Energy Efficiency Evaluation, Measurement, and Verification

A Regional Review of Practices in China, the European Union, India, and the United States

RAP Energy solutions for a changing world

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A Regional Review of Practices in China, the European Union, India, and the United States

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About the Global Power Best Practice Series

Worldwide, the electricity sector is undergoing a fundamental transformation. Policymakers recognize that fossil fuels, the largest fuel source for the electricity sector, contribute to greenhouse gas emissions and other forms of man-made environmental contamination. Through technology gains, improved public policy, and market reforms, the electricity sector is becoming cleaner and more affordable. However, significant opportunities for improvement remain and the experiences in different regions of the world can form a knowledge base and provide guidance for others interested in driving this transformation.

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4. Time-Varying and Dynamic Rate Design
5. Rate Design Where Advanced Metering Infrastructure Has Not Been Fully Deployed
6. Strategies for Decarbonizing the Electric Power Supply
7. Innovative Power Sector Business Models to Promote Demand-Side Resources
8. Integrating Energy and Environmental Policy
9. Energy Efficiency Evaluation, Measurement, and Verification
10. Strategies for Energy Efficiency Financing
11. Integrating Renewable Resources into Power Markets

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12. Regional Power Sector Profiles in the U.S., Europe, India, and China
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The draft paper submitted to RAP by Navigant was then revised by David Crossley, Senior Advisor with RAP, who edited the original Navigant material and added more material throughout the paper.

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1. Executive Summary

This paper reviews energy efficiency evaluation, measurement, and verification (EM&V) in four regions of the world: China, Europe, India, and the United States.

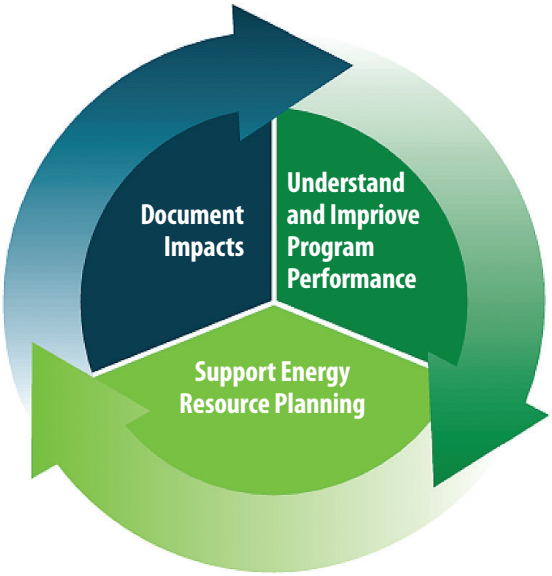
Energy efficiency EM&V comprises actions undertaken to assess and document the outcomes of energy efficiency activities. This paper focuses mostly on EM&V of energy efficiency programs where businesses or households are provided with some incentive to purchase and install energy efficient measures or to take actions that will increase the energy efficiency of a business or residence.

EM&V has three primary objectives, shown in Figure ES-1.

1. **Document the benefits** (i.e., impacts) of a program, and determine whether the subject program (or portfolio of programs) met its goals
2. **Identify ways to improve current and future programs** through determining why program-induced impacts occurred
3. **Support energy demand forecasting and resource planning** by understanding the historical and future resource contributions of energy efficiency compared to other energy resources

Figure ES-1

Objectives of Energy Efficiency EM&V[1]



Regional Summaries

China

China has three decades of experience in implementing a range of energy efficiency programs to achieve energy intensity targets set by governments. Typically, energy savings are estimated by undertaking audits of enterprise energy consumption records. Project-based energy efficiency EM&V is in its infancy and is limited to impact evaluations; process evaluations are usually not undertaken. Currently, China is in a period of active development of more sophisticated, robust, and stringent energy efficiency EM&V. A range of EM&V protocols and practices, including deemed savings for common energy efficiency measures, is being developed by government and private sector organizations in consultation with a number of international advisory bodies. EM&V development is moving rapidly; training a cadre of technically qualified evaluators and integrating EM&V into existing and new energy efficiency programs are areas of current and continuing interest and activity.

European Union

In the European Union, energy efficiency EM&V is largely driven by the necessity to estimate the energy savings achieved by those energy suppliers subject to energy efficiency obligations (EEOs) in some Member States. The need for robust and stringent EM&V will increase as all Member States respond to the requirement in the 2012 Energy Efficiency Directive that they implement EEO schemes or alternative energy efficiency policies and programs that deliver 1.5-percent energy savings each

1 State and Local Energy Efficiency Action Network (2012).

year. EM&V methodologies are not uniform across the European Union and Member States are free to develop their own EM&V protocols, baselines, and methodologies for estimating energy savings. There has been a great deal of work, especially in the United Kingdom, on establishing deemed energy savings values for a range of energy efficiency measures, but in some Member States these values are not updated regularly. The United Kingdom and Denmark are the only Member States to estimate net energy savings. The majority of evaluations have been impact evaluations, and some process evaluations have been carried out on programs implemented under EEO schemes. EM&V practitioners are still a small group and training and career paths are not well established. In addition to continuing to develop harmonized EM&V protocols and methodologies, E.U. Member States need to recognize and allocate adequate financial resources to energy efficiency EM&V and to train the next generation of evaluators.

India

India is in a relatively early stage of developing and implementing energy efficiency EM&V. There is a significant requirement for EM&V, particularly as energy efficiency programs under the National Mission for Enhanced Energy Efficiency are implemented, especially the Perform, Achieve and Trade scheme that places EEOs on large energy users. Some progress has been made in developing energy efficiency EM&V protocols and methodologies, particularly for projects implemented under the Kyoto Protocol Clean Development Mechanism. Currently, evaluations of energy efficiency programs are mainly impact evaluations; there are virtually no process evaluations. Indian EM&V practitioners are building experience and, like China, India is developing EM&V protocols and methodologies with internal resources and ongoing assistance from a range of international organizations.

United States

In the United States, more than three decades of energy efficiency programs delivered by energy utilities and other program administrators, largely funded by ratepayer dollars, have resulted in extensive implementation of energy efficiency EM&V. EM&V has been developed and implemented at the state level and there is no national approach or uniform set of EM&V protocols and methodologies, although the International Performance Measurement and Verification Protocol has become the de facto framework for measurement and verification (M&V) of energy efficiency programs in many states. In recent years, there has been some convergence in EM&V practices, bolstered by initiatives such as the National Action Plan for Energy Efficiency, the U.S. Department of Energy's Uniform Methods Project, and work by the North American Energy Standards Board. Energy efficiency EM&V in the United States has focused mainly on programs delivered by utilities and other program administrators, but there are also active energy efficiency efforts in residential and commercial building codes, and in energy performance standards for appliances and equipment. EM&V methodologies for assessing compliance with these codes and standards are still being developed.

Variable Characteristics of EM&V Across Regions

The **sophistication, robustness, and stringency** of energy efficiency EM&V varies greatly among the regions covered by this paper, and even within some individual regions. In all regions, there is some recognition of the importance of EM&V and efforts are being made to improve EM&V protocols, methodologies, and practices and to establish or develop training for EM&V practitioners.

Deemed energy and demand savings are used to varying extents in all regions. Deemed savings require substantial investment to establish initial savings values, which then require periodic updating. Provided that the initial values are established with adequate levels of stringency, deemed savings are a cost-effective way to provide a level of certainty for common types of simple energy efficiency measures. Deemed energy and demand savings are appropriate in certain situations in which the measure and end use are applicable to the deemed savings value.

Estimating **net energy and demand savings** is carried out primarily in the United States where net savings are an important input into the calculation of remuneration levels for administrators of energy efficiency programs. Net savings are also estimated in some European Union Member States, principally the United Kingdom and Denmark, but are not considered at all in China and India.

Net savings estimations are useful in determining whether an efficiency program is achieving its objectives, but are less relevant when program administrators' remuneration is not based on the level of energy or demand savings, or when energy efficiency programs are being implemented simply to meet energy efficiency or energy intensity targets set by governments to meet national or regional economic goals.

Similarly, **cost-effectiveness testing** of energy efficiency programs is largely restricted to the United States, where it is used to determine whether an energy efficiency program is more cost-effective than a supply-side option and therefore a good use of ratepayers' funds. Cost-effectiveness testing is likely to be introduced in other regions as recognition grows of the importance of energy efficiency as a resource.

Next Steps

The drivers and practices of energy efficiency EM&V vary among regions, as does the level of EM&V development and implementation. There are some commonalities in EM&V implementation among the regions, but there is no single set of EM&V best practices that can be applied uniformly across all regions. Nevertheless, there are also commonalities in the gaps in EM&V practices that exist among regions and in the steps that can be taken to close those gaps.

As EM&V methods and practices have matured in some regions, we see increasing consideration of energy efficiency in resource and reliability planning. One goal applicable in all regions is to maintain or instill confidence that the energy and demand savings claimed by various types of energy efficiency activities are valid and reliable. When this is accomplished, energy efficiency can be more confidently incorporated into resource and reliability planning, as a strategy in pollution emissions reduction, and as a measure to achieve an increasingly efficient and competitive economy. Achieving that goal requires developing and/or maintaining sophisticated, robust, and stringent EM&V protocols, methodologies, and practices.

When there is cross-border regulation, the most critical need in all regions relates to developing and agreeing upon consistent intraregional EM&V protocols, methodologies, and practices appropriate to the types of energy efficiency programs being implemented now and expected to be implemented in the future. Furthermore, all regions need to provide adequate technical, institutional, financial, and human resources to ensure that energy efficiency EM&V can be developed and implemented effectively.

The following actions could be implemented by relevant authorities and/or EM&V practitioners in the regions studied to help solidify regional EM&V information sharing and capacity building:

- Support and strengthen ongoing regional work aimed at harmonizing EM&V approaches, protocols, and methods resources in each region, and develop an interregional knowledge base
- Sponsor and encourage professional forums with participation by energy and environmental regulators in and among regions to promote EM&V knowledge exchange and networking opportunities
- Develop a basis for EM&V training curricula, including what skills are needed for different types and levels of evaluation (e.g., top-down deemed savings, econometric approaches, and bottom-up field data approaches)

1. Introduction

1.1 Purpose

This paper reviews energy efficiency evaluation, measurement, and verification (EM&V) in four regions of the world: China, Europe, India, and the United States.

Energy efficiency EM&V comprises actions undertaken to assess and document the outcomes of energy efficiency activities. This paper focuses mostly on EM&V of energy efficiency programs in which businesses or households are provided with some incentive to purchase and install energy efficient measures or to take actions that will increase the energy efficiency of a business or residence.

The purpose of energy efficiency EM&V is:

- to determine the level of energy and/or demand savings achieved by an energy efficiency program (measurement);
- to confirm that these savings were actually achieved (verification); and
- to assess the effectiveness of the methods used to achieve the energy savings (evaluation).

The EM&V protocols, methodologies, and practices discussed in this paper may also be applied, with appropriately varying emphases, to assessing energy efficient building codes, energy performance standards for appliances and equipment, and impacts on wholesale and retail energy markets.

Energy efficiency EM&V is often used in situations in which there are direct financial consequences, such as utilities or energy services companies (ESCOs) receiving performance rewards for achieving set levels of energy or demand savings. EM&V can also be used to assess a range of issues, such as the level of acceptance and enforcement of energy efficiency codes and standards, and whether changes in the marketplace require additional program efforts, tax credits, regulatory actions, or other interventions to achieve the desired level of energy or demand savings.

1.2 Objectives

This paper is designed to serve the following key objectives:

- to provide an overview of energy efficiency targets, policies, and programs within each of the four regions covered in the paper that determine potential requirements for energy efficiency EM&V;
- to suggest how states/provinces/nations in each region can more effectively implement energy efficiency EM&V, in the context of the region's unique goals and circumstances; and
- to identify gaps in EM&V practices in each region, and possible solutions to these gaps.

1.3 Organization of Paper

In the remainder of this paper:

- Chapter 2 reviews the general characteristics of energy efficiency EM&V, including: identifying various types of energy efficiency activities, defining the major terms used in EM&V, describing the objectives of energy efficiency EM&V, categorizing the different types of evaluations, and outlining impact evaluation methodologies;
- Chapters 3 to 6 outline for each region: energy efficiency policies and programs, institutional arrangements regarding energy efficiency, and energy efficiency EM&V practices and trends; and
- Chapter 7 summarizes findings and recommendations.

The paper also includes four appendices that contain supporting information as follows:

- Appendix A: Compliance Evaluation Scheme for the Energy Efficiency Obligation in China
- Appendix B: Glossary of EM&V Terms
- Appendix C: Abbreviations and Acronyms
- Appendix D: People Interviewed for this Project

2. Characteristics of Energy Efficiency EM&V[2]

2.1 Energy Efficiency Activities

Figure 1

Hierarchy of Energy Efficiency Activities[3]

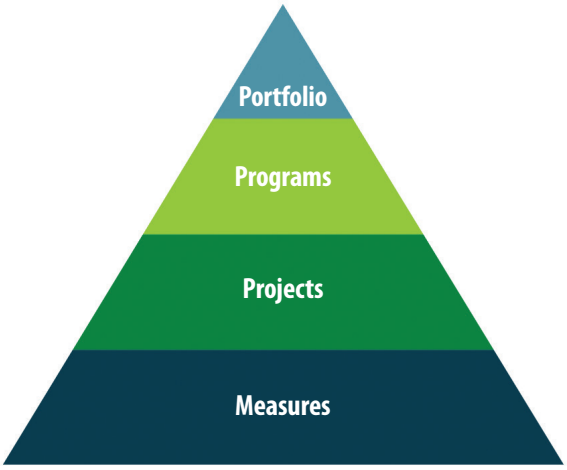


Figure 1 shows the hierarchy of activities undertaken during the process of acquiring energy savings.

Energy efficiency measures are the activities implemented at an end-use energy consumer facility that directly reduce energy or demand use while maintaining or improving service. A measure may comprise: an installed piece of equipment or system; or a strategy intended to affect consumer energy use behaviors; or modification of equipment, systems, or operations that reduces the amount of energy that would otherwise have been used to deliver an equivalent or improved level of end-use service. Examples include lighting retrofits, HVAC retrofits, and building commissioning.

Energy efficiency projects are coordinated activities to install one or more measures at a facility. A project is an activity or course of action involving one or multiple energy efficiency measures at a single facility or site. Examples include home energy efficiency retrofits and commercial new construction projects.

Energy efficiency programs are collections of similar projects that are intended to motivate customers in a specific market segment to implement more energy efficiency. A program is an activity, strategy, or course of action undertaken by a program implementer or administrator. Each program is defined by a unique combination of program strategy, market segment, marketing approach, and energy efficiency measure(s). Programs consist of a group of projects with similar characteristics and installed in similar applications. Examples include a utility program to install energy-efficient lighting in commercial buildings, a developer's program to build a subdivision of homes that exceed common practice in relation to energy efficiency, or a jurisdiction's effort to improve compliance with energy efficiency codes.

Energy efficiency portfolios are multiple program initiatives in specific market sectors. A portfolio may be either (1) a collection of similar programs addressing the same market segment (e.g., a portfolio of residential programs), technology (e.g., motor efficiency programs), or mechanisms (e.g., loan programs), or (2) the set of all programs administered by one organization, such as a utility.

2.2 EM&V Definitions

The term **evaluation, measurement, and verification (EM&V)** is a catchall term used to describe the process of determining either or both program and project impacts.

Evaluation involves the conduct of any of a wide range of assessment studies and other activities aimed at

2 This chapter is based on the *Energy Efficiency Program Impact Evaluation Guide* prepared by Steven Schiller (State and Local Energy Efficiency Action Network, 2012). Steve Schiller has been working on energy efficiency EM&V for more than 30 years and the *Evaluation Guide* is a summary of definitions, approaches, and best practices he developed during that time. Rather than reinventing the wheel, this chapter draws heavily on Steve Schiller's material in the *Evaluation Guide*.

3 State and Local Energy Efficiency Action Network (2012).

determining the effects of an energy efficiency program (or a portfolio of programs). This includes understanding or documenting program performance, program or program-related markets and market operations, program-induced changes in energy efficiency markets, levels of demand or energy savings, or program cost-effectiveness.

Measurement and verification (M&V) activities comprise the documentation of energy (and/or demand) savings at individual sites or projects using one or more options that can involve measurements, engineering calculations, statistical analyses, and/or computer simulation modeling. M&V activities can be stand-alone or they can be a subset of program impact evaluation.

Generally speaking, the differentiation between evaluation and M&V is that evaluation is associated with programs (or portfolios), whereas M&V is associated with projects. Contractors and the owners of facilities tend to be interested only in M&V on their own project(s), while program administrators are interested in evaluation of their programs and portfolios.

Although the acronym EM&V is used to cover all three activities, it is important to separate out the individual activities and who can do them. **Measurement** can be done by the proponent of an energy efficiency project or by an independent party; **verification** has to be done by the program administrator or by a party engaged by the program administrator who is independent of the project proponent; and **evaluation** should be carried out by a party who is independent of both the project proponent and the program administrator. There is also a time difference between the three activities – M&V activities are almost continuous, whereas evaluation is periodic.

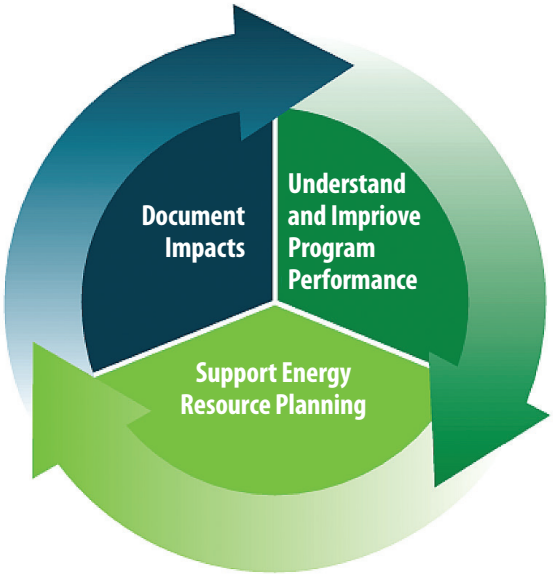
2.3 Objectives of Energy Efficiency EM&V

EM&V has three primary objectives, shown in Figure 2:

1. **Document the benefits** (i.e., impacts) of a program, and determine whether the subject program (or portfolio of programs) met its goals
2. **Identify ways to improve current and future programs** through determining why program-induced impacts occurred
3. **Support energy demand forecasting and resource planning** by understanding the historical and future resource contributions of energy efficiency compared to other energy resources

Figure 2

Objectives of Energy Efficiency EM&V[4]



2.4 Types of Evaluations[5]

The variety of evaluation activities that are associated with energy efficiency can be categorized in several different ways, one of which is to define evaluations as either formative or outcome. **Formative evaluations** are associated with helping efficiency programs be as effective as possible. **Outcome evaluations** are associated with documenting program results.

The most common way to categorize energy efficiency evaluations is as impact, process, or market evaluations.

