precision[a]
On-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
On-site electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.)						
Off-site fuel use (Terajoules = 10^{12} joules/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
Off-site electricity use (MWh/yr.)						
Carbon emissions factor [b] **Type of fuel:**						
Carbon emissions (tC/yr.) [c]						
TOTAL **Carbon emissions (tC/yr.)**						

[a] Indicate the level of precision used for project values: use either (1) standard deviation around the mean value, or (2) general level of precision (e.g., low, medium, high) — if more information is available, additional levels of precision can be used.

[b] Specify type of fuel used for calculating carbon emissions factor.

[c] Indicate carbon reductions from off-site electric utility plant(s).

B7. Data Collection and Analysis Methods [Only to be completed by verifier if additional data collection and analysis were conducted as part of verification]

B7.1. Check one or more of the following data collection and analysis methods used for calculating energy savings:

☐	Engineering methods
☐	Basic statistical models
☐	Multivariate statistical models
☐	End-use metering
☐	Short-term monitoring
☐	Integrative methods

B8. Quality Assurance Guidelines (*to be completed by verifier*)

The Quality Assurance Guidelines (QAG) are contained in six tables, one table for each data collection and analysis method. Check the box to indicate that these issues were addressed. If not addressed, or if there were problems, discuss on a separate sheet for each table.

Table QAG-1	**Quality assurance guidelines for engineering methods**	
Data	☐ ☐ ☐ ☐	1. Was the data collection process described that supported the analysis? 2. Were the source(s) and method(s) of collecting these data described? 3. Were data identified by source: site inspection, building plans, default values, or other sources of data? 4. Were the loads, systems, and plants components of the model specified?
Calibration	☐ ☐ ☐	1. Were the models calibrated to observed data on usage levels? 2. Were criteria used to judge whether the model was appropriately calibrated described? 3. Were the input values that were changed to bring the simulation into calibration described? And were reasons given why a value was changed?
Weather	☐	Were the weather data chosen for the simulation described? And did the weather data correspond to the geographic location and climate conditions of the building?

Table QAG-2	**Quality assurance guidelines for basic statistical models**
Sampling	1. If a sample was used, describe the sample design (e.g., was a random sample used? proportional sample? cluster sample? stratified sample?). 2. Describe the size of the expected sample and achieved sample (e.g., how many questionnaires were mailed out and how many completed ones were returned?). 3. Describe the response rate for each of the major data collection efforts. 4. Describe any efforts to estimate the extent of non-response bias. 5. Describe any efforts to correct for non-response bias. 6. Describe any procedures used to determine the size of the samples in order to achieve a specific level of precision at a given level of confidence. 7. Describe any tests or comparisons made to examine whether the sample was representative of the population of participants (or comparison population). 8. If a stratified sample was used, describe how the strata were defined and how the allocation to strata was determined. 9. If the sample was weighted for analysis, describe the basis for the weighting.
Data	1. Describe the data that were collected to support the analysis. 2. Describe the source(s) and method(s) of collecting these data. 3. Describe the screens used to eliminate customers from the analysis and the number of customers eliminated as the result of each screen (where applicable). 4. Describe where data collection instruments can be found.
Outliers	If outliers were identified, describe how they were identified, how many there were, and how they were handled.
Missing data	Describe how missing data were handled.
Weather	1. Describe the weather normalization model used. 2. Describe the source of the weather data used for analysis. 3. Describe how weather normalization adjusted for heating degree-days only, cooling degree-days only, or both. 4. Describe the degree-day base used for heating and for cooling.
Comparison group	1. If a comparison group was not used to estimate gross savings, describe what was done to control for the effects of background variables (e.g., economic and political activity) that may account for any increase or decrease in consumption in addition to the project itself. 2. If a comparison group was used to estimate gross or net savings, describe how the group was defined and what, if anything, was done to control for differences between the comparison and participant groups and any suspected self-selection bias.