Impact evaluations are outcome evaluations of the changes attributable to energy efficiency programs. Impact evaluations usually focus on determining the quantity of changes in energy use and demand associated with a program. Calculation of non-energy benefits (or co-benefits) such as avoided emissions and job creation that directly or indirectly result from a program can also be an output of impact evaluations. Impact evaluations often support cost-effectiveness analyses that document the relationship between the value of program results (i.e.,

4 State and Local Energy Efficiency Action Network (2012).

5 This section is based upon State and Local Energy Efficiency Action Network, (2012).

energy, demand, and emissions savings) and the costs incurred to achieve those benefits. Cost-effectiveness (sometimes called cost-benefit) analyses may also be aimed at identifying relative program costs and benefits of energy efficiency as compared with other energy resources, including both demand- and supply-side options.

Process evaluations are formative evaluations of energy efficiency programs that document program operations and identify and recommend improvements to increase the programs' effectiveness in acquiring energy efficiency resources, preferably while maintaining high levels of participant satisfaction. For example, process evaluations can include an assessment of program delivery from design to implementation, to identify bottlenecks, successes, failures, constraints, and potential improvements. Process evaluations also assist in interpreting the results of impact evaluations.

Market evaluations are assessments of the structure or functioning of a market, the behavior of market participants, and/or market changes that result from one or more energy efficiency programs. Market evaluations indicate how the overall supply chain and market for energy efficiency products works and how they have been affected by a program. They may include estimates of the current market role of energy efficiency (market baselines), as well as the potential role of energy efficiency in a local, state, regional, or national market (potential studies).

2.5 Impact Evaluation Methodologies

This paper is primarily concerned with impact evaluations of energy efficiency programs.

2.5.1 Counterfactual Scenario[6]

In theory, the actual energy saving achieved by an energy efficiency program is the difference between the amount of energy that participants in the program use relative to the amount of energy those same participants would have used had they not taken part in the program during the same time period. This baseline is called the **counterfactual scenario**. Defining the counterfactual scenario is the fundamental concept and the greatest challenge to estimating the level of energy or demand savings and documenting the benefits of an energy efficiency program.

In practice, we can never directly observe how much energy participants would have used had they not taken part in an energy efficiency program. There is no direct way of measuring energy or demand savings, because (1) it is not possible to measure a participant's energy use, at the same time, with and without the program; and (2) one cannot measure the absence of energy use. Consequently, the energy and demand savings values (and any associated non-energy benefits) for an energy efficiency program that are produced by EM&V are always going to be estimates. The use of these estimates as a basis for decision-making can be called into question if their sources and level of accuracy are not analyzed and described.

2.5.2 Gross vs Net Savings

For energy and demand savings, the primary metrics are known as gross (energy or demand) savings and net (energy or demand) savings.

Gross energy or demand savings are the change in energy consumption and/or demand that results directly from program-related actions taken by participants in an efficiency program, regardless of why they participated. This is the physical change in energy use after taking into account factors not caused by the program-related (e.g., changes in weather or building occupancy).

Adjusted gross savings are gross savings that are adjusted to include what can be physically counted and reliably measured, such as installation/in-service rates, breakage of equipment, data errors, hours of use, measure persistence rates, and so on. Adjusted gross savings can also be calculated by applying a **realization rate** to **gross savings** estimates. Most regions determine adjusted gross savings through M&V activities, although the M&V methods vary substantially. A **realization rate** is the ratio of what was expected based on the data tracking system versus what was verified. **Net energy or demand savings** are the change in energy consumption and/or demand that is attributable to a particular energy efficiency program. Estimating net energy savings typically involves assessing free ridership and spillover: **free ridership**[7] refers to the portion of energy savings that participants would have achieved in the absence of the program through their own initiatives and expenditures; **spillover** refers to the

6 This section is based upon State and Local Energy Efficiency Action Network (2012).

7 In the United Kingdom, free ridership is called "deadweight."

program-induced adoption of measures by non-participants and participants who did not claim financial or technical assistance for additional installations of measures supported by the program.

The difference between these two metrics is associated with: (1) attribution of the savings, whether the savings were caused (entirely or partially) by the program being considered, or by other influences such as prior year programs or other programs/influences operating at the same time as the program; and (2) differences in how different entities (e.g., regulatory bodies) define net and gross savings.

2.5.3 Impact Evaluation Approaches

Impact evaluation approaches used to determine energy and demand savings can be grouped into two conceptual frameworks: non-control group approaches and control group approaches.

Non-control group approaches. With these approaches, pre-project (or pre-program) baseline energy use is defined using one or more of a variety of different methodologies. This baseline is compared with post-project (or post-program) energy use measurements or assumptions to estimate savings. These non-control group approaches generate estimates of gross savings, which require adjustments to determine net savings.

Control group approaches. These approaches use analysis of large-scale energy consumption data. With these approaches, a comparison group's energy use is compared with the energy use of program participants. These approaches, in most cases, generate estimates of net savings, taking into consideration free ridership and participant spillover, but do not take into account non-participant spillover and long-term market effects, which some jurisdictions include in the net savings determination.

Non-Control Group Approaches

Measurement and verification. M&V is the process of using actual measurements to reliably determine energy and/or demand savings created within an individual facility. The International Performance Measurement and Verification Protocol (IPMVP), an international M&V guidance document[8], defines four M&V options used to assess energy efficiency projects and programs: two end-use metering approaches, energy use data (billing data) regression analysis, and calibrated computer simulation.

Deemed energy or demand savings. Deemed energy savings are based on specified energy savings values for each installed energy efficiency measure, drawn from historical values in typical projects. Sources of such historical values include prior year M&V or large-scale consumption data analysis studies. Unlike the M&V approach, in projects where deemed savings are used there are no (or very limited) measurements taken; instead, only the number of measures implemented is verified (e.g., number of motors installed correctly, number of point-of-sale compact fluorescent lamps [CFLs] that were sold). The energy or demand savings achieved by the project are estimated by multiplying the number of installed measures by the specified (or deemed) savings per measure. This approach is only valid for projects with fixed operating conditions and well-known, documented deemed energy saving values.

A variant of deemed savings is the **deemed savings calculation**, in which a specified engineering algorithm is used to calculate the energy and/or demand savings associated with each installed energy efficiency measure. These calculations may include specified assumptions for one or more parameters in the algorithm, but typically they require users to input data associated with the actual installed measure into the algorithm.

Control Group Approaches

The control group approach involves estimating energy or demand savings from projects by measuring the difference between the energy use of facilities (e.g., houses) participating in a program (the "treatment group") and the energy or demand use of a similar comparison group of non-participating facilities (the "control group") during the same period of time.

Randomized controlled trials. In a randomized controlled trial, a study population (e.g., single-family houses in a particular city that have electric heat) is defined and randomly assigned to either the treatment group or the control group. Energy use data are collected for all of the households in the treatment and control group in order to estimate energy or demand savings. The energy savings are then estimated by comparing the difference between the measured energy use (or preferably the difference between

8 Efficiency Valuation Efficiency Valuation Organization (2012).

the measured change in energy use) of the treatment households and the energy use of the control households during the same period.

Quasi-experimental methods. Unlike randomized controlled trials, in quasi-experimental methods the assignment of the control group is not totally random. Because of the difficulty and costs of conducting randomized controlled trials, quasi-experimental approaches are more common, with perhaps the most common being the "pre-post" approach. With this approach, sites in the treatment group after they were enrolled in the program are compared with the same sites' historical energy use before program enrollment. In effect, this means that each site in the treatment group is its own non-random control group. Quasi-experimental methods often suffer from selection bias and may produce biased estimates of energy or demand savings.

In projects using control group approaches, statistical analyses are conducted on the energy use data (typically collected from the meter data reported on monthly utility bills) and other important independent variable data (e.g., weather). These approaches are primarily used for programs with relatively homogenous participants and measures, when project-specific analyses are not required or practical.

3. Energy Efficiency EM&V In China

3.1 Energy Efficiency Policies and Programs

3.1.1 Overview[9]

China's consumption of primary energy has been growing rapidly for many years, as shown in Figure 3.

While energy consumption is increasing in tandem with the growth in gross domestic product (GDP), the energy intensity of the Chinese economy has been decreasing steadily since 1980, except for a short-term blip between 2002 and 2005 (Figure 4). Currently, energy intensity in China is still higher than in the United States but is continuing to trend downward, whereas the energy intensity trend in the United States is essentially flat.

The continuing reduction in the energy intensity of the Chinese economy is largely the result of government policies and programs. In China, development of the country's broad and comprehensive energy efficiency programs stems from a realization that, if energy is not used more efficiently, the country's economic growth will be compromised by inadequate energy supply. The main goal of government energy efficiency policy is to uncouple economic growth from proportionate increases in energy use. Severe environmental consequences of continued rapid growth in coal

Figure 3

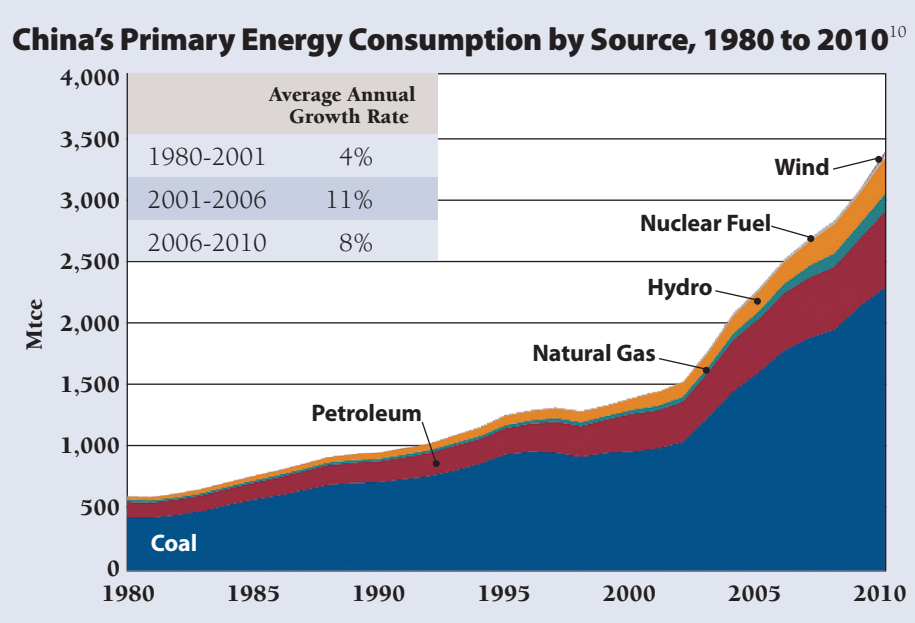
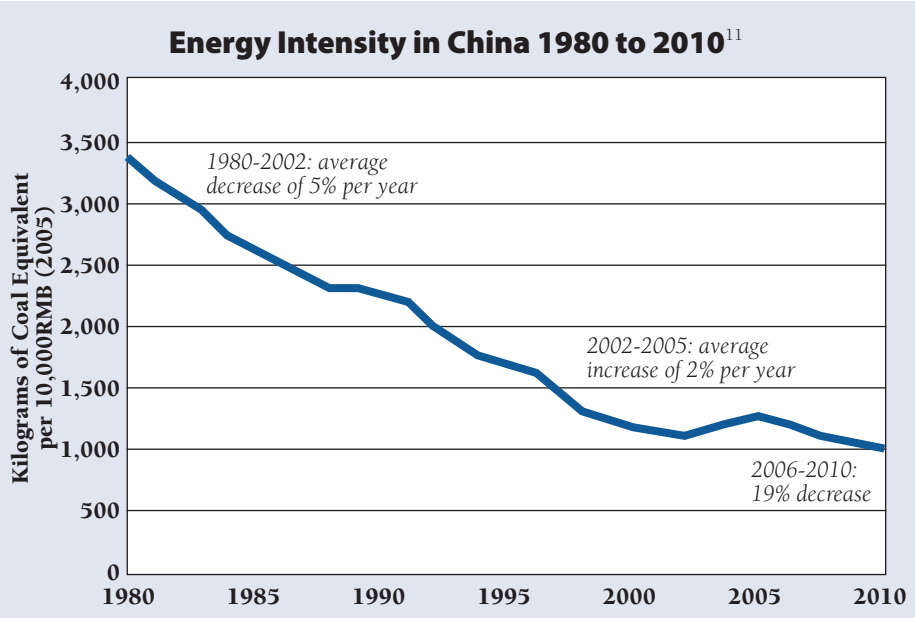


Figure 4



9 This section is mostly taken from Crossley (2013a).
10 Levine (2012).
11 Lin (2011); data from National Bureau of Statistics, China Statistical Abstract, various years.
12 Taylor (2013).

consumption also are a key concern.[12]

Industry, which accounts for 69 percent of final energy use (with electricity accounted at thermal replacement value), is the largest single focus of China's energy efficiency programs, but programs cover all sectors and are implemented primarily through government agencies.

Chinese government involvement in energy efficiency commenced in the 1980s with the establishment of energy efficiency agencies with managerial functions at various levels of government. Energy engineers and energy administrative bodies were also introduced into large- and medium-sized state-owned enterprises, and special personnel were assigned to manage energy efficiency. Over 200 Energy Conservation Centers (ECCs) were set up by local governments and sectoral agencies; their mission was to serve as consultants to government, and to provide energy efficiency service to end users, including training and information. The Centers were originally supported with government funds, but later became dependent on revenues from sales of their services.

In 1997, an Energy Conservation Law was passed by the National People's Congress. This Law provided a policy framework that enabled China's 33 provincial-level governments to promulgate detailed local bylaws and regulations on energy conservation. In particular, the Law required all levels of government to arrange funds to implement energy conservation measures and to set limits, in terms of energy consumption per physical unit of product, for products that are energy-intensive to produce. The Law also required local governments to establish a system for discontinuing backward, over energy-intensive, energy-consuming products and equipment. This led to major programs to close down old, small-scale, and inefficient energy-intensive industrial capacity, including the progressive closure of old, emissions-intensive power stations. These programs continue today.

The 1997 Energy Conservation Law identified key energy-using entities as those that had an annual energy consumption equivalent to more than 10,000 tons of standard coal equivalent (tce). These entities were required to appoint an energy manager and to submit periodic reports to the government on energy consumption, energy use efficiency, and the energy conservation measures they implemented. The Law also authorized various levels of government to "supervise and manage" energy conservation work in their jurisdictions. This led to the establishment of Energy Conservation Supervision Centers (ECSCs) by many provincial-level governments, with powers to inspect facilities, to levy fines on offenders, and even to close down offenders.

In 2004, in response to the increase in energy intensity commencing in 2002, the national planning body in China issued the Medium and Long-Term Energy Conservation Plan. The overriding goal of the Plan was to reduce national energy intensity by 20 percent between 2005 and 2010. The Plan specifically defined "Ten Key Energy-Saving Projects," including: coal-fired industrial boiler retrofits, residual heat and pressure utilization, petroleum saving and substitution, motor system energy saving, and energy system optimization. The Plan set energy intensity targets for the years 2010 and 2020 for individual energy-intensive industries, including cement, steel, petrochemicals, oil refining, and electricity generation. The Plan also specified raising energy efficiency standards for major energy-using appliances to international levels by 2010. In 2007, many of the same targets, objectives, and policies appeared in both the 11th Five-Year Plan and the China National Climate Change Program.

In 2007, the National People's Congress passed an amended Energy Conservation Law. The 2007 Law includes a provision that the state "will implement a system of accountability for energy conservation targets and a system for energy evaluation whereby the fulfillment of energy conservation targets is taken as one part of the evaluation of local people's governments and their responsible persons." The Law therefore makes achievement of energy intensity targets a component of the performance evaluation of local governments and their officials. Individual government officials may be subject to sanctions if energy intensity targets in their areas of responsibility are not met.

The 2007 Law requires reports to government by key energy-using entities to be made annually. In addition to the requirements under the 1997 Law, these reports must also contain information about whether the entity's energy intensity targets were achieved. The Law authorizes the imposition of penalties on key energy-using entities that fail to achieve targets or implement energy efficiency measures; this covers more than 15,000 enterprises. The Law also authorizes the implementation of a system of differential electricity pricing whereby enterprises in some energy-intensive industries can be charged higher prices if their operations fail to meet energy intensity targets. Differential electricity pricing is applied to enterprises in eight industries.

Enterprises are classified into four categories, depending on the energy efficiency level of the technology they are using: "Disallowed," "Restricted," "Allowed," and "Encouraged." Enterprises using technologies falling into the first two categories are charged premium prices for electricity; enterprises using the other two technology categories are charged normal prices.

Table 1

Key Energy and Pollution Reduction Goals in China's Five-Year Plans[16]

	11th Five-Year Plan		12th Five-Year Plan	
Key Indicators	**Targets**	**Actual**	**Mandatory Targets**	**Guiding Targets**
Energy intensity reduction	20.00%	19.10%	16.00%	
Carbon intensity reduction	not set	n/a	17.00%	
Non-fossil-fuel energy share	not set	8.3%	11.40%	
Annual GDP growth rate	7.50%	11.20%		7.00%
R&D investments as share of GDP	2.00%	1.75%		2.20%
Urbanization as portion of total population	47.00%	47.50%		51.50%
Major pollutant reductions:				
Sulfur dioxide (SO_2)	10.00%	14.29%	8.00%	
Chemical oxygen demand (COD)*	10.00%	12.45%	8.00%	
Nitrous oxides (NOx)	not set	n/a	10.00%	
Ammonia nitrogen (NH_3-N)	not set	n/a	10.00%	
Total forest coverage	20.00%	20.36%	21.66%	

**An indirect measure of water pollution*

3.1.2 Energy Intensity and Carbon Reduction Targets

Energy intensity targets (targeted declines in energy use per unit GDP) have been the centerpiece of China's energy efficiency policy since national targets were first set in the 2004 Energy Conservation Plan. Currently, five-year and annual targets are set at national, provincial, and local levels, and rigorously monitored and supervised. Government agencies responsible for oversight of target compliance, and implementation of the large number of energy efficiency programs designed to help meet them, have become sophisticated in their planning and management practices. Energy intensity targets are readily converted to energy savings delivery goals (and often absolute energy consumption goals as well) assuming a planned GDP growth rate. Energy savings delivery targets are assigned to various groups and sectors, allowing some room for underperformance or differences from planned GDP growth. Estimated total incremental energy use "space" available, given the energy intensity targets and assumed GDP growth, is often actively managed, especially toward the end of the five-year plan.[13] Large new energy-using projects may be evaluated against available "space" as part of the project approval process.

China's leadership continues to insist that achieving energy intensity targets is essential. Macro-level energy intensity targets are expected to be an important policy mechanism in China for the foreseeable future. In addition, in late 2013, driven largely by concerns about air quality, China commenced a transition toward absolute energy use, coal use, and carbon emission caps, with absolute coal consumption caps set for the Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta regions.[14] Provided that some form of "safety valve" is incorporated to accommodate large unforeseen changes in economic output trends, transition to absolute caps may not be a radical departure from the current system.[15]

Table 1 shows the key energy intensity and pollution reduction targets in the previous 11th Five-Year Plan (2006 to 2010) and the current 12th Five-Year Plan (2011 to 2015).

Table 2 provides more detail on energy intensity targets and programs in the 11th and 12th Five-Year Plans and in

13 Taylor (2013).

14 Clean Air Alliance of China (2013).

15 Taylor (2013).

16 Source: Lin (2011).

Table 2

Comparison of Energy Efficiency Policies and Programs in China's 11th and 12th Five-Year Plans[17]

		11th Five-Year Plan (2006–2010)	12th Five-Year Plan (2011–2015)
National Plan	Target*	• By 2010, energy intensity should be reduced by 20 percent from 1.22 tce/10,000 RMB in 2005 to 1.0 tce/10,000 RMB in 2010. • A total of about 600 million tce of energy will be saved during the 11th Five-Year Plan.	• By 2015, energy intensity should be reduced by 16 percent from 1.034 tce/10,000 RMB in 2010 to 0.869 tce/10,000 RMB, decreasing by 32 percent compared to 1.276 tce/10,000 RMB in 2005. • A total of about 670 million tce of energy will be saved during the 12th Five-Year Plan.
		Top 1000 Enterprises	**Top 10,000 Enterprises**
Action Plan	Target	A total of 100 million tce of energy was saved during the 11th Five-Year Plan.	A total of 250 million tce of energy will be saved during the 12th Five-Year Plan.
	Numbers	1008 "Top 1000" enterprises in 2004	About 17,000 "Top 10,000" enterprises in 2010
	Percentage	In 2004, the Top 1000 enterprises consumed 670 million tce of energy, accounting for 33 percent of national energy consumption.	The energy consumed by the Top 10,000 enterprises accounts for over 60 percent of national energy consumption.
	Threshold	Enterprises with total annual energy consumption that exceeds 180,000 tce	Enterprises with total annual energy consumption that exceeds 10,000 tce
		Ten Key Projects	**Key Energy Conservation Projects**
	Target	A total of 240 million tce of energy was saved during the 11th Five-Year Plan.	A total of 300 million tce of energy will be saved during the 12th Five-Year Plan.

RMB = renminbi (China's currency unit).
**Energy intensity targets are calculated at 2005 constant prices.*

the action plans that accompany the Five-Year Plans.

National level targets are set by the central government, and are then subdivided and assigned with clear accountabilities for delivery to provincial-level governments and to administrators of key national programs. Provincial-level targets are set by the State Council, based on submissions from provincial-level governments that include factors such as: the development level, industrial structure, energy intensity, total energy consumption, per capita energy consumption, and level of energy self-supply in the province. Energy intensity targets for lower levels of government at the prefectural and county levels are allocated and supervised by provincial-level governments. Targets for individual enterprises under energy savings responsibility contracts are set by the central government for large energy users and by lower levels of government for smaller users. ECSCs are responsible for supervising the energy efficiency and energy consumption of local enterprises on behalf of the local government. The central government's evaluation of each province's performance in meeting its energy intensity target is led by the National Development and Reform Commission (NDRC) in cooperation with other central government agencies. Individual government officials may be subject to penalties and/or sanctions if energy intensity targets in their areas of responsibility are not met.[18]

17 Liu (2012).

18 Crossley (2013a).

3.1.3 Individual Energy Efficiency Programs[19]

Top Energy-Using Enterprises Program

In 2006, the central government established a program of agreements between government and individual enterprises on specific enterprise energy intensity targets, including monitoring and supervision of compliance with these targets. Initially the government required the top 1008 energy-using enterprises that consume at least 180,000 tce per annum to participate in the program. In 2011, the program was expanded to become the so-called Top 10,000 Energy-Using Enterprise Program covering the 16,078 total enterprises that consume at least 10,000 tce per annum. In addition, provinces and prefectures have added thousands of enterprises consuming between 5000 and 10,000 tce per year to the program.

Under the program, agreements on energy efficiency measures and energy intensity targets are established in energy savings responsibility contracts. Central government agencies set the objectives, targets, scope, and implementation guidelines in the contracts. Provincial-level governments are in charge of most of the details of implementation. Progress in each individual enterprise is evaluated annually.

Enterprises are required to report on energy use patterns in specified formats, to assign energy management personnel, and to meet energy use ceiling standards for various processes and equipment, as well as to achieve their energy intensity targets. For new large investment projects, enterprises also must prepare an energy impact assessment, similar in many ways to an environmental impact assessment, which must be approved by the government. Government supervising authorities are required to assess progress toward targets and compliance with regulations every year. The authorities also assist enterprises to take advantage of the wide range of government support programs available; this assistance is provided through the ECSCs.

With the additional enterprises signed up by provincial- and prefectural-level governments, the energy savings responsibility contracts system now covers well over 20,000 key industrial enterprises. These enterprises account for approximately 85 percent of China's total industrial energy use, approximately 60 percent of China's total final energy use, and approximately 60 percent of China's final electricity use.

Energy Efficiency in Buildings

In 1986, China adopted its first mandatory national energy efficiency building codes; these were for new residential buildings in the cold region and in the severe-cold region. Codes were adopted for the hot-summer/cold-winter region in 2001, the hot-summer/warm-winter region in 2003, and for new public and commercial buildings in 2005. These codes are being progressively updated. In recent years, China has put significant emphasis on code compliance and enforcement and there has been a sharp increase in compliance by new residential buildings. New programs have been established for energy conservation retrofitting of existing buildings. Progress has also been made on the reforms necessary to achieve significant energy savings in buildings served by district heating schemes in northern China.

Appliance Energy Performance Labeling and Standards

China has established both energy performance labeling and minimum energy performance standards (MEPS) for appliances. The MEPS program mandates maximum allowable energy consumption for numerous types of appliances and equipment, with each MEPS revision typically increasing stringency by approximately 10 percent over the previous level. Currently China does not have adequate market data to assess the penetration of energy efficient appliances covered by the standards in place. The central government has increased efforts to improve enforcement and monitoring of appliance energy-efficiency standards but does not yet have a clear picture of what is happening in the marketplace.

Support for an Energy Services Industry

A new energy services industry in China was launched as part of a deliberate plan by the Chinese government with support from the World Bank. In 1995 and 1996, the World Bank and the government agreed to mobilize technical and financial assistance to introduce and develop energy performance contracting (EPC) in China. Funding was provided to three new pilot Chinese ESCOs that were started with assistance from three provincial-level

19 This section is mostly taken from Crossley (2013a).

governments. This provided the three pilot ESCOs with a dedicated large line of credit to assist with making the EPC business model actually work. Subsequently, private sector ESCOs were started and the industry grew rapidly so that in 2011 there were approximately 3900 ESCOs in China. In 2010, the State Council issued a policy document instructing local governments and ministries to support development of the energy services industry. The government also extended its existing financial incentives for energy efficiency measures to cover qualified EPC projects. In mid 2013, the incentive was RMB (renminbi) 240 per tce energy saving from the central government and a matching incentive of at least RBM 60 per tce saved from the local government.

Grid Company Energy Efficiency Obligation

From January 2011, the central government placed an energy efficiency obligation (EEO)[20,21] on State Grid and China Southern Grid, the two large government-owned combined electricity transmission, distribution, and retail companies. The obligation requires the grid companies to achieve energy savings of at least 0.3 percent in sales volumes and 0.3 percent in maximum load compared with the previous year. The obligation also lays a foundation for the expansion of demand response programs by requiring the installation of load monitoring equipment on 70 percent of the peak load, and load control equipment on 10 percent of the peak load, in any locality. The energy and demand targets set by the obligation can be met with end-use energy savings from all economic sectors and from any facility. In addition, reduction of losses in transmission and distribution networks can also be used to meet part of the targets.

Demand-Side Management Pilot Cities Program

A program to promote integrated demand-side management (DSM) activities in up to 100 cities has been launched for implementation during the 12th Five-Year Plan (2011 to 2015). Four pilot cities were selected in 2011: Beijing, Suzhou, Foshan, and Tangshan. In March 2012, the Ministry of Finance (MOF) and the NDRC issued their joint method for managing investment awards (post-project-commissioning investment grants) for complying activities implemented under the DSM pilot cities program. The central government is providing grants of RMB 450 per kilowatt (kW) of peak load reduced permanently through specific projects in eastern China, and RMB 550 per kW in western China. Temporary peak load reductions are awarded RMB 100 per kW. There are specific definitions of "permanent" and "temporary" load reductions; permanent load reductions equate mainly to energy efficiency and load shifting, whereas temporary load reductions are primarily demand response. In November 2012, MOF and NDRC announced that the first four pilot cities had been granted access to the investment grants. Aware of the opportunity for receiving similar grant support, a number of additional cities applied in 2013 to be included in a second batch of DSM pilot cities.

3.2 Institutional Arrangements[22]

Responsibilities for implementation of China's energy efficiency programs are divided among a number of different government agencies. Figure 5 provides an overview of the key agencies involved at both the central and provincial government levels.

Central government ministries report directly to the State Council, provincial government agencies report directly to the Provincial Governor's Office, prefecture government agencies report directly to the Prefectural Director's Office, and so forth. Prefecture governments, and county governments further below them, are organized along very similar lines as their provincial governments, with units with responsible staff covering the same assignments in most cases, but at lower levels. Additional but generally quite narrow energy efficiency programs are implemented by other government agencies, also organized with vertical work systems, but those are not included in Figure 5 for simplicity (two examples include transportation and public institution energy conservation programs).

In Figure 5, units depicted in the same color are part of the same government hierarchical "work system" (xitong). For example, MOF and provincial finance bureaus (both green) are in the same work system. Ministries, commissions, and departments operating in the same "work

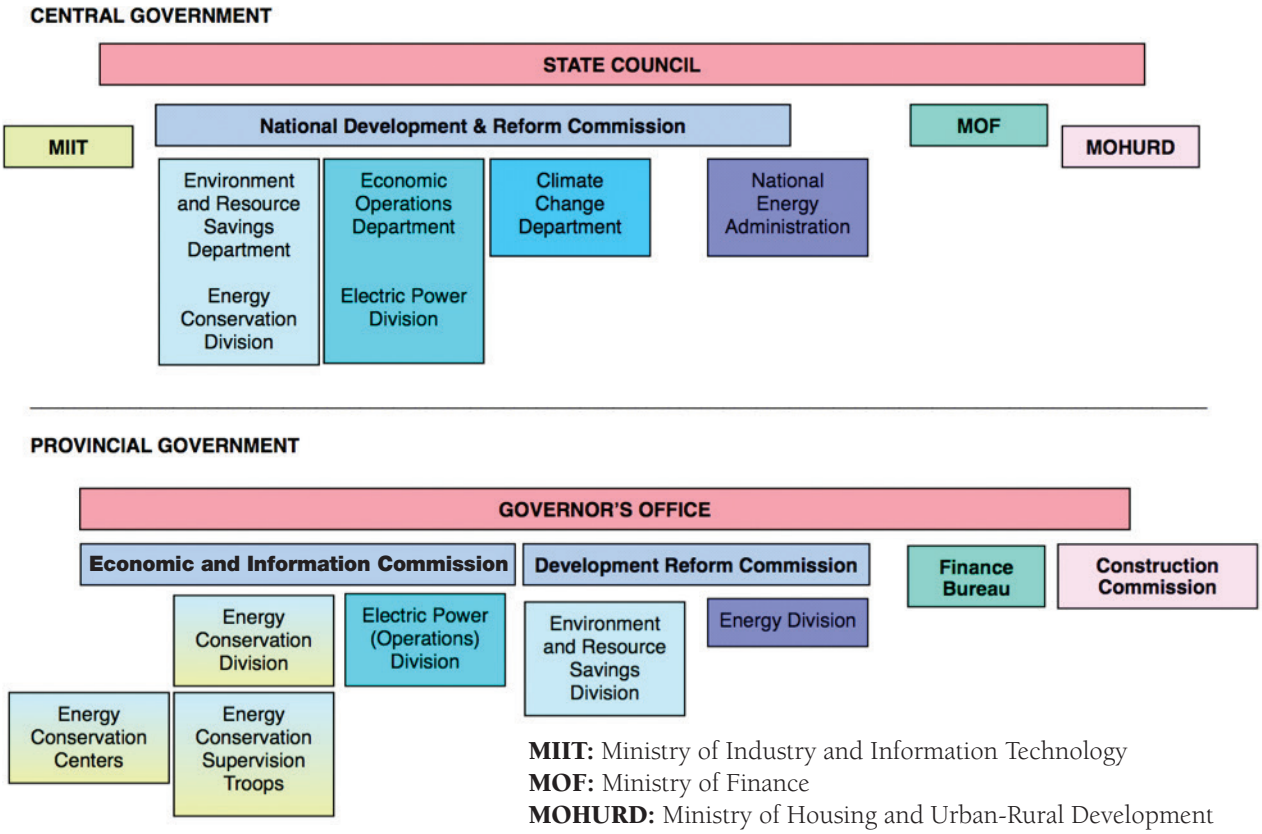
20 National Development and Reform Commission (2010).

21 Crossley, D., Gerhard, J., Kadoch, C., Lees, E., Pike-Biegunska, E., Sommer, A., Wang, X., Wasserman, N., and Watson, E. (2012).

22 This section is mostly taken from Taylor (2013).

Figure 5

Key Government Agencies Responsible for Implementing Energy Conservation Programs in China[23]



system" have a strong hierarchical operational relationship on the professional matters of their work. MOF cannot give a direct order to a provincial finance bureau (which reports to the Governor), but it does set policy, operational procedures, and program implementation guidance for provincial finance bureaus. The vertical professional work system thus greatly facilitates program implementation across the country within a given work system. However, attempts to cross work systems are usually challenging.

Because of the importance of energy efficiency to the country, "leading groups" are organized at the highest integrated levels of government, including representatives of the key government agencies involved, to coordinate the overall effort. The State Council has organized a leading group for energy efficiency and emissions reduction. The Governor's Offices in the provinces also have organized such leading groups. Subject to leading group coordination, energy efficiency programs are implemented by separate government agencies and their vertical hierarchy work systems.

3.2.1 Central Government Agencies

The main central government agencies involved in energy efficiency, and their work systems at the provincial level, are described below.

NDRC and provincial/local Development Reform Commissions and Economic Commissions. The National Development and Reform Commission (NDRC) provides integrated management of the economy at national, provincial, and local levels and is a merger of two previously separate bodies, the former Planning Commission and Economic Commission. The Planning Commission has always been in charge of preparation and oversight of the five-year and annual economic plans, capital investment, pricing, and some other key tasks. The Economic Commission has always been in charge of the operation or "dispatch" of the (planned) economy,

23 Taylor (2013).

day-to-day coordination of problems, and investment in energy efficiency. At the provincial and local level, almost all governments have retained separate commissions: Development and Reform Commissions (DRCs, analogous to previous Planning Commissions), and Economic and Information or Economic and Industry Commissions (EICs, basically analogous to previous Economic Commissions). In terms of vertical work systems, NDRC departments with previous Economic Commission functions work together with provincial and local EIC division counterparts, whereas NDRC departments with previous Planning Commission functions work together with provincial and local DRC division counterparts.

NDRC's Environment and Resource Savings Department. This department has a particularly strong role in China's energy efficiency efforts. It is responsible for the drafting and oversight of the energy efficiency aspects of the five-year plans. It supervises progress on achieving China's energy intensity targets and leads the annual review of the compliance of all provinces with these targets. It has designed and supervises the Top 10,000 Enterprise Program. It is involved in many industrial energy efficiency programs (in conjunction with the Ministry of Industry and Information Technology [MIIT]), and reviews programs and progress on buildings, transport, household appliances, and other areas implemented by other ministries. It oversees government policies relating to ESCOs and energy savings monitoring and verification. It is responsible for the substantive aspects of the government investment award programs for renovation projects, ESCOs, and appliance rebates (whereas MOF is responsible for fiduciary and disbursement aspects). Its work system arrangements in the provinces, however, are complicated, relating to both DRC environment and resource savings divisions, and together with MIIT, with EIC energy efficiency divisions and their sub-agencies. These provincial government agencies generally report professionally (i.e., for work system purposes) to both NDRC and to MIIT (hence the blended color in Figure 5).

NDRC's Economic Operations Bureau. This bureau carries out economic operational dispatch functions, including administering the EEO placed on the grid companies. It has work system affiliations with provincial EICs.

NDRC's Climate Change Department. This is a new department without historical affiliations. Work system affiliations in the provinces relate to provincial DRCs. Separate DRC Climate Change Divisions are beginning to be formed in some provinces.

National Energy Administration. Now reporting directly to the State Council but administratively still housed with NDRC, the National Energy Administration (NEA) carries energy supply industry oversight and regulatory functions. In 2013, the former State Electricity Regulatory Commission was merged into the NEA. The NEA's work system in the provinces involves energy units of DRCs.

Ministry of Industry and Information Technology. MIIT is a relatively new ministry, established in 2008. It maintains an Energy Conservation and Comprehensive Utilization Department, with an Energy Conservation Division. Although charged with oversight responsibility for industrial energy efficiency, there have been work scope disagreements with NDRC's Environment and Resource Savings Department. MIIT's work system affiliations in the provinces are with the energy conservation units of EICs.

Ministry of Finance. MOF's Economic Construction Department manages the central government's special energy conservation funds. While NDRC oversees the technical appraisal and supervision aspects of these funding programs, MOF has fiduciary and disbursement responsibility. Provincial and local government energy conservation fund management responsibilities similarly lie with provincial and local finance bureau economic construction divisions.

Ministry of Housing and Urban-Rural Development (MOHURD). The Science and Technology Department of MOHURD and its affiliates in provincial and local Construction Commissions implement the government's main programs on building energy efficiency.

3.2.2 Provincial Government Agencies

At the provincial government level, in addition to the major agencies that are part of the central government work system, there are two types of specialized agencies that are directly involved in implementing and monitoring energy efficiency activities.

Energy Conservation Centers. ECCs are affiliated with the local EIC. Key functions of ECCs include policy research related to energy efficiency, development of energy efficiency standards, conducting energy saving pilots in key areas, evaluation and promotion of energy saving products

and technologies, provision of technical assistance, trainings, and education related to energy efficiency.

Energy Conservation Supervision Centers.[24] ECSCs are also affiliated with the local EIC. They are responsible for monitoring and inspecting the energy-related activities of enterprises in their jurisdictions to ensure compliance with energy saving-related laws, rules, regulations, and standards. ECSCs also investigate violations of relevant laws and are responsible for ensuring that energy intensity targets are met. Typical major responsibilities include:

- oversight of the energy savings responsibility contract system on behalf of the signatory government, including assessing annual results; this includes organizing large assessment efforts in the spring of every year;
- development and management of new enterprise energy consumption data reporting, compilation, and analysis systems; these are quite detailed and require frequent reporting; and
- arranging and organizing energy audits for enterprises, especially for enterprises that are obligated to carry out energy audits.

3.3 Energy Efficiency EM&V Practices and Trends

3.3.1 Current EM&V Practices

Because China relies so heavily on setting and monitoring compliance with targets to achieve its energy efficiency goals, there is a significant requirement for energy efficiency EM&V. Indeed, provincial governments in China have established an extensive system of dedicated government agencies, the ECSCs, one of whose major functions is to monitor compliance with energy intensity targets. However, until recently the methodologies used by the Centers, and also by other organizations concerned with energy efficiency EM&V, have been relatively unsophisticated and lacking in stringency.

In China, governments currently focus on reporting program impact results at high, aggregate levels. Process evaluations of energy efficiency programs are almost never undertaken. The main focus of government energy efficiency programs is on achieving energy intensity targets with cost effectiveness being a secondary consideration. Compliance with individual enterprise energy intensity targets is usually assessed by an audit of the enterprise's accounting books to determine the quantity of energy purchased by the enterprise and the quantity of products produced. Evaluating individual energy-efficiency programs and policies to determine the magnitude of their contributions has been difficult because of lack of data. In most cases, program results are based on calculated savings from known details of the programs (appliance standards), surveys (enforcement of building codes), or statements by government officials indicating the magnitude of industrial energy savings without documented sources.

3.3.2 Recent Developments

Recently there have been some moves to improve the sophistication and stringency of energy efficiency EM&V in China. Most of the efforts are on project M&V rather than systematic evaluation. The understanding of holistic program evaluation is very low in China.

In the energy services industry, where payments under shared savings contracts rely on accurate ex ante estimates of energy savings,[25] some ESCOs are working to improve the accuracy of these estimates, including carrying out investment-grade energy audits at sites before energy efficiency measures are implemented.

Government organizations are also improving the M&V methodologies used in impact evaluations of energy efficiency programs. In 2008, NDRC and MOF released a guidance document for auditing energy savings from energy efficiency programs[26] that includes some basic instructions on M&V methodologies and procedures. The document states that the audit process should include auditing of relevant documents, an initial onsite measurement of baseline energy consumption, and a second onsite measurement after energy efficiency measures have been installed. The energy leakage from a project should also be estimated; this is the positive or negative impact of the project on energy use by the relevant processes outside the project boundary. The actual energy saving achieved by the project is then equal to the change in energy use after

24 The staff of ECSCs are sometimes referred to as "Energy Conservation Supervision Troops" because they are often organized on a semi-military basis and wear uniforms.

25 Crossley (2013b).

26 National Development and Reform Commission and Ministry of Finance (2008).

the energy efficiency measures have been installed minus the energy leakage. The document also calls up a national standard that outlines the general principles for monitoring and testing of energy conservation.[27]

In 2011, NDRC established a compliance scheme[28] for the grid company EEO program (see Appendix A), based on a scoring system that awards points for both energy savings achieved and implementation actions completed. Claimed energy savings are currently self-reported by the grid companies using their own EM&V methodologies, including deemed savings values developed for some energy efficiency measures by China Electric Power Research Institute, a subsidiary of the largest grid company, State Grid. In early 2013, NDRC circulated a draft procedures manual for measurement, reporting, and verification of energy savings for trial by the grid companies and provincial governments that was largely based on EM&V practices the United States.

NDRC is currently developing measurement, reporting, and verification protocols and procedures for the DSM pilot cities program. Most of the existing pilot cities have established data platforms to monitor and record energy consumption data for selected major enterprises in their jurisdictions. In addition, the EEO placed on grid companies in 2011 also requires the installation of load monitoring equipment on 70 percent of the peak load. The energy use data being collected by these data platforms will eventually form a valuable national resource that will provide a unique insight into how energy is being used in China.[29] These data will also open up major opportunities for the development and implementation of highly accurate EM&V of energy efficiency projects and programs.

In August 2012, the Efficiency Valuation Organization (EVO) and the China National Institute of Standardization agreed to implement a capacity building program for sustainable energy conservation in China through the standardized M&V of energy savings. The China M&V Capacity Building Program is intended to enhance the capacity of energy professionals to develop transparent M&V plans that measure, calculate, and report energy savings in adherence with Chinese standards and EVO's IPMVP. The program is designed to provide the opportunity for energy professionals to become qualified as a Certified Measurement and Verification Professional through a program conducted in conjunction with the Association of Energy Engineers and an extensive knowledge-transfer initiative.

3.3.3 Improving Current EM&V Practices

It is fair to say that energy efficiency EM&V in China is in its early stages. Work is being done to establish rigorous protocols, standards, and evaluation methodologies, but much remains to be done. Implementing comprehensive, site-based energy audits before and after implementation of energy efficiency measures, in accordance with the 2008 guidance document, will increase the reliability of and confidence in claimed energy savings, especially in the industrial sector. Best practice methodologies designed to identify weaknesses in energy efficiency program design and implementation and to help measure a program's overall impact should include both process and impact evaluations.

Establishing workable EM&V in China is not simply a matter of importing what's been developed and used in other regions of the world. EM&V in China needs to be responsive to the country's current organization and implementation of longstanding and robust energy efficiency programs. Table 3 identifies some issues and gaps and recommends some approaches and actions that may be useful in developing more sophisticated and robust energy efficiency EM&V in China.

27 China National Institute of Standardization (2009).

28 National Development and Reform Commission (2011).

29 Crossley (2013c).

Table 3

Energy Efficiency EM&V Issues and Gaps in China	
EM&V level	Currently focused on M&V of energy savings based on audits of energy consumption records before and after implementation of energy efficiency measures; virtually no process evaluation
EM&V protocols	Introduction of trained third-party independent evaluators to conduct M&V in addition to the ECSCs would help increase the reliability of energy savings reports.
Attribution	No standard methodologies to measure and verify energy and demand savings
Understanding of product markets	Need robust sector and industry-specific M&V protocols; continue supporting current development efforts by domestic and international organizations There is no consideration of gross versus net energy or demand savings; free riders are not identified. Lack of definitive data on what sells in the rapidly growing consumer marketplace; programs aimed at market transformation do not exist currently, but understanding what is happening in those markets would be important for program design and evaluation for those sectors. Well-developed energy performance standards for some appliances and equipment; energy efficiency building codes have been developed, but some questions about the level of implementation and compliance
Guidelines for financial resources committed to EM&V	Guidelines for appropriate EM&V expenditures are needed, as are recognition and commitment of financial resources to train and support a corps of evaluators.
Capacities needed among program administrators at central and provincial levels	Provincial program administrators often lack personnel needed to oversee EM&V with respect to both numbers and appropriate skills. Continued need to develop EM&V technical and training capacities at the national level and at provincial ECSCs. ECSCs need to move beyond auditing energy consumption records to more sophisticated and robust EM&V methodologies.
Capacities needed among grid companies	Better knowledge about customers, including characteristics and key behavioral factors, to understand why customers react to energy efficiency programs as they do and to assist in developing more effective EM&V; this is likely to become more important as China's energy efficiency efforts move more into the commercial sector and possibly into the residential sector.
Overall needs	Current energy efficiency programs focus on achieving mandated energy intensity targets. Cost effectiveness is not a consideration now but may become important as approaches to energy efficiency and EM&V develop further. Better consideration of top-down versus bottom-up EM&V; determine what is most appropriate for varying circumstances Encourage development of process evaluation focusing on optimizing industrial energy efficiency and capturing and disseminating lessons learned as steps toward developing EM&V best practices that are specific to industry needs

4. Energy Efficiency EM&V In The European Union

4.1 Energy Efficiency Policies and Programs

4.1.1 Overview

Several individual Member States of the European Union have been active in implementing energy efficiency policies and programs since the 1980s, acting under their own initiatives. During the 1990s, the European Union commenced imposing various requirements relating to energy efficiency on all the Member States, including specifying energy efficiency targets.

4.1.2 Energy Intensity and Carbon Reduction Targets

In December 1998, the Council of the European Union approved a resolution on energy efficiency[30] in the European Community that endorsed a target for the Community as a whole to improve energy intensity of final consumption by an additional one percentage point per annum up to the year 2010. In April 2006, an E.U. Directive on energy efficiency and energy services[31] required E.U. Member States to adopt, and aim to achieve, an overall national indicative energy savings target of 9 percent by 2016, to be reached by deploying energy services and other energy efficiency improvement measures. The Directive also required Member States to submit National Energy Efficiency Action Plans that listed measures undertaken in the context of the Directive, and to review their effect as far as possible.

In October 2006, the *Action Plan for Energy Efficiency*[32] first proposed that the European Union could save 20 percent of primary energy consumption by 2020. This was formalized into an official target in the 2007 *An Energy Policy for Europe*[33] and was further confirmed in the 2008 document *Energy Efficiency: Delivering the 20% Target.*[34]

The *Europe 2020 Strategy for Smart, Sustainable and Inclusive Growth*[35] was launched by the European Commission in March 2010 and approved by the Heads of States and Governments of E.U. countries in June 2010. The Strategy includes five headline targets that set out where the European Union should be in 2020. One of these targets relates to climate and energy: Member States committed themselves to reducing greenhouse gas (GHG) emissions by 20 percent, increasing the share of renewables in the European Union's energy mix to 20 percent, and achieving the 20-percent energy efficiency target by 2020.[36] The energy efficiency target is the only one of these targets that is nonbinding on Member States.

In March 2011, the European Commission released an *Energy Efficiency Plan 2011*[37] aimed at saving more energy through concrete measures. The purpose of the plan was to set out ideas for binding measures to save energy to achieve the 20-percent energy efficiency target. Projections at that time showed that the measures implemented since 2007 would achieve only a nine-percent reduction in projected "business as usual" energy consumption in 2020 and the 20-percent target would not be met unless further efforts were made. The European Commission's proposals in the 2011 plan focused on instruments to trigger energy efficient renovations in public and private buildings, to improve the energy performance of the appliances used in them, and to foster energy efficiency in households and industry.

30 Council of the European Union (1998).

31 European Parliament and Council (2006).

32 European Commission (2006).

33 European Commission (2007).

34 European Commission (2008).

35 European Commission (2010).

36 This target translates into a savings of 368 million tons of oil equivalent (Mtoe) of primary energy (gross inland consumption minus non-energy uses) by 2020 compared to projected consumption in that year of 1842 Mtoe.

37 European Commission (2011).

In October 2012, the European Union adopted a Directive on energy efficiency[38] that makes some of the measures in the 2011 energy efficiency plan binding on E.U. Member States. This Directive is the current major E.U. legislation that imposes legally binding obligations on E.U. Member States designed to help achieve the 20-percent energy efficiency objective and to pave the way for further energy efficiency improvements beyond that date. The purpose of the Directive is to help Member States meet the European Union's GHG emissions reduction commitments and to contribute to meeting the European Union's goals for moving to a competitive low-carbon economy in 2050, in particular by reducing GHG emissions from the energy sector, and by achieving zero-emission electricity production by 2050.

The Energy Efficiency Directive establishes a common framework of measures for the promotion of energy efficiency within the European Union. It lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy, and provides for the establishment of national energy efficiency targets. The Directive requires each E.U. Member State to set an indicative national energy efficiency target for 2020, based on either primary or final energy consumption, primary or final energy savings, or energy intensity, and report those targets to the European Commission. These are nonbinding national targets and the Commission will propose binding national targets if in 2014 it concludes that the European Union is not likely to achieve the 20-percent energy efficiency target by 2020. The Directive also continues the requirement in the 2006 Energy Efficiency and Energy Services Directive that each Member State must submit a National Energy Efficiency Action Plan and specifies that such plans must be submitted every three years.

4.1.3 Individual Energy Efficiency Programs

The major energy efficiency measures in the Energy Efficiency Directive comprise:

- a legal obligation requiring all Member States to establish energy efficiency obligation (EEO) schemes[39] under which energy distributors or retail energy sales companies are obliged to save every year 1.5 percent of their energy sales, by volume, through implementing energy efficiency measures in end-use customers' premises, such as improving the efficiency of the heating system, installing double glazed windows, or insulating roofs;
- a legal obligation requiring Member States to ensure that public sector agencies purchase energy efficient buildings, products, and services; in addition, agencies have to progressively reduce the energy consumed on their own premises by carrying out every year energy efficient renovation works covering at least three percent of their total floor area;
- a requirement that Member States ensure that energy suppliers provide consumers with easy and free-of-charge access to data on their real-time and historical energy consumption through more accurate individual metering, enabling consumers to better manage their energy consumption; consumer bills should be based on their actual energy consumption as measured by data from the metering;
- a requirement that Member States: (1) ensure that large industrial companies are required to carry out regular audits of their energy consumption to help them identify the potential for reduced energy consumption; and (2) provide incentives for small and medium enterprises to undergo energy audits and ensure that they have access to energy efficiency best practices; and
- a requirement that Member States monitor efficiency levels of new energy generation facilities and establish national heat and cooling plans as a basis for a sound planning of efficient heating and cooling infrastructures, including the application of high-efficiency cogeneration and efficient district heating and cooling, and recovery of waste heat.

4.2 Institutional Arrangements

There are a number of key players in relation to energy efficiency in the European Union. The European Parliament and Council of the European Union, as the legislative

38 European Parliament and Council (2012).

39 Instead of establishing EEO schemes, Member States may choose alternative policies to ensure that the target of 1.5 percent of new energy savings is achieved every year. All policies that contribute to the 1.5-percent target must follow common methods and principles for calculating the impact of the policies as laid out in the Energy Efficiency Directive.

bodies, set high-level goals for energy efficiency and climate change. The European Commission is the executive institution, charged with proposing, implementing, monitoring, and if necessary enforcing Directives and regulations. With respect to energy efficiency, the E.U. Member States take into account the currently nonbinding overall E.U.-wide 20-percent energy efficiency target and develop their own specific energy efficiency targets,[40] policies, and programs.[41] These are detailed in National Energy Efficiency Action Plans produced by each Member State every three years, commencing in April 2014, for review by the European Commission. Each Member State then establishes its own institutional arrangements to implement national energy efficiency policies and programs.

This general method of operation will guide the implementation of the various energy efficiency measures required under the 2012 Energy Efficiency Directive. It allows for considerable flexibility at the national level but it complicates the question of rationalizing the achievement of targets across the European Union as a whole. There are some commonalities:

- in all Member States, the Government sets the energy savings target using the method set out by the European Commission;
- in all Member States, any energy savings from energy taxes designed to stimulate energy efficiency can only be credited for that part of the tax that exceeds E.U. minimum specified levels;
- a level playing field across the European Union multi-country market is set by a common energy efficiency rating or labeling system for electrical appliances and lighting, and soon to cover heating equipment;
- appliance MEPS are uniform across the European Union and set a baseline for determining energy saving improvements;
- building codes are subject to the E.U. Energy Performance of Buildings Directive, which requires that all new public buildings and all other new building construction meet "nearly zero-energy" requirements by the end of 2018 and 2020, respectively; this sets a baseline for determining energy saving improvements that can only be credited if they are beyond building code requirements.

4.3 Energy Efficiency EM&V Practices and Trends

4.3.1 Current EM&V Practices

In the European Union, individual Member States are generally responsible for energy efficiency EM&V. The arrangements for implementing EM&V vary among the Member States. In France, responsibility for EM&V lies with the central government. In Germany, a federated republic, much authority resides within the national government, but in general state governments are largely responsible for determining the extent to which energy efficiency projects have met their goals. Other E.U. Member States handle EM&V responsibilities in accordance with their particular modes of organization and operation. As a result of these differences, most standards and practices are not uniform across the European Union.

The greatest convergences happen because there are in existence extensive databases of deemed energy savings values for specific energy efficiency measures, particularly measures involving lighting, appliances in the residential sector, and industrial and commercial equipment. During the 1990s, the United Kingdom Government carried out substantial research involving thousands of residences, establishing baselines and deemed energy savings values. These UK values are regularly updated about every three years. Other Member States also have databases of deemed energy savings values, particularly those Member States that had implemented EEO schemes prior to the requirement in the 2012 Energy Efficiency Directive,[42] but some of these databases are not updated regularly.

The baselines used for determining energy savings are not uniform among Member States, which can dramatically affect reported savings. For example, regarding appliances,

40 National energy efficiency targets are not necessarily equal to a 20-percent reduction in energy use by 2020.

41 This is in line with the principle of subsidiarity promulgated in the *Treaty of the European Union,* which states that the Union shall act only if and in so far as the objectives of the proposed action cannot be sufficiently achieved by the Member States, either at central level or at regional and local level, but can rather, by reason of the scale or effects of the proposed action, be better achieved at Union level.

42 Crossley, D., Gerhard, J., Kadoch, C., Lees, E., Pike-Biegunska, E., Sommer, A., Wang, X., Wasserman, N., and Watson, E. (2012).

one Member State may use as a baseline the minimum efficiency level currently available for an appliance in the marketplace, or the average efficiency level of models currently sold, and compare this with the savings from the most efficient available model. Another Member State may use as a baseline the efficiency level of older models being replaced. This lack of uniformity in baselines makes it difficult to compare progress in achieving energy efficiency targets across the European Union as a whole.

EU experts interviewed for this study consistently said that there are few resources available for energy efficiency EM&V, and the resources that do exist are devoted primarily to monitoring and verification studies, which are largely oriented to reviews of deemed energy savings values. In the regular E.U. M&V processes, there is little to no collection of primary energy efficiency data. Also, there are very few market and process evaluations carried out.

The extent to which net versus gross savings are estimated varies among E.U. Member States. The United Kingdom has used net savings since inception; in one example, net savings factors reduced allowable savings claims for residential blown wall insulation by 50 percent.[43] However, respondents in other Member States said net effects were not a strong factor in their States.

4.3.2 Recent Developments

The 2006 Energy Efficiency and Energy Services Directive included a general framework for M&V of energy savings using both top-down and bottom-up calculations. A committee of experts was designated to produce detailed uniform methodologies, but the committee's recommendations were not adopted.[44] The 2012 Energy Efficiency Directive seeks to coordinate and harmonize EM&V standards, requiring that each E.U. Member State develop EM&V standards by 2014. There is no legal requirement to develop a single set of EM&V standards for the European Union as a whole, although the European Commission will wish to satisfy themselves that any energy savings claimed by Member States satisfy the methods and principles set out in the 2012 Directive and that energy savings supported by more than one energy efficiency policy measure are not double-counted.

There have been a number of efforts to codify and coordinate EM&V policies and methodologies across the European Union. The most prominent are associated with a voluntary organization called CENELEC (European Committee for Electrotechnical Standardization).[45] CENELEC is a nonprofit technical organization set up in 1973. CENELEC's purpose is to develop a variety of European standards through a stakeholder process, involving businesses, public authorities, trade organizations, academics, and non-governmental organizations (NGOs). CENELEC uses a consensus process to arrive at a variety of technical standards. The organization promotes standardization of energy efficiency EM&V approaches and techniques. Going forward, CENELEC may have an enhanced role under the 2012 Energy Efficiency Directive.

In 2012, in an attempt to harmonize EM&V practices in the European Union and to help with the accountancy requirements for the new energy savings required under the Energy Efficiency Directive, two NGOs, the European Council for an Energy Efficient Economy and The Regulatory Assistance Project (RAP), produced a report on determining energy savings.[46] The report reviews practices in three Member States with published EM&V procedures and sets out best practice procedures for determining energy savings in a variety of commonly encountered real-life situations.

4.3.3 Improving Current EM&V Practices

In the European Union, energy efficiency EM&V has relied principally on deemed energy savings values and engineering calculations to determine realized energy savings. The primary gaps in E.U. EM&V appear to be inconsistencies in the standards used among the Member States for determining how much energy has been saved. Harmonizing EM&V standards could provide a more robust assessment of how the European Union as a whole and Member States individually are progressing toward the 20-percent energy efficiency target. However, establishing uniform standards might effectively reduce reported savings in some Member States and increase savings in others. Additionally, the extent to which customer satisfaction and installation quality standards are monitored in energy

43 Eoin Lees, personal communication, January 2013.

44 Eoin Lees, personal communication, December 2012.

45 CENELEC (2013).

46 Staniaszek and Lees (2012).

efficiency projects varies widely and in general should be expanded.

The most likely outcome of compliance with the 2012 Energy Efficiency Directive as it applies to EM&V may be the development of parallel but not standard approaches and methodologies and other evaluation techniques, such as developing better understanding of the interactions of energy efficiency programs and the marketplace. Additionally, those interviewed were concerned that there are not enough human resources to conduct more rigorous energy efficiency EM&V than is now typically implemented in E.U. Member States. Training in EM&V is needed, starting at basic levels and likely requiring upgraded skills compared to those currently available. Robust EM&V education and training regimes may succeed in strengthening energy efficiency EM&V among the E.U. Member States and increasing convergence among the States as a larger corps of evaluators emerges and shares ideas across the European Union in academia, professional forums, and other venues. The opportunity for vigorous exchange is important to EM&V evolution and should be encouraged.

Table 4 identifies some issues and gaps and recommends some approaches and actions that may be useful to developing more uniform and robust energy efficiency EM&V in the European Union.

Table 4

Energy Efficiency EM&V Issues and Gaps in the European Union	
EM&V level	Heavy emphasis on deemed energy and demand savings in most jurisdictions, with periodic updates; collection of primary data for periodic evaluations varies among Member States Baselines are specific to and differ among Member States, making direct comparisons difficult. Generally not a lot of process evaluation – requires development of best practices.
EM&V protocols	No common E.U. standards; professional groups and committees working to develop harmonized protocols to provide common approaches to differing Member State practices Some determination of the net-to-gross ratio in energy and demand savings; varies by E.U. Member State; varying attitudes about the importance of determining net savings More project-specific primary data collection protocols for EM&V purposes are required.
Attribution	No defined E.U.-level policy; impacts of free riders are estimated in the United Kingdom and Denmark, with little activity in other Member States.
Understanding of product markets	Well-developed energy performance standards for many appliances and equipment; strong energy efficiency building codes Programs aimed at market transformation need market data to influence program design and evaluation. Data are commercially available but not all Member States have access to this data.
Guidelines for financial resources committed to EM&V	General agreement among interviewees that financial resources for EM&V are not sufficient; EM&V not a high priority and more attention is needed
Capacities needed among program administrators at E.U. and Member State levels	Member State program administrators may lack personnel needed to oversee EM&V with respect to both numbers and skills. Also lacking core of trained EM&V professionals to accommodate the scale of EM&V needed
Capacities needed among obligated parties	Better knowledge about energy end users, including characteristics and key behavioral factors, to understand why end users react to energy efficiency programs as they do and to assist in developing more effective EM&V
Overall needs	Determination of the cost effectiveness of energy efficiency programs is done only in some member States. Development of E.U.-wide methodologies for cost-effectiveness testing is required. Current top-down and bottom-up evaluation protocols are not oriented to site-level data primary collection assessments, although bottom-up measuring was strengthened by the 2012 Energy Efficiency Directive; determine what is most appropriate for varying circumstances among E.U. Member States.

5. Energy Efficiency EM&V In India

5.1 Energy Efficiency Policies and Programs

5.1.1 Overview[47]

India has a history of concern about energy efficiency reaching back to the petroleum embargos of the 1970s. Study groups were formed in the 1980s, including an Inter-Ministerial Working Group on Energy Conservation that was constituted in 1981 to develop policies to achieve energy savings targets, although no targets were actually set. Also during the 1980s, the Government of India introduced various fiscal incentives to prioritize energy conservation in industries. Effective from April 1983, a 100-percent depreciation allowance on import duties of specific energy-saving devices and systems was introduced (in 2004, the allowance was reduced to 80 percent). In addition, energy audit subsidy schemes were made available through various agencies, and banks and other financial institutions established funding schemes to support energy conservation, energy audits, and installation of energy efficiency measures.

From 1985, the Department of Power (now the Ministry of Power) functioned as the nodal point for the Government of India to facilitate the implementation of a coordinated strategy on energy conservation. The Department also provided funding support for strengthening energy conservation programs, including outreach programs. An important post of Advisor, reporting to the Cabinet Secretariat, was created to provide a boost to the national effort on energy conservation.

In 1989, with the assistance of the World Bank and the United Nations Development Programme, an Energy Management Center was set up as an autonomous organization to promote energy conservation. The Centre coordinated energy auditing of consumers' facilities, energy management systems, education and training, and energy generation- and conservation-based employment and poverty alleviation programs. In 1986, the Petroleum Conservation Research Association, under the aegis of the Ministry of Petroleum and Natural Gas, started focusing on energy auditing and implemented a major initiative on training and accreditation of energy auditors.

During the 1990s, further concrete proposals for addressing energy conservation began to emerge, but there was no relevant legislation and hence there were no legal powers to enforce energy conservation and efficiency activities. In 1994, the Ministry of Power constituted a working group of representatives from various ministries to formulate legislation on energy conservation, but it was not until 2001 that an Energy Conservation Act was put in place.

Key provisions of the Energy Conservation Act include:

- reconstitution of the Energy Management Centre as the Bureau of Energy Efficiency (BEE) with responsibility for enforcing various provisions of the Act, including penalties for noncompliance;
- establishment of energy performance labeling and MEPS for appliances and equipment, with prohibition of the manufacture, sale, and import of products not conforming to MEPS;
- identification of energy-intensive industries and other establishments to be notified as Designated Consumers;
- requirement for energy audits to be carried out periodically at Designated Consumers' facilities by accredited energy auditors, including requiring these facilities to implement technically and financially viable energy efficiency recommendations and to comply with energy consumption norms and standards;
- promotion of energy efficiency improvements in the residential and agriculture sectors;
- amendment of Energy Conservation Building Codes (ECBCs) to suit local conditions; and

47 This section is based on Vasudevan (2011).

- establishment of a Central and State Energy Conservation Fund.

5.1.2 Energy Intensity and Carbon Reduction Targets

Commencing in 1951, India developed a series of Five Year Plans that form the basis for economic planning in the country. One of the objectives of the Eleventh Plan (2007 to 2012) is to reduce the energy intensity per unit of GHG emissions by 20 percent over the period 2007 and 2008 to 2016 and 2017.

In addition, India is a signatory of the Copenhagen Accord, developed at the Copenhagen climate summit in December 2009. As part of international mitigation efforts, India registered under the United Nations Framework Convention on Climate Change its voluntary endeavor to reduce the GHG emissions intensity of its GDP by 20 to 25 percent by 2020 compared with the 2005 level.

India's objectives for GHG emissions reduction were formally addressed when the Government of India launched the National Action Plan for Climate Change in mid-2010. The National Action Plan for Climate Change relies on eight "missions," including a National Mission for Enhanced Energy Efficiency (NMEEE).

5.1.3 Individual Energy Efficiency Programs

National Mission for Enhanced Energy Efficiency

The NMEEE aims to boost the programs implemented under the Energy Conservation Act through four major initiatives, all administered by the BEE.

Perform, Achieve and Trade. The Perform, Achieve and Trade (PAT) scheme[48] is a market-based mechanism to enhance energy efficiency in Designated Consumers' facilities. Each facility under the PAT scheme has been assigned a specific energy consumption (SEC) reduction target, compared with its baseline SEC, to be achieved by March 2013. SECs are designated as energy consumed per unit of production, a measure of energy intensity. Those who achieve energy intensity gains beyond their targets receive certified energy savings credits that can be traded with other Designated Consumers. If a facility falls short of its target, it can buy energy savings credits to make up the difference. A total of 478 energy-intensive industrial facilities are covered by the PAT scheme, in the iron and steel, aluminum, cement, chlor-alkali, fertilizer, oil refining, pulp and paper, and thermal electricity generation industries.

Market Transformation for Energy Efficiency. The Market Transformation for Energy Efficiency program is designed to accelerate the shift to energy efficient appliances, concentrating on the residential sector, through innovative measures to make energy efficient products more affordable. The program focuses on leveraging international financial instruments, including the Clean Development Mechanism (CDM), to increase domestic penetration levels for energy efficient products, as well as to increase foreign markets for energy efficient products manufactured in India.

Energy Efficiency Financing Platform. The Energy Efficiency Financing Platform program helps stimulate necessary funding for delivery of energy efficiency services through ESCOs. To reduce government costs, funds provided for ESCO projects are expected to be recovered from project energy savings.

Framework for Energy Efficient Economic Development (FEEED). The FEEED program seeks to develop fiscal instruments to promote energy efficiency, such as the Partial Risk Guarantee Fund and Venture Capital Fund for Energy Efficiency, instruments for public procurement of energy efficient goods and services, and support for utility-delivered DSM. FEEED operates from the assumption that government efforts to create a market for energy efficiency need to be supplemented with appropriate fiscal instruments.

Energy Efficiency in Large Enterprises

Energy efficiency policies and programs directed to large enterprises focus mainly on Designated Consumers notified under the Energy Conservation Act. In 2007 and 2008, Designated Consumers (excluding the Railways) accounted for approximately 54 percent of the total energy consumed in the country.

In addition to the PAT scheme, the Energy Conservation Act makes a provision for the BEE to prescribe and enforce energy consumption norms and standards for Designated Consumers. It permits the government to direct any who exceed these energy consumption norms and standards to prepare and implement a scheme to conserve energy. Each

48 Bureau of Energy Efficiency (2011).

Designated Consumer is required to:

- report their energy consumption to BEE and to the respective state nodal agencies known as the State Designated Authority;
- assign an energy manager responsible for implementing energy conservation policy and measures;
- submit a three-year plan for implementing financially viable measures from the energy audit report;
- hire an energy auditor to independently validate the submitted data on SEC; and
- submit a report on the status of implementation as well as verified energy and cost reductions.

BEE has developed guidelines for industry-specific energy management practices with guidance on energy auditing, budgeting, and setting up of an energy management cell.

Energy Efficiency in Micro, Small, and Medium Enterprises

The micro, small, and medium enterprises (MSME) sector in India employs 59.7 million people across 26.1 million enterprises and constitutes more than 80 percent of all the industrial enterprises in the country. It is estimated that MSMEs contribute 45 percent of manufacturing output and 40 percent of total exports. Energy is a substantial part of production cost in MSMEs.

The majority of MSMEs are run by entrepreneurs and are typically leanly staffed. Most of them do not have the knowledge or the manpower to deploy energy efficiency practices on their own. BEE has established a program that aims to address potential impediments to deploying energy efficiency measures in MSMEs. The program includes:

- energy use and technology analysis to understand the status of energy use and technology and to identify energy efficiency measures, viable technology, expertise, and best practices;
- capacity building for local energy efficiency services and technology providers;
- preparation of bankable Detailed Project Reports for implementation of energy efficiency measures in specific MSME facilities, including matching the expertise of local service providers to specific projects; and
- facilitation of innovative financing mechanisms in the form of risk-mitigating measures for energy efficiency projects.

Energy Efficiency in Buildings

The regulatory framework for energy efficiency in buildings began with the 2001 Energy Conservation Act and the subsequent formation of the BEE. During the 2000s, the Ministry for New and Renewable Energy, the Ministry of Environment and Forests, the Ministry of Power, and the Ministry of Urban Development have introduced sustainability components with overarching policy objectives to promote energy conservation in buildings. Table 5 lists key national policies and guidelines that recommend energy efficiency in buildings.

The National Building Code is intended for adoption by local bodies, Public Works Departments, other government construction departments, and private construction agencies. The code, revised in 2005, recommends that municipalities and development authorities should incorporate energy efficiency elements like daylight integration, electrical standards, and heating, ventilation, and air conditioning standards in their design norms.

The Energy Conservation Building Code (ECBC) was introduced by BEE in 2007. This was the first real effort in the country to set a minimum performance standard that enables energy efficient design and construction of new buildings and major renovations. Initially, the ECBC was introduced as a voluntary code and now the code is being adopted by state governments. The ECBC applies if the connected load exceeds 110 kVA or if peak demand is greater than 100 kW. It draws from standards set by various international bodies. Compliance with the code is achieved either by a prescriptive approach that requires all building materials, construction, and equipment to meet a minimum performance standard or by a whole-building performance approach that allows flexibility in design but requires specialized energy simulation to demonstrate compliance. An Energy Performance Index measured in kWh/m^2/year is used for assessing compliance.

The Leadership in Energy and Environmental Design (LEED-INDIA) Green Building Rating System is a nationally and internationally accepted benchmark for the design, construction, and operation of high-performance green buildings. LEED-INDIA provides building owners, architects, consultants, developers, facility managers, and project managers the tools they need to design, construct, and operate green buildings. LEED-INDIA promotes a whole-building approach to sustainability by recognizing performance in five key areas: sustainable site

Table 5

Policies on Energy Efficiency in Buildings in India[49]

Policy/Code	Year	Ministry	Status	Energy Conservation Guidance
National Building Code (NBC)	1970 Revised 2005 (under revision for 2011)	Ministry of Urban Development Bureau of Indian Standards	Model code (Building Bylaw)	• No mandatory energy performance standards • Building material • Construction technologies • Building and plumbing services
Energy Conservation Building Code (ECBC)	2007 Amendment 2010	Ministry of Power Bureau of Energy Efficiency	Initially voluntary, made mandatory in 2012	• Minimum performance standards for building envelope • Roofs and windows • Lighting system • Air conditioning system • Electrical distribution system • Water heating and pumping systems
Integrated Energy Policy (IEP)	2008	Planning Commission	Policy guidance	• Design and construction • HVAC • Lighting • Household appliances
Environment Clearance Notification – Environmental Impact Assessment (EIA)	Manual on Norms & Standards for Environmental Clearance of Large Construction Projects, 2007	Ministry of Environment and Forests	Environmental clearance is mandatory for large construction projects with built-up area of 20,000 – 150,000 m2. The manual provides recommendations for energy conservation	• Low energy design concepts • Energy efficient techniques and technologies • Solar passive techniques – landscaping, optimum building orientation, arrangement and shape of buildings, effective surface-to-volume ratio, proper location and size of opening, glazing type, shading of windows and selection of building materials
National Mission on Sustainable Habitat (NMSH)	Approved in 2010	Ministry of Urban Development	Policy guidance document	• Sustainable habitat standards • Energy performance of buildings • Structural safety • Energy efficient construction

49 Vasudevan (2011).

development, water savings, energy efficiency, materials selection, and indoor environmental quality. The LEED-INDIA rating system provides a roadmap for measuring and documenting success for every building type and phase of a building lifecycle.

Environmental impact assessments mandated by the Ministry of Environment and Forests for large development projects reinforce the objectives of the National Building Code and the ECBC. Environmental impact assessments rate projects on various environmental criteria like energy management, use of renewable energy, water harvesting, location, and land use impact.

The National Mission on Sustainable Habitat was launched by the Ministry of Urban Development to promote energy efficiency as a core component of urban planning. The National Mission on Sustainable Habitat stresses the need for awareness, for incentives for widespread adoption of energy efficiency programs, for promoting a mix of voluntary guidelines and mandatory rules for energy efficiency in buildings, and for capacity-building of state- and city-level bodies for implementing and enforcing these rules.

Energy Efficiency in Agriculture

Electricity used for agriculture in India is highly subsidized. A flat, unmetered charge based on the horsepower rating of the irrigation pumps used is payable by agricultural customers and this translates into a very low per-kWh charge. This is a legacy from the 1970s when electricity for agricultural use enjoyed a highly subsidized tariff. In the mid-1970s, the State Electricity Boards found that installing and reading meters, billing, and collection for agricultural supply were costly, and they opted to switch to a flat-rate regime. A metered alternative was introduced in 1993 at a flat rate of 50 paise per unit, but currently a very small proportion of agricultural customers has metered electricity supply.

Agricultural sector customers have no economic incentive to implement energy efficiency measures, although improved reliability could be a positive factor. Interviewees report that agricultural energy users are apprehensive about the government measuring their energy consumption, as they fear they then might have to pay more for the energy they use.

Policy impetus for electricity reforms commenced in the 1990s. The 2003 Electricity Act included a commitment to reduce and eventually phase out cross-subsidies between customer classes, a requirement for new policies to develop standalone systems for rural areas based on renewable and non-conventional energy sources, and a strong legal framework for pursuing DSM activities in the agriculture sector.

Improving the efficiency of agricultural pumps has been identified as critical, and various pilot programs have been carried out in India. Many of these programs were done through utility-driven DSM programs that replaced inefficient pumps in bulk. In 2006, BEE initiated a standards and labeling program that provides a voluntary scheme for induction motors and agriculture pump sets. Under this program, pumps are star-rated from one to five, with pumps rated with five stars being the most efficient. Since the introduction of labeling of pumps, various state governments now mandate star-rated pumps in their pump replacement program. BEE has also initiated a pump replacement program that aims to replace inefficient agriculture pump sets with high-efficiency, star-rated pump sets at zero cost to the farmers with repayment over time from the stream of project benefits.

Implementing even targeted energy efficiency programs in the agricultural sector remains challenging. An efficient pumps program, introduced by the United States Agency for International Development, provides a good example. Approximately 500 pumps were installed in the agricultural lands in rural parts of Karnataka, a state in South India. Most farmers then sold the pumps for cash. Recently there has been more acceptance regarding energy efficiency in the agricultural sector, but a lack of education, widespread poverty, and the lack of a strong economic incentive continue to hinder energy efficiency programs.[50]

Utility-Delivered Demand Side Management

Seventy percent of government-owned electricity utilities in India today have an energy department that operates DSM programs. The utility programs have not been effective yet; awareness and technical expertise in India are lagging when compared with other regions, but progress is being made. Utilities are being provided with financial aid from the central government, and international

50 Interview with Natasha Bhan, Shakti Foundation, December 17, 2012.

organizations such as the United States Agency for International Development and the World Bank provide funds to the central government to indirectly help run these programs. Although there is funding from different sources, it has not yet been significant enough to establish utility DSM programs on a large scale.

Private sector utilities have been more active in implementing DSM programs than their publicly owned counterparts. Private utilities only function in eight to ten cities and account for approximately two percent of India's utility electrical consumption.[51] Tata Power and Reliance Energy have been involved in DSM programs since 2002 and work in collaboration with the central government and various manufacturers to provide programs to their customers. Tata Power is also participating in automated demand response programs in 2013 and is planning to develop its own M&V protocols over the next one to two years.

5.2 Institutional Arrangements

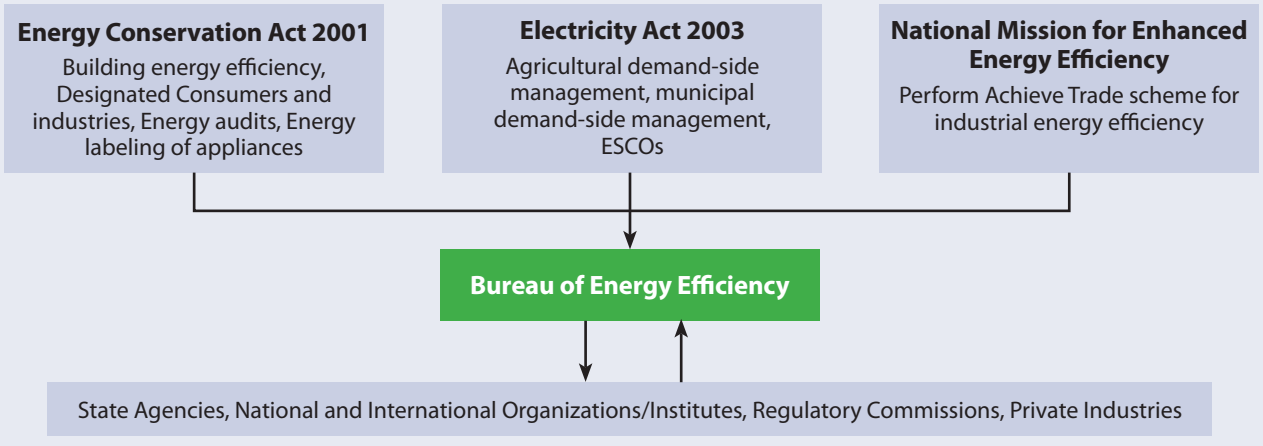
Figure 6 shows that the BEE is the main Government of India agency responsible for implementing energy efficiency policies and programs. BEE was formed, under the Ministry of Power, as a vehicle for deploying the provisions of the Energy Conservation Act. BEE is also the legal entity for executing the initiatives under the NMEEE, including engaging in public/private partnership in implementing various energy efficiency programs. The energy efficiency policy provisions in the Electricity Act reinforce BEE's role as the central agency for developing and establishing systems and procedures necessary for achieving India's overarching energy efficiency goals.

State governments, in consultation with BEE, are responsible for: amending the ECBC to reflect differences among regional and local climates; directing consumers to comply with the codes; designating agencies to coordinate, regulate, and enforce the provisions of the Energy Conservation Act in each state; and taking necessary measures to create awareness and disseminate information for the efficient use and conservation of energy.

The Forum of Regulators has been entrusted with the responsibility to evolve common and coordinated approaches to the issues faced by the various Electricity Regulatory Commissions in India. The Forum of Regulators constituted a working group on "DSM and Energy Efficiency" to address issues related to the implementation of energy efficiency and DSM measures in the electricity distribution sector in India.

Figure 6

Role of the Indian Bureau of Energy Efficiency[52]



51 Interview with Mr. Jayanta Chatterjee, Tata Power, December 20, 2012.

52 Vasudevan (2011).

5.3 Energy Efficiency EM&V Practices and Trends

5.3.1 Current EM&V Practices

There are substantial gaps in energy efficiency EM&V in India. EM&V is valued but has not been resourced and nurtured at the ground level.[53] Nevertheless, there is a significant requirement for energy efficiency EM&V and some progress has been made.

Many energy efficiency projects in India have been implemented under the Kyoto Protocol Clean Development Mechanism (CDM); these projects require robust processes for measuring and verifying energy savings to be eligible to generate tradable Certified Emission Reductions. One of the first CDM projects in India, the Bachat Lamp Yojana scheme developed by BEE, aimed to deliver CFLs to millions of households at the cost of normal light bulbs. The difference in cost was covered by the sale of Certified Emission Reductions. Because there were no data on energy consumption by residential sector lighting in India, the CDM Executive Board initially required a very stringent M&V methodology, including smart meters attached to a proportion of the installed CFLs.

To introduce a more data collection- and analysis-oriented regime, several state governments, including Maharashtra, Gujarat, and Tamil Nadu introduced M&V data collection standards for energy efficiency pilot programs implemented by government-owned electricity utilities. However, because these programs did not include funds for the M&V activities the governments desired, there was little M&V undertaken.

The PAT scheme requires strong EM&V processes, and particularly independent verifiers to certify energy savings. The original design of the PAT scheme[54] envisaged that M&V would be conducted by designated energy auditors according to a suitable M&V protocol. These auditors would apply standard auditing techniques to assess the correctness of the information provided by the project Designated Consumer, including:

- assessment and verification that the implementation of the project activity and the steps taken to report that the specific energy consumption (SEC) complies with the PAT criteria and relevant guidelines as prescribed by BEE. This assessment would involve a review of relevant document action as well as an onsite assessment; and
- verification of project documentation would be based upon both quantitative and qualitative information. Quantitative information comprises the reported numbers in the monitoring reports submitted to the auditor. Qualitative information comprises information on internal management controls, calculation procedures, frequency of SEC reports, and review and internal audit of calculations and data.

5.3.2 Recent Developments

People interviewed for this report believe that there will be greater emphasis on EM&V in commercial and industrial energy efficiency programs but also emphasize that governments in India should provide adequate resources to train EM&V practitioners and produce high quality evaluations. Energy efficiency program administrators must be provided with resources to enable effective implementation of energy efficiency EM&V.

M&V is still taking shape in India and it is likely that markets for energy savings will determine what sort of EM&V is necessary and suitable. In the meantime, Indian organizations are currently putting a great deal of time and effort into establishing an energy efficiency EM&V "industry."

A member-driven industry association founded in 2008, the Alliance for an Energy Efficient Economy (AEEE)[55] has been actively involved in developing EM&V regulations, as well as working with organizations such as the Lawrence Berkeley National Laboratory to build EM&V capacity at regulatory agencies and utilities. AEEE has been the primary Efficiency Valuation Organization Indian affiliate since 2009. As part of this affiliation, the Alliance has conducted a number of awareness seminars and training-certification programs on the International Performance, Measurement, and Verification Protocol. Between 2008 and 2011, EM&V training programs run by AEEE reached out to more than 250 professionals, and 65 were certified eligible to apply IPMVP standards. AEEE has also sponsored a number of EM&V conferences, including an international conference in October 2012 on India's EM&V experiences that mostly concentrated on the PAT scheme.

53 Interview with Natasha Bhan, Shakti Foundation, December 17, 2012.

54 Bureau of Energy Efficiency (2011).

55 Alliance for an Energy Efficient Economy (2013).

5.3.3 Improving Current EM&V Practices

Launching pilot projects on EM&V in energy efficiency programs in the industrial sector could be a next step in collecting and reporting energy and demand savings data, and could serve to create guidelines for further EM&V activity. International EM&V professionals could help to implement these pilot projects by sharing their knowledge and continuing to train Indian organizations to enable them to carry out EM&V work in the future. Reporting the findings of these pilot projects could help increase implementation of energy efficiency programs and assist in understanding the value of EM&V in India.

Table 6 identifies some issues and gaps and recommends some approaches and actions that may be useful in developing more sophisticated and robust energy efficiency EM&V in India.

Table 6

Energy Efficiency EM&V Issues and Gaps in India

EM&V level	Reliance on deemed savings and some engineering estimates for industrial energy efficiency projects Most ESCO projects focus on M&V of energy savings; little to no process evaluation.
EM&V protocols	CDM projects and PAT scheme have developed M&V protocols. Some private sector electricity utilities are developing M&V protocols.
Attribution	Some recognized methodologies for determining the extent to which individual programs influence customer energy efficiency decisions EM&V methodologies for CDM projects generally attempt to estimate gross-to-net ratio for energy and demand savings.
Understanding of product markets	Market transformation energy efficiency programs being implemented; actual market transformation varies. Lack of definitive data on what sells in the marketplace; programs aimed at market transformation need market data to optimize program design and evaluation.
Guidelines for financial resources committed to EM&V	No guidelines in place; additional financial resources would be helpful in the EM&V protocol development process.
Capacities needed among program administrators	Better knowledge about energy end users, including characteristics and key behavioral factors to understand why end users react to energy efficiency programs as they do and to assist in developing more effective EM&V
Capacities needed among obligated parties	Designated Consumers under the PAT scheme generally have a low level of awareness and skills in relation to EM&V.
Overall needs	General capacity building on EM&V; development of an EM&V "industry" Better consideration of top-down versus bottom-up EM&V; determine what is most appropriate for varying circumstances Designated Consumers generally need more EM&V awareness and skills. Carry out testing and implementation of the EM&V standards in development; move beyond EM&V pilots to regular implementation

6. Energy Efficiency EM&V In The United States

6.1 Energy Efficiency Policies and Programs

6.1.1 Overview

Development and implementation of energy efficiency policies and programs in the United States commenced as a response to the oil price shocks in the 1970s. During this time, both the federal government and state governments developed and implemented a broad range of policies and programs directed to improving the energy efficiency of the United States economy. Commencing in the 1980s, however, there was a progressive reduction in government attention and resources directed to energy efficiency. In late 2013, the United States has no clearly defined or legislated policy or plan at the federal level for increasing energy efficiency. In contrast, some state governments have established energy efficiency policies and plans applicable within their jurisdictions.

A private-public initiative, the National Action Plan for Energy Efficiency,[56] was developed in July 2006 to create a sustainable, aggressive national commitment to energy efficiency through the collaborative efforts of gas and electric utilities, utility regulators, and other partner organizations. The Action Plan was led by a diverse Leadership Group of more than 60 leading gas and electric utilities, state agencies, energy consumers, energy service providers, environmental groups, and energy efficiency organizations. The Leadership Group identified key barriers limiting greater investment in cost-effective energy efficiency, made five key policy recommendations to overcome the barriers, and documented policy and regulatory options for greater attention and investment in energy efficiency.

Many Leadership Group organizations were joined by other states, utilities, and key stakeholders across 49 states in making aggressive commitments to energy efficiency and endorsing the recommendations of the National Action Plan for Energy Efficiency. The State and Local Energy Efficiency Action Network is continuing to build on the progress made by the Action Plan and strives to help the nation achieve all cost-effective energy efficiency by 2020 by focusing on the assistance that state and local governments need to perform their critical role in advancing policies and practices that bring energy efficiency to scale.

6.1.2 Energy Intensity and Carbon Reduction Targets

The United States has not set national energy intensity or carbon reduction targets. Nevertheless, a number of standalone initiatives have been established through legislation and regulation that over time are having a positive effect on curbing the nation's energy intensity.

Commencing in the 1970s, a range of federal legislation set energy efficiency standards for appliances, electronics and commercial equipment such as central air conditioning, residential and commercial boilers and furnaces, set design standards for commercial new construction, and established processes for advancing those standards.[57] These federal standards supersede state-level standards. Standards revisions often result in substantial improvements to products such as residential and commercial heating systems, air conditioning, refrigerators, and lighting.

Over the past 20 years, federal legislation has also addressed building codes, low-income energy efficiency in residences, and various energy efficiency and renewable energy tax credits. In addition, ENERGY STAR®,[58] a

56 Leadership Group (2006).

57 This legislation includes the *Energy Policy and Conservation Act 1975,* (Public Law 94–163); the *Energy Conservation and Production Act 1976* (Public Law 94–385); and the *Energy Policy Act 2005* (Public Law 109–58).

58 US Environmental Protection Agency (2013).

voluntary energy performance labeling program, covers a range of home and consumer appliances and other equipment, as well as new home construction. ENERGY STAR® promotes energy efficient products to the public by working with manufacturers and retailers to provide detailed information about a variety of products that voluntarily meet ENERGY STAR® energy performance standards.

Recent attempts to pass national climate change legislation that could result in increased energy efficiency have failed. In contrast, the Environmental Protection Agency's (EPA) authority to regulate GHG emissions was affirmed by the U.S. Supreme Court in 2010, which may lead to the development of regulations that could stimulate further energy efficiency improvements. It has been suggested that, under Section 111(d) of the Clean Air Act, the EPA could set state-specific carbon emissions standards for existing power plants, which could result in increased energy efficiency. Energy-efficiency projects could earn credits for avoiding power generation and its pollution, and generators could purchase those credits to use toward their emissions targets.[59] In fact, the opportunity to use energy efficiency for a portion of compliance with EPA regulations goes back to the late 1990s. At that time, the EPA added to its nitrogen oxide (NOx) compliance regulations the opportunity for some part of the compliance requirement to be met through energy efficiency. The EPA provided guidance on how energy and demand savings needed to be measured and reported in order for states to claim these set aside credits. Only a few states took advantage of this opportunity.

6.1.3 Individual Energy Efficiency Programs

An exception to the reducing interest in energy efficiency occurred at the state level where, in the early 1980s, energy utility regulators in many states commenced requiring utilities to assist their customers to improve the energy efficiency of their homes and premises. Since the mid 1980s, utility-delivered DSM programs have been the major energy efficiency vehicle in the United States, with investment in DSM programs in 2011 estimated at approximately U.S. $8 billion[60] across the country. Utility DSM programs mostly started in regions of the United States with high-energy costs, such as New England, the upper Midwest, and California; and also in the Pacific northwest, which, in spite of low energy costs historically, has managed its electric grid through regional integrated resource planning that placed an emphasis on energy efficiency.

State-level regulations often require utilities to supply energy services to customers at the lowest cost possible. This makes utility DSM programs viable, as a wide range of electric efficiency resources typically cost less than the available supply-side options. Sometimes regulated utilities receive a rate of return on investments in demand-side resources comparable with supply-side investments. Alternatively, utilities may receive performance incentive payments for meeting and exceeding energy efficiency targets and/or penalties for not meeting targets. To ensure cost-effectiveness, independent energy efficiency program evaluators in the United States review DSM programs under rigorous benefit/cost rules that examine the stream of energy saving benefits provided by the programs over the expected measure lifetimes, against the costs of installing the efficient measures. Cost effectiveness is a primary goal of utility DSM and energy efficiency programs in the United States. Although public demand for energy efficiency, customer service, and environmental goals can be important drivers, all programs must offer cost-effective energy and demand savings to meet the industry's least-cost requirements.

6.2 Institutional Arrangements

6.2.1 Federal Government Agencies

There are two main federal government agencies that are important players in the U.S. energy efficiency industry, with responsibility for implementing a range of legislation, regulation, and in some cases executive orders relating to energy efficiency.

U.S. Department of Energy

The mission of the U.S. Department of Energy (DOE) is to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions. The DOE works with universities, businesses, and the national laboratories to develop new, energy efficient technologies while boosting the efficiency of current technologies on the

59 Natural Resources Defence Council (2013).

60 Foster (2012).

market. In particular, the DOE implements the regulatory process for evaluating and approving proposed energy performance standards for appliances and commercial equipment. Together with the U.S. EPA, the DOE supported the National Action Plan for Energy Efficiency.

US EPA

The mission of the U.S. Environmental Protection Agency (EPA) is to protect human health and the environment. In particular, the EPA has regulatory power with respect to air and water pollution, including regulation of GHG emissions, that is just beginning to influence power generation in the United States. The EPA also implements the ENERGY STAR® energy performance labeling program for some appliances and technologies. The EPA sets ENERGY STAR® energy performance standards through a cooperative process with a variety of stakeholders, including manufacturers and retailers.

6.2.2 State Government Agencies

State governments in the United States, particularly those in the Northeast and West Coast, have long been leaders in energy efficiency. States serve as incubators for initiatives that are often adopted at the federal level or diffused through the marketplace. Within their own jurisdictions, states initiate energy efficiency standards, develop building codes, establish energy efficiency obligations (EEOs)[61] for utilities, and implement other strategies facilitating increased energy efficiency. Although building codes and standards have the greatest long-term efficiency impact, much of the U.S. building stock will not be replaced for many years. Hence, most states have established efficiency strategies for existing buildings of all types.

Each individual state sets its own efficiency program rules and requirements through legislation and/or regulation and then enforces those rules via state regulatory commissions. Based on these rules and requirements, programs are developed and delivered by the regulated electric and natural gas utilities within each state, or by program administrators who generally act as third-party implementers, such as Efficiency Vermont or the Energy Trust of Oregon, which have built their business models around addressing energy and demand savings. There are often similarities among states in their approaches, but most states have some unique elements in their regulatory legislation, philosophy, or practices. Rules about the definition of energy and demand savings, measurement baselines, measure life, benefit/cost variables, and EM&V vary greatly between states. These differences pose substantial obstacles to determining what savings the utility DSM programs achieve and how cost effective these are compared to programs elsewhere.

6.2.3 Energy Services Companies

ESCOs are another major player in the U.S. energy efficiency market. Focused largely on government, education, health, and other institutional facilities, and often closely linked to utility energy efficiency programs, ESCOs reported revenues of approximately $5.3 billion in 2011, with approximately 85 percent of revenues coming from energy efficiency services.[62] ESCOs provide a variety of services, including approaches that either share or guarantee savings, as well as financing, to allow organizations to engage in substantial energy efficiency projects with little or no initial capital investment. ESCO services have been especially attractive since the late 2000s, a period of tight government budgets, rising energy costs, and increased federal funding for energy efficiency through economic stimulus initiatives in response to the global financial crisis.

6.3 Energy Efficiency EM&V Practices and Trends

6.3.1 Current EM&V Practices

The United States was an early trailblazer in energy efficiency EM&V, largely because of the way in which energy efficiency was pursued. The United States relies heavily on energy utilities (electricity and natural gas suppliers) to advance energy efficiency. These utilities typically require recovery of the cost of energy efficiency programs, compensation for lost revenues resulting from lower sales volumes, and/or payment of financial incentives for achieving energy efficiency targets. To provide a robust methodology for calculating payments due to utilities, their investments in energy efficiency are accompanied by a solid EM&V framework.

61 In the United States, EEOs are frequently referred to as "energy efficiency portfolio standards" or "energy efficiency resource standards."

62 Stuart (2013).

Who Carries Out EM&V?

For regulated utilities and other program administrators of energy efficiency programs, EM&V is most commonly carried out by third-party evaluators who may be hired directly by the utility or program administrator, by the state regulatory commission, or by another designated stakeholder body, such as a state sanctioned Energy Efficiency Advisory Council. State regulatory commissions have oversight and varying levels of engagement in the evaluation process, depending upon state law, regulatory authority, and practice. No matter who procures EM&V, the process is essentially through competitive solicitations to recognized evaluation companies (both for-profit and nonprofit entities). The client organization develops a scope for an evaluation and evaluators implement it as independent parties but often working closely with the utility or program administrator to refine questions, obtain data, review processes, and make findings and recommendations. Much, if not most, energy efficiency EM&V in the United States uses a form of the IPMVP[63] as a framework for evaluation activities, providing a de facto industry standard for organizing evaluation work.

EM&V Implementation

First, EM&V measures program impacts, determining and documenting the energy and demand savings actually achieved. Second, EM&V examines program processes, which include aspects such as program structure and effectiveness of operations and customer satisfaction and motivation. Third, EM&V also measures and verifies financial costs and savings; these data are used as the basis for establishing the cost effectiveness of utility programs. As EM&V standards become more stringent, cost effectiveness is becoming an increasing concern. Some states also include in their EM&V activities measurement of GHG emissions reductions and reductions in other pollutants such as nitrogen and sulfur oxides (NOx and SOx).

Verified gross energy savings are adjusted to determine net savings by taking account of behavioral factors such as free ridership (actions that would have occurred anyway if the programs were not available), program effects (participants and others induced by the programs to take further actions on their own), and market effects (impacts of the program on the markets for energy efficient products and services). There is no single set of factors or measurement techniques employed to determine net savings, which can make comparisons of savings achievements difficult to establish.[64]

Determining Cost-Effectiveness

In the United States, determining the cost-effectiveness of energy efficiency programs is an important component of EM&V. Cost-effectiveness provides the rationale for undertaking most energy efficiency activities and is also often the basis for calculating remuneration for utilities and other program administrators of energy efficiency programs.

The vast majority of methodologies used in the United States for determining the cost-effectiveness of energy efficiency programs are based on the Standard Practice Manual (SPM),[65] which was originally developed in California for evaluating utility-delivered DSM programs. Since it was originally published in 1983, the SPM has been updated a few times, with the 2001 version being the most recent, along with a 2007 correction memo. Some version of the SPM is in use in most regions in the United States, and it has also been adapted to apply in other Organization for Economic Co-operation and Development countries.[66]

The first step in determining cost-effectiveness involves defining the stakeholder perspective from which the determination is being made. The SPM sets out five tests for evaluating DSM and energy efficiency programs and each test examines a program from a different stakeholder perspective. Following are brief descriptions, modified from the SPM, of the five tests and their stakeholder perspectives.

Participant Test. The Participant Test provides a measure of the quantifiable benefits and costs to an energy end-use customer from participating in a DSM or energy efficiency program. Because many customers do not base their decision to participate in a program entirely on quantifiable variables, however, this test cannot be a complete measure of the benefits and costs of a program to a customer.

63 Efficiency Valuation Organization (2012).

64 NMR Group (2010).

65 California Public Utilities Commission (2001).

66 Violette (2006).

Ratepayer Impact Measure Test. The Ratepayer Impact Measure test measures what happens to customer energy bills or rates (tariffs) owing to changes in the program administrator's revenues and operating costs caused by a DSM or energy efficiency program. Rates will go down if revenues collected after program implementation are greater than the total costs incurred by the program administrator. Conversely, rates or bills will go up if revenues are less than the program administrator's costs. This test indicates the direction and magnitude of the expected change in customer bills or rate levels.

Total Resource Cost Test. The Total Resource Cost (TRC) Test measures the net costs of a DSM or energy efficiency program as a resource option based on the total costs of the program, including both the participants' and the program administrator's costs. This test represents the combination of the effects of a program on both the participating customers and those not participating in the program but who bear a portion of the program costs through impacts on electricity rates.

Societal Cost Test. The Societal Cost Test is sometimes considered a variant on the TRC Test. The Societal Cost Test differs from the TRC Test in that it includes the effects of externalities and uses a different (societal) discount rate. The Societal Cost Test goes beyond the TRC test in that it attempts to quantify the change in the total resource costs to society as a whole rather than to only the program administrator and its customers.

Utility System Cost Test. The Utility System Cost Test, sometimes referred to as the Program Administrator Cost Test, measures the net costs of a DSM or energy efficiency program as a resource option based on the costs incurred by the program administrator (including incentive costs) and excluding any net costs incurred by the participant.

Use of EM&V Results

States, regulatory bodies, and program administrators primarily use EM&V results for compliance purposes, specifically to determine whether an energy efficiency program is achieving what was intended in a cost-effective manner. States and regulators also use EM&V to determine the levels of remuneration to be provided to utilities and other program administrators, to identify the contribution made by energy efficiency to energy resource acquisition, and to recommend improvements to energy efficiency program operations and processes. ESCOs use EM&V (mostly monitoring and verification only) to determine whether a project is meeting its energy or demand savings targets, and to calculate the level of remuneration the ESCO is entitled to under energy performance contracts or other project models.

For regulated utilities and other program administrators, savings are established in financial terms for the purposes of determining cost effectiveness, determining utilities' revenue requirements (in most cases regulated utilities are guaranteed a rate of return), and for determining rewards for meeting and exceeding energy efficiency targets and sometimes penalties for not meeting targets. Remuneration for utilities and program administrators is often based on net energy and demand savings, estimated according to the law and protocols of each state.[67] EM&V is also used to measure progress against specific state targets, such as the percentage of the energy resource provided by energy efficiency, GHG emissions reductions, or compliance with state energy efficiency codes.

Oversight of EM&V

Oversight of the EM&V of energy efficiency programs has traditionally been the province of state regulatory commissions. EM&V standards may be established or guided by state legislation but in practice are most influenced by regulatory procedures and precedents. States also determine the level of evaluation, which may include the full portfolio of a utility or program administrator's programs or may focus on a specific customer sector (residential, commercial, industrial) program, or even on individual energy efficiency measures.

Stakeholders from outside the utility or program administrator, such as the state regulatory commission or a state-designated energy efficiency council, are increasingly influencing how energy efficiency EM&V is conducted. In addition, organizations such as the American Council for an Energy Efficient Economy, the Natural Resources Defense Council, the American Society of Heating, Refrigeration and Air-Conditioning Engineers, the National Association of Energy Standards Board, and regional nonprofit organizations, such as the Northeast Energy Efficiency Partnerships, and similar organizations from across the United States promote their views on energy efficiency EM&V.

67 Titus (2008).

Evaluators themselves play a substantial role in influencing EM&V policies and practices. Evaluation practitioners implement evaluations as independent third parties, serve as consultants to state and nonprofit organizations, advance the theory and practice of evaluation within the professional community, and influence program designs and program designers. Professional certification of EM&V practitioners is provided by the Efficiency Valuation Organization, in conjunction with the Association of Energy Engineers, which offers the Certified Measurement and Verification Professional program.[68]

6.3.2 Recent Developments

There have been several attempts to develop uniform energy efficiency EM&V standards and protocols across regional areas within the United States, and also nationally. In the northeast of the United States, a nonprofit organization, the Northeast Energy Efficiency Partnerships, has established an EM&V Forum whose purpose is to support the development and use of consistent protocols to evaluate, measure, verify, and report the savings, costs, and emission impacts of energy efficiency and other demand-side resources.[69] At the national level, the U.S. DOE has established a Uniform Methods Project[70] that is developing a framework and a set of protocols for determining the energy and demand savings from specific energy efficiency measures and programs. The protocols provide a straightforward method for evaluating gross energy or demand savings for common residential and commercial measures offered in ratepayer-funded initiatives in the United States. They represent a refinement of the body of knowledge supporting energy efficiency EM&V activities. They have been written by technical experts within the field and reviewed by industry experts.

Relatively recent players in energy efficiency EM&V include the Independent System Operators ISO New England, New York ISO, and the Regional Transmission Organization PJM Interconnection that operate regional power markets in the United States. Under an Order issued by the Federal Energy Regulatory Commission,[71] energy efficiency can be bid into regional energy markets as a resource to meet system requirements for peak periods. The ISOs and regional transmission organizations have a strong interest in having uniform EM&V standards among their members to ensure the validity and reliability of savings claimed. These entities have each developed EM&V requirements that market participants must follow in order to bid energy efficiency resources into their markets. The North American Energy Standards Board has developed more generic business practice standards for M&V of energy efficiency products offered in organized wholesale electricity markets that were eventually adopted by the Federal Energy Regulatory Commission.[72]

In a number of cases, utilities and other program administrators have expanded their energy efficiency programs to target improved energy efficiency building codes and appliance and equipment energy performance standards. The impacts of these activities can be beneficial in improving energy efficiency, but assigning credit for these efforts that translates into financial rewards for the program administrators is complex. EM&V of these programs involves determining compliance levels for the relevant codes and standards, and methodologies for measuring compliance are evolving. The U.S. DOE's Building Energy Codes Program[73] supports compliance verification and has developed methodologies and tools to help state and local jurisdictions measure and report code compliance.

6.3.3 Improving Current EM&V Practices

The United States is the world leader in energy efficiency EM&V and its EM&V practices are generally sophisticated, robust, and have high levels of stringency. Nevertheless there are some areas that require improvement.

National EM&V Standards and Protocols

In the United States, the practice of energy efficiency EM&V is state-oriented. There are no national standards or protocols for measuring and verifying energy or demand savings, or to guide evaluation processes. Given the diversity of state legislation and practice, it may be difficult to implement national EM&V standards and protocols absent federal legislation. The U.S. DOE is currently

68 Association of Energy Engineers (2013).

69 NorthEast Energy Efficiency Partnerships (2013).

70 U.S. Department of Energy (2013b).

71 Federal Energy Regulatory Commission (2006).

72 Federal Energy Regulatory Commission (2013).

73 U.S. Department of Energy (2013a).

attempting to establish a national template through the Uniform Methods Project, which is currently focused on the most common measures in energy efficiency programs. Whether a truly uniform set of evaluation standards is needed is uncertain. The goals for the Uniform Methods Project have been pared back from the initial intent to create national EM&V standards toward an emphasis on modeling best practice EM&V methods and practices. Better harmonization among states and some national consensus on measuring and verifying gross energy or demand savings, together with some suggested methods for estimating net savings, may be very helpful going forward.

Attribution of Energy or Demand Savings

Understanding why business and residential customers do (or don't) undertake energy efficiency actions is crucial for estimating net versus gross energy or demand savings. In the United States, a large part of EM&V activity considers the extent to which individual programs influence customers to engage in energy efficient behaviors or purchase energy efficient equipment,[74] but the issue is far more complex than direct interactions between program administrators and customers. Utilities and other program administrators promote their energy efficiency programs in a variety of ways, including direct communications, public service advertising, and newspaper and radio stories. However, people encounter many voices in many contexts; they may be influenced by an energy efficiency program incentive payment or by a message unrelated to the program, which could lead to them being counted as free riders under some definitions. Determining what influences energy efficiency behavior relies heavily on self-reports about intentions and actions, often reported well after the fact. A variety of techniques has been developed to crosscheck self-reports in customer surveys through multiple questions involving past, present, and intended actions, but the methodologies for estimating net energy or demand savings remain more of an art than a science.

Understanding of Product Markets

Reliable data on sales of standard and high energy-efficient products are often difficult to obtain in the United States. Manufacturers and product associations consider data on shipments and sales confidential, making it difficult to understand what is happening in the markets for specific products except at a fairly abstracted level. Other regions, such as the European Union, seem to have better access to such data and therefore better understanding of how product markets are affected by energy efficiency initiatives.

Guidelines for EM&V Financial Resources

States vary widely in the financial resources devoted to energy efficiency EM&V. Most commonly, three to four percent of energy efficiency funds are directed to evaluation purposes, but there are no clear guidelines. Thus, some U.S. states may believe evaluation investments of one to two percent are adequate, whereas one state, California, briefly invested as much as eight percent of energy efficiency resources in evaluation. There is a need for consensus among program administrators and regulators on the appropriate levels of financial resources for energy efficiency EM&V.

Capacity Among Utilities and Other Program Administrators

Utilities and other program administrators generally understand their energy efficiency programs well and increasingly are knowledgeable about their customers, but not all are skilled at applying customer knowledge and marketing techniques to energy efficiency programs. The most common promotion for energy efficiency programs still relies on incentive payments, rarely considering behavioral, cultural, or other "soft" factors that affect decisions to participate in programs as well as the manner in which customers participate.

Capacity at the State Regulator Level

State regulatory staffs are often not adequately staffed to properly oversee energy efficiency EM&V, even where energy efficiency budgets have increased dramatically. Furthermore, oversight staff often do not have EM&V training, making the task of assessing the quality of evaluations and evaluated results more difficult and inconsistent within and among regulators.

Table 7 identifies some issues and gaps and recommends some approaches and actions that may be useful in improving energy efficiency EM&V in the United States.

74 Although estimating net energy savings is not considered important in many other countries.

Table 7

Energy Efficiency EM&V Issues and Gaps in the United States	
EM&V level	Utilities and other program administrators heavily involved in impact and process evaluations for energy efficiency programs, particularly where incentive payments are involved ESCO projects focus on M&V, little to no evaluation Need to determine how good is good enough for national and state level energy efficiency EM&V
EM&V protocols	No national energy efficiency EM&V standards or protocols (states determine their own standards and protocols), but some efforts are being made to coordinate policy and practices within regions and nationally. No standard ways to measure and verify energy or demand savings No agreement on definitions of gross and net savings
Attribution	Most energy efficiency programs estimate gross to net ratios for energy and demand savings and identify free riders and free drivers. Recognized methodologies for determining the extent to which individual programs influence customer energy efficiency decisions
Understanding of product markets	Lack of definitive data on what sells in the marketplace; programs aimed at market transformation need market data to influence program design and evaluation. Some attempts to measure impacts of utility-supported efforts to improve building codes and equipment standards, but EM&V methodologies for assessing compliance with these codes and standards are still being developed.
Guidelines for financial resources committed to EM&V	Some "rule of thumb" practices but no broad-based agreement on adequate levels for energy efficiency EM&V expenditure
Capacities needed among utilities and other program administrators	Better knowledge about customers, including characteristics and key behavioral factors, to understand why customers react to energy efficiency programs as they do and to assist in developing more effective EM&V
Capacities needed among state regulators	State regulators often lack personnel needed to oversee energy efficiency EM&V with respect to both numbers and skills.
Overall needs	Review cost effectiveness criteria, especially where EEOs are in place, to take account of energy resource requirements and potential contribution of increased energy efficiency to GHG emissions reductions Increased knowledge about non-energy benefits of energy efficiency (sometimes applied to low-income programs) Better understanding of the persistence of energy efficiency measures Better consideration of top-down versus bottom-up EM&V; determine what is most appropriate for varying circumstances Better understanding of energy efficiency risks (e.g., when energy efficiency is bid into energy markets, how reliable is it and what are the system costs of mitigating those risks?)

7. Summary and Recommendations

7.1 EM&V Issues and Gaps

In this chapter we summarize our findings on energy efficiency EM&V in each region and suggest some next steps that can further the development of EM&V in each region, as well as possible cross-regional development work.

7.1.1 Regional Summaries

China

China has three decades of experience in implementing a range of energy efficiency programs to achieve energy intensity targets set by governments. Typically energy savings are estimated by undertaking audits of enterprise energy consumption records. Project-based energy efficiency EM&V is in its infancy and is limited to impact evaluations; process evaluations are usually not undertaken. Currently China is in a period of active development of more sophisticated, robust, and stringent energy efficiency EM&V. A range of EM&V protocols and practices, including deemed savings for common energy efficiency measures, is being developed by government and private sector organizations in consultation with a number of international advisory bodies. EM&V development is moving rapidly; training a cadre of technically qualified evaluators and integrating EM&V into existing and new energy efficiency programs are areas of current and continuing interest and activity.

European Union

In the European Union, energy efficiency EM&V is largely driven by the necessity to estimate the energy savings achieved by those energy suppliers subject to EEOs in some Member States. The need for robust and stringent EM&V will increase as all Member States respond to the requirement in the 2012 Energy Efficiency Directive that they implement EEO schemes or alternative energy efficiency policies and programs that deliver 1.5 percent energy savings each year. EM&V methodologies are not uniform across the European Union and Member States are free to develop their own EM&V protocols, baselines, and methodologies for estimating energy savings. There has been a great deal of work, especially in the United Kingdom, on establishing deemed energy savings values for a range of energy efficiency measures, but in some Member States these values are not updated regularly. The United Kingdom and Denmark are the only Member States to estimate net energy savings. The majority of evaluations have been impact evaluations and some process evaluations have been carried out on programs implemented under EEO schemes. EM&V practitioners are still a small group, and training and career paths are not well established. In addition to continuing to develop harmonized EM&V protocols and methodologies, E.U. Member States need to recognize and allocate adequate financial resources to energy efficiency EM&V and to train the next generation of evaluators.

India

India is in a relatively early stage of developing and implementing energy efficiency EM&V. There is a significant requirement for EM&V, particularly as energy efficiency programs under the National Mission for Enhanced Energy Efficiency are implemented, especially the PAT scheme that places EEOs on large energy users. Some progress has been made in developing energy efficiency EM&V protocols and methodologies, particularly for projects implemented under the Kyoto Protocol Clean Development Mechanism. Currently evaluations of energy efficiency programs are mainly impact evaluations; there are virtually no process evaluations. Indian EM&V practitioners are building experience and, like China, India is developing EM&V protocols and methodologies with internal resources and ongoing assistance from a range of international organizations.

United States

In the United States, more than three decades of energy efficiency programs delivered by energy utilities and other program administrators, largely funded by ratepayer dollars, have resulted in extensive implementation of energy efficiency EM&V. EM&V has been developed and implemented at the state level and there is no national approach or uniform set of EM&V protocols and methodologies, although the IPMVP has become the de facto framework for M&V of energy efficiency programs in many states. In recent years, there has been some convergence in EM&V practices, bolstered by initiatives such as the National Action Plan for Energy Efficiency, the DOE's Uniform Methods Project, and work by the North American Energy Standards Board. Energy efficiency EM&V in the United States has focused mainly on programs delivered by utilities and other program administrators, but there are also active energy efficiency efforts in residential and commercial building codes, and in energy performance standards for appliances and equipment. EM&V methodologies for assessing compliance with these codes and standards are still being developed.

7.1.2 Major Regional EM&V Issues

The sophistication, robustness, and stringency of energy efficiency EM&V varies greatly among the regions covered by this paper, and even within some regions. In all regions, there is some recognition of the importance of EM&V, and efforts are being made to improve EM&V protocols, methodologies, and practices and to establish or develop training for EM&V practitioners.

Deemed energy and demand savings are used to varying extents in all regions. Deemed savings require substantial investment to establish initial savings values, which then require periodic updating. Provided that the initial values are established with adequate levels of stringency, deemed savings are a cost-effective way to provide a level of certainty for common types of simple energy efficiency measures.

Estimating net energy and demand savings is carried out primarily in the United States where net savings are an important input into the calculation of remuneration levels for administrators of energy efficiency programs. Net savings are also estimated in some E.U. Member States, principally the United Kingdom and Denmark, but are not considered at all in China and India. Net savings estimations are useful in determining whether an efficiency program is achieving its objectives, but are less relevant when program administrators' remuneration is not based on the level of energy or demand savings, or when energy efficiency programs are being implemented simply to meet energy efficiency or energy intensity targets set by governments to meet national or regional economic goals.

Similarly, cost-effectiveness testing of energy efficiency programs is largely restricted to the United States, where it is used to determine whether an energy efficiency program is more cost-effective than a supply-side option and therefore a good use of ratepayers' funds. Cost-effectiveness testing is likely to be introduced in other regions as recognition grows of the importance of energy efficiency as a resource.