Table QAG-3	Quality assurance guidelines for multivariate statistical models
Sampling	See Table QAG-2.
Data	1. Describe the data that were collected to support the analysis. 2. Describe the source(s) and method(s) of collecting these data.
Specification and error	1. Describe any substantial errors in measuring important independent variables and how these errors were minimized. 2. If autocorrelation was a problem, describe the diagnosis carried out, the solutions attempted, and their effects. If left untreated, explain why. 3. If heteroskedasticity was a problem, describe the diagnosis carried out, the solutions attempted, and their effects. If left untreated, explain why.
Collinearity	If collinearity was a problem, describe the diagnosis carried out, the solutions attempted, and their effects. If left untreated, explain why.
Outliers	See Table QAG-2.
Missing data	See Table QAG-2.
Triangulation	If more than one estimate of impact is calculated, describe how the results have been combined to form a single estimate.
Weather	See Table QAG-2.
Engineering priors	If prior engineering estimates of usage or savings were used in the models, describe the source(s) of the priors.
Comparison group	See Table QAG-2.
Interactions	Describe how interaction effects (e.g., between heating and lighting) were addressed.

Table QAG-4	Quality assurance guidelines for end-use metering
Sampling	See Table QAG-2.
Data	See Table QAG-3.
Outliers	See Table QAG-2.
Missing data	See Table QAG-2.
Weather	See Table QAG-2.
Comparison group	See Table QAG-2.
Interactions	See Table QAG-3.
Measurement duration	Describe the duration and interval of the metering.

Table QAG-5	**Quality assurance guidelines for short-term monitoring**
Sampling	See Table QAG-2.
Data	See Table QAG-3.
Outliers	See Table QAG-2.
Missing data	See Table QAG-2.
Weather	See Table QAG-2.
Comparison group	See Table QAG-2.
Interactions	See Table QAG-3.
Measurement duration	Describe the duration and interval of the monitoring.

Table QAG-6	**Quality assurance guidelines for integrative methods**
Sampling	See Table QAG-2.
Data	See Table QAG-3.
Specification and error	See Table QAG-3
Collinearity	See Table QAG-3
Outliers	See Table QAG-2.
Missing data	See Table QAG-2.
Triangulation	See Table QAG-2.
Weather	See Tables QAG-1 and QAG-2.
Engineering priors	See Table QAG-2.
Comparison group	See Table QAG-2.
Calibration	See Table QAG-1.
Measurement duration	See Tables QAG-4 and QAG-5.
Interactions	See Table QAG-3.

B9. IPMVP Options [*Only to be completed by verifier if additional data collection and analysis were conducted as part of verification*]

B9.1. Describe which of the following options from the International Performance Measurement and Verification Protocol (IPMVP) were used (see Section 4.2.9 of report):

☐	Option A
☐	Option B
☐	Option C
☐	Option D

B10. Data Collection and Analysis Methods [*Only to be completed by verifier if additional data collection and analysis were conducted as part of verification*]

B10.1. Describe which of the following methods were used for calculating net energy savings:

☐	Default “net-to-gross” factors
☐	Project-estimated net-to-gross factors
☐	50% deduction of first-year savings

B11. Free Riders [*to be completed by verifier*]

B11.1. Describe how free ridership was evaluated, compare to measured free ridership, and explain inconsistencies:

B11.2. What methods were used to evaluate free ridership:

☐	Surveys
☐	Discrete choice modeling
☐	Multivariate statistical models

B12. Positive Project Spillover [*to be completed by verifier*]

B12.1. Describe how positive project spillover was evaluated, compare to measured spillover, and explain inconsistencies:

B12.2. What methods were used to evaluate positive project spillover:

☐	Surveys
☐	Discrete choice modeling
☐	Multivariate statistical models

B12.3. Evaluate the effectiveness of the project's plan that identifies potential positive project spillover and discusses options within the project to minimize, or account for, spillover:

B13. Market Transformation [*Only to be completed by verifier if additional data collection and analysis were conducted as part of verification*]