7.2 Next Steps

The drivers and practices of energy efficiency EM&V vary among regions, as does the level of EM&V development and implementation. There are some commonalities in EM&V implementation among the regions, but there is no single set of EM&V best practices that can be applied uniformly across all regions. Nevertheless, there are also commonalities in the gaps in EM&V practices that exist among regions and in the steps that can be taken to close those gaps.

As EM&V methods and practices have matured in some regions we see increasing consideration of energy efficiency in resource and reliability planning. One goal applicable in all regions is to maintain or instill confidence that the energy and demand savings claimed by various types of energy efficiency activities are valid and reliable. When this is accomplished, energy efficiency can more confidently be incorporated into resource and reliability planning, as a strategy in pollution emissions reduction, and as a measure to achieve an increasingly efficient and competitive economy. Achieving that goal requires developing and/or maintaining sophisticated, robust, and stringent EM&V protocols, methodologies, and practices.

The most critical need in all regions relates to developing and agreeing upon consistent intraregional EM&V protocols, methodologies, and practices appropriate to the types of energy efficiency programs being implemented now and expected to be implemented in the future. Furthermore, all regions need to provide adequate

technical, institutional, financial, and human resources to ensure that energy efficiency EM&V can be developed and implemented effectively.

The following actions could be implemented by relevant authorities and/or EM&V practitioners in the regions studied to help solidify regional EM&V information sharing and capacity building:

- Support and strengthen ongoing regional work aimed at harmonizing EM&V approaches, protocols, and methods in each region, and develop an interregional knowledge base;
- Sponsor and encourage professional forums with participation by energy and environmental regulators in and among regions to promote EM&V knowledge exchange and networking opportunities; and
- Develop a basis for EM&V training curricula, including what skills are needed for different types and levels of evaluation (e.g., top-down deemed savings, econometric approaches, and bottom-up field data approaches).

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Appendix A

Compliance Evaluation Scheme For The Energy Efficiency Obligation In China

Compliance by grid companies with their energy and demand savings targets is assessed by a points system as shown in the following table. The maximum achievable score is 100 points, with measures related to the targets receiving a maximum of 60 points and performance in implementing DSM receiving a maximum of 40 points. There are four defined performance levels: Excellent (>90 points), Good (80–90 points), Qualified (70–79 points), and Failed (<70 points).

Compliance Evaluation Scheme for the Energy Efficiency Obligation in China[75]

Criteria	Points	Evaluation Standard
Electricity Savings (60 points)		
***Electricity consumption saving**	30	Achieve 100% of target: 30 points Achieve 50% to 90% of target: 15 to 27 points Achieve less than 50% target: 0 points For each 0.01% of additional savings, add 1 point; the maximum extra points is 5
***Electricity load reduction**	30	Achieve 100% of target: 30 points Achieve 50% to 90% of target: 15 to 27 points Achieve less than 50% target: 0 points For each 0.01% of additional savings, add 1 point; the maximum extra points is 5
DSM Implementation Performance (40 points)		
System design	3	Develop DSM regulation and policy: 2 points Develop DSM regulation working plan: 1 point
Institutional management	2	Establish DSM management position: 1 point Allocate DSM experts: 1 point
Communication and training	3	Conduct at least four communication activities each year: 1 point Hold at least two training activities: 1 point Develop training plans for related employees: 1 point
Technical assistance	5	Load monitoring capacity reaches 70% of peak load in the region: 3 points Load control capacity reaches 10% of peak load in the region: 2 points
Financial input	5	Establish and operate DSM special fund: 5 points
Implementation of DSM rules	6	Establish at least one energy service company and carry out energy contract management projects: 3 points Participate in the regional energy efficiency network and organize activities: 3 points
Key project results	6	Deduct 1 point if one key energy-saving project fails according to the evaluation results
Other evaluation	10	These points may be allocated by provincial government agencies that manage electricity industry operations

** These are threshold criteria; grid companies that do not meet their targets for electricity consumption reduction or electricity load reduction are considered to have failed.*

75 Source: Crossley, D., Gerhard, J., Kadoch, C., Lees, E., Pike-Biegunska, E., Sommer, A., Wang, X., Wasserman, N., and Watson, E. (2012).

Appendix B
Glossary of EM&V Terms

This Appendix contains a subset of commonly used EM&V terms. For a more complete, detailed glossary of EM&V terminology, see the Energy Efficiency Program Impact Evaluation Guide (State and Local Energy Efficiency Action Network, 2012).

Attribution – Attribution ascribes or establishes a causal relationship between action(s) taken and an outcome. For energy efficiency EM&V, this is associated with the difference between net and gross savings. For example, an impact evaluation indicates that 30 percent of the gross energy savings associated with a ceiling fan incentive program could be attributed to the ENERGY STAR® labeling program rather than the incentive program.

Adjusted Gross Energy Savings – These are gross energy savings that are adjusted to include what can be physically counted and reliably measured, such as installation/in-service rates, breakage of equipment, data errors, hours of use, measure persistence rates, and the like. Adjusted Gross Energy Savings can also be calculated by applying a Realization Rate to Gross Savings estimates.

Baseline – The conditions that would have occurred without implementation of an energy efficiency measure or project. Baseline conditions typically include energy consumption and related pollution emissions, and they are sometimes referred to as "business-as-usual" conditions. Baselines are used to calculate program-related energy, demand savings, or emissions reductions. Baselines can be defined as either project-specific baselines or performance standard baselines (e.g., building codes).

Baseline Estimate – An estimate of what a program participant's energy consumption (and related pollution emissions) would have been in the absence of an energy efficiency program. The participant's energy consumption can be measured after the implementation of a program, but the estimation challenge is to determine an appropriate baseline. Baseline determination has important ramifications for the evaluation plan design and analytical methods selected. Arguably this is the most important part of energy efficiency program evaluation.

Bottom-Up Evaluation – An evaluation method in which estimates of aggregate energy or demand savings for a program are obtained by summing savings that have been determined at a more granular level (e.g., at the level of individual measures). For example, energy savings obtained through the implementation of a specific energy efficiency measure are determined and then added to energy savings results from other specific energy efficiency measures to determine "total" savings from an individual program or portfolio of programs within a specified geographic area (e.g., a utility service territory or a region or state.) The major advantage of bottom-up evaluation methods is that they allow a direct determination of the energy or demand savings that are achieved by specific efficiency measures, projects, or programs against known baselines.

Cost-Benefit Evaluation – An evaluation that compares the value of the outcomes of an energy efficiency program and the costs incurred to achieve those benefits, compared with alternatives.

Counterfactual Scenario – An estimate of the amount of energy that program participants would have used (and related pollution emissions) if they had not taken part in an energy efficiency program during the same time period.

Demand-Side Management (DSM) – Strategies used to manage energy demand, including energy efficiency, load management, fuel substitution, and load building.

Deemed Energy or Demand Savings – Deemed energy savings are based on specified energy savings values for each installed energy efficiency measure, drawn from historical values in typical projects. Sources of such historical values include prior year M&V or large-scale consumption data analysis studies. In projects in which deemed savings are used there are no (or very limited) measurements taken; instead, only the number of measures implemented is verified. The energy or demand savings achieved by the project are estimated by multiplying the number of installed measures by the specified (or deemed) savings per measure. This approach is only valid for projects with fixed operating conditions and well-known, documented deemed energy saving values.

EM&V Framework – A primary document that lays out EM&V principles, metrics, allowable approaches, net versus gross savings issues, reporting requirements, schedules, who does what, and so forth. An EM&V framework document tends to be "fixed" but can be updated periodically and often sets the expectations for the content and format of other EM&V documents and annual portfolio and evaluation reports prepared by government agencies, program administrators, and/or independent evaluators charged with assessing impacts and results of energy efficiency programs.

EM&V Standard and EM&V Protocol – An EM&V standard is a set of conditions and requirements, typically established by a government entity, which must be satisfied by EM&V processes, procedures, conventions, or test methods. An EM&V protocol is a document that may be adopted by a government entity that describes how EM&V activities should be performed. EM&V protocols may vary in their level of detail and specificity and the extent to which they adopt prescriptive approaches (e.g., specifying how each EM&V activity must be performed versus a collection of guidelines indicating various options). These definitions are not universally adopted and the terms are sometimes used interchangeably.

Energy Efficiency Measure – An activity implemented at an end-use energy consumer facility that directly reduces energy use while maintaining or improving service. A measure may comprise (1) an installed piece of equipment or system, (2) a strategy intended to affect consumer energy use behaviors, or (3) modification of equipment, systems, or operations that reduces the amount of energy that would otherwise have been used to deliver an equivalent or improved level of end-use service.

Energy Efficiency Obligation (EEO), Energy Efficiency Resource Standard, Energy Efficiency Portfolio Standard – All terms used interchangeably to describe a regulatory mechanism that requires obligated parties to meet quantitative energy saving targets by delivering or procuring eligible energy or demand savings produced by implementing approved end-use energy efficiency measures. The requirement to meet quantitative energy-saving targets distinguishes EEOs, Energy Efficiency Resource Standards, and Energy Efficiency Portfolio Standards from other similar mechanisms, such as a general requirement to acquire all cost-effective energy efficiency with no target specified.

Energy Efficiency Portfolio – A collection of multiple energy efficiency program initiatives in specific market sectors. A portfolio may be either (1) a collection of similar programs addressing the same market segment (e.g., a portfolio of residential programs), technology (e.g., motor efficiency programs), or mechanisms (e.g., loan programs), or (2) the set of all programs administered by one organization, such as a utility.

Energy Efficiency Program – A collection of similar energy efficiency projects that are intended to motivate customers in a specific market segment to implement more energy efficiency. A program is an activity, strategy, or course of action undertaken by a program implementer or administrator. Each program is defined by a unique combination of program strategy, market segment, marketing approach, and energy efficiency measure(s). A program consists of a group of projects with similar characteristics and installed in similar applications.

Energy Efficiency Project – A coordinated activity to install one or more energy efficiency measures at a facility. A project is an activity or course of action involving one or multiple energy efficiency measures at a single facility or site. Examples include home energy efficiency retrofits and commercial new construction projects.

E.U. Directive – E.U. directives lay down certain end results that must be achieved in every E.U. Member State. National authorities have to adapt their laws to meet these goals but are free to decide how to do so. Directives may concern one or more Member States, or all of them. Each directive specifies the date by which the national laws must be adapted, giving national authorities the room to maneuver within the deadlines necessary to take account of differing national situations. Directives are used to bring different national laws into line with each other and are particularly common in matters affecting the operation of the European single market (e.g., product safety standards).

Energy Services Company (ESCO) – A firm that provides a range of energy efficiency and financing services and guarantees that specified results will be achieved under an energy performance contract.

Evaluation – The conduct of any of a wide range of assessment studies and other activities aimed at determining the effects of an energy efficiency program (or a portfolio of programs). This includes understanding or documenting program performance, program or program-related markets and market operations, program-induced changes in energy efficiency markets, levels of demand or energy savings, or program cost-effectiveness. The term "evaluation" is often used broadly to include market analysis for program or portfolio design, inputs for overall resource planning or procurement, and so forth.

Evaluation, Measurement, and Verification (EM&V) – A catch-all term used in energy efficiency evaluation literature to describe the process of determining the impacts of either or both energy efficiency programs and projects.

Ex-ante Calculation of Energy or Demand Savings – A calculation method that predefines the amount of energy or demand used and saved by an energy efficiency measure before its implementation.

Ex-post Calculation of Energy or Demand Savings – Calculation of savings after an energy efficiency measure has been implemented.

Free Driver, Non-Participant – A program non-participant who has adopted particular energy efficiency measure(s) or practice(s) as a result of the evaluated energy efficiency program. See Spillover.

Free Driver, Participant – A program participant who has adopted additional or incremental energy efficiency measure(s) or practice(s) as a result of the evaluated energy efficiency program, but which were not directly induced by the program. See Spillover.

Free Rider – A program participant who would have implemented the evaluated energy efficiency program's measure(s) or practice(s) in the absence of the program. Free riders can be (1) total, in which the participant's activity would have completely replicated the program measure; (2) partial, in which the participant's activity would have partially replicated the program measure; or (3) deferred, in which the participant's activity would have partially or completely replicated the program measure, but at a future time beyond the program's time frame.

Gross Impacts – An engineering construct of energy or demand savings given a specific set of conditions, tied to a design baseline.

Gross Energy or Demand Savings – The change in energy consumption and/or demand that results directly from program-related actions taken by participants in an efficiency program, regardless of why they participated. This is the physical change in energy use after taking into account factors not caused by the program-related (e.g., changes in weather or building occupancy).

Harmonization – Adjustment of differences and inconsistencies among different measurements, methods, procedures, schedules, specifications, or systems to make them uniform or mutually compatible.

Impact Evaluation – An outcome evaluation of the changes attributable to an energy efficiency program. Impact evaluations usually focus on determining the quantity of changes in energy use and demand associated with a program. Calculation of non-energy benefits (or co-benefits) such as avoided emissions and job creation that directly or indirectly result from a program can also be an output of impact evaluations. Impact evaluations often support cost-effectiveness analyses that document the relationship between the value of program results (i.e., energy, demand, and emission savings) and the costs incurred to achieve those benefits.

Market Evaluation – An assessment of the structure or functioning of a market, the behavior of market participants, and/or market changes that result from one or more energy efficiency programs. Market evaluations indicate how the overall supply chain and market for energy efficiency products works and how they have been affected by an energy efficiency program. They may include estimates of the current market role of energy efficiency (market baselines), as well as the potential role of energy efficiency in a local, state, regional, or national market (potential studies).

Measurement and Verification (M&V) – The documentation of energy (and/or demand) savings at individual sites or projects using one or more options that can involve measurements, engineering calculations, statistical analyses, and/or computer simulation modeling. M&V activities can be standalone or they can be a subset of program impact evaluation.

Monitoring – The collection of relevant measurement data over time at a facility, including but not limited to energy consumption or pollution emissions data for the purpose of analyzing energy or demand savings or evaluating equipment or system performance.

Natural Change – The change in overall energy consumption or demand that would have occurred over the same time period in the absence of an energy efficiency program.

Net Energy or Demand Savings – The change in energy consumption and/or demand that is attributable to a particular energy efficiency program. This change may include, implicitly or explicitly, the effects of free riders, spillover, energy efficiency standards, changes in the level of energy service, and other causes of changes in energy consumption or demand. See Free Rider, Spillover.

Net-to-Gross Ratio (NTGR) – A factor representing net energy or demand savings achieved by an energy efficiency program divided by the gross savings from the same program. An NTGR is applied to gross program load impacts to convert them into net program load impacts. The NTGR itself may be made up of a variety of factors that create differences between gross and net savings, commonly including free riders and spillover. Other adjustments may include a correction factor to account for errors within the project tracking data, breakage, and other factors that may be estimated which relate the gross savings to the net effect of the program. An NTGR can be applied separately to either energy or demand savings.

Process Evaluation – A formative evaluation of an energy efficiency program that documents program operations and identifies and recommends improvements to increase the program's effectiveness in acquiring energy efficiency resources, preferably while maintaining high levels of participant satisfaction. For example, process evaluations can include an assessment of program delivery from design to implementation, to identify bottlenecks, successes, failures, constraints, and potential improvements. Process evaluations also assist in interpreting the results of impact evaluations.

Program Evaluation – A series of systematic, objective studies that are conducted either periodically or on an ad hoc basis, to assess how well an energy efficiency or DSM program is achieving its intended goals.

Realization Rate – How the expected (ex-ante) program and the verified (ex-post) energy and demand savings align. A realization rate is the ratio of what was expected based on the data tracking system versus what was verified.

Site-Specific M&V Plans – Site-specific M&V plans may be required for energy efficiency project sites that are locations for energy efficiency EM&V activities.

Spillover – Reductions in energy consumption and/or demand caused by the presence of an energy efficiency program, beyond the program-related gross energy or demand savings of the participants and without direct financial or technical assistance from the program. There can be participant and/or non-participant spillover.

Top-Down Evaluation – An evaluation method that relies on energy consumption data or per-unit energy consumption indicators (e.g., energy consumption per unit of output or per person) defined by sector, utility service territory, state, region, or country as the starting point for determining energy or demand savings. Top-down evaluations may incur lower evaluation costs than bottom-up evaluations. Top-down evaluation does not easily enable attribution of energy or demand savings to specific energy efficiency policies and/or particular programs and actions and may rely on potentially unreliable energy performance indicators.

Appendix C
Abbreviations and Acronyms

AEE – Alliance for Energy Efficiency (India)

BEE – Bureau of Energy Efficiency (India)

CDM – Clean Development Mechanism

CENELEC – European Committee for Electrotechnical Standardization

CFL – Compact Fluorescent Lamp

DOE – Department of Energy (United States)

DRC – Development and Reform Commission (China)

DSM – Demand-Side Management (United States)

ECBC – Energy Conservation Building Code (India)

ECC – Energy Conservation Center (China)

ECSC – Energy Conservation Supervision Center (China)

EEO – Energy Efficiency Obligation

EIC – Economic and Information Technology Commission (China)

EM&V – Evaluation, Measurement, and Verification

EPA – Environmental Protection Agency (United States)

EPC – Energy Performance Contracting

ESCO – Energy Services Company

E.U. – European Union

EVO – Efficiency Valuation Organization

FEEED – Framework for Energy Efficient Economic Development (India)

GDP – Gross Domestic Product

GHG – Greenhouse Gas

IPMVP – International Performance Measurement and Verification Protocol

ISO – Independent System Operator (United States)

kVA – Kilo-Volt Ampere (of apparent electricity demand)

kW – Kilowatt (of real electricity demand)

kWh – Kilowatt-Hour (of electric energy)

M&V – Measurement and Verification

MEPS – Minimum Energy Performance Standards

MIIT – Ministry of Industry and Information Technology (China)

MOF – Ministry of Finance (China)

MOHURD – Ministry of Housing and Urban-Rural Development (China)

MSME – Micro, Small, and Medium Enterprises

NDRC – National Development and Reform Commission (China)

NEA – National Energy Administration (China)

NGO – Non-Governmental Organization

NMEE – National Mission for Enhanced Energy Efficiency (India)

NOx – Nitrogen Oxides (significant air pollution component)

PAT – Perform, Achieve and Trade energy efficiency obligation scheme (India)

RAP – Regulatory Assistance Project

RMB – Renminbi (currency unit, China)

SEC – Specific Energy Consumption (India)

SOx – Sulfur Oxides (significant air pollution component)

SPM – Standard Practice Manual for cost-effectiveness of energy efficiency programs

tce – ton of coal equivalent

TRC – Total Resource Cost cost-effectiveness test

U.S. – United States

Appendix D

People Interviewed For This Project

The Navigant study team interviewed the following people for this project.

Name	Organization	Region
David Crossley	Regulatory Assistance Project	China
Timothy Hui	EcoTech International (ETI)/EVO Board Member	China
Mona Yew	National Resources Defense Council (