B13.1. Which of the following indicators were used to describe how the market has been transformed, or that the savings from the project are expected to persist? [Check all that may apply]

☐	Changes in government standards or regulations
☐	Physical changes in production or distribution practices that are not easily undone
☐	Institutional changes in standard practice
☐	New market entrants
☐	Profitable market entities continue the market transformation
☐	Key market barriers removed or reduced
☐	Market saturation of equipment

B13.2. Which of the following methods were used to evaluate market transformation? [Check all that may apply]

☐	Surveys
☐	Sales tracking
☐	Multivariate statistical models
☐	Modeling of market processes
☐	Econometric studies
☐	Process evaluations

B13.3. Compare verified changes from market transformation to measured changes from market transformation, and explain inconsistencies:

B14. Emissions [*Only to be completed by verifier if additional data collection and analysis were conducted as part of verification*]

B14.1. Which of the following methods were used for calculating carbon emissions:

☐	Default emissions factors
☐	Project-estimated emissions factors

B15. Uncertainty [*to be completed by verifier*]

B15.1. Identify and discuss key measurement and operational uncertainties affecting all energy and emission estimates. If there are differences or discrepancies with the information in the Monitoring and Evaluation Reporting Form, explain the inconsistencies.

Measurement Uncertainties:

Operational Uncertainties:

B15.2. Describe the project's contingency plan that identifies potential project uncertainties and discusses the contingencies provided within the project estimates to manage the uncertainties.

Contingency plan:

B15.3. Assess the possibility of local or regional political and economic instability in the short-term (5 years or less) and how this may affect project performance.

Political and economic instabilities:

C. ENVIRONMENTAL IMPACTS

C1. Identify and check whether the project will have one or more environmental impacts and, where appropriate, describe the type of impact. If there are differences or discrepancies with the information in the Monitoring and Evaluation Reporting Form, explain the inconsistencies. [*to be completed by verifier*]

	Potential Environmental Impacts	
	Impact Category	**Comments**
☐	Dams and reservoirs*	Implementation and operation
☐	Effluents from power plants	Air, water and solid effluents from power plants
☐	Hazardous and toxic materials	Manufacture, use, transport, storage and disposal
☐	Indoor air quality	Measures to maintain and/or improve indoor air quality
☐	Industrial hazards	Prevention and management
☐	Insurance claims	Reduced losses in personal and commercial lines of coverage
☐	Occupational health and safety	Plans
☐	Water quality	Protection and enhancement
☐	Wildlife and habitat protection or enhancement	Protection and management

*Without project

C2. Identify any proposed mitigation activities. [*to be completed by verifier*]

Mitigation activities:

C3. Indicate whether an environmental impact statement (EIS) has been filed and that the response to the checklist of environmental impacts is consistent with the EIS. [*to be completed by verifier*]

☐	EIS filed
☐	EIS not filed
☐	Checklist consistent with EIS
☐	Checklist not consistent with EIS. Explain reasons:

C4. Indicate whether any environmental laws apply to these impacts and that the response to the checklist of environmental impacts is consistent with the environmental laws. [*to be completed by verifier*]

☐	Applicable environmental laws
☐	Checklist consistent with environmental laws
☐	Checklist not consistent with environmental laws. Explain reasons:

D. SOCIOECONOMIC IMPACTS

D1. Indicate whether the project will have one or more socioeconomic impacts and, where appropriate, describe the type of impact. [*to be completed by verifier*]

☐	Cultural properties (archeological sites, historic monuments, and historic settlements)
☐	Distribution of income and wealth
☐	Employment rights
☐	Gender equity
☐	Induced development and other sociocultural aspects (secondary growth of settlements and infrastructure)
☐	Long-term income opportunities for local populations (e.g., jobs)
☐	Public participation and capacity building
☐	Quality of life (local and regional)

D2. Identify any proposed mitigation activities. [*to be completed by verifier*]

Mitigation activities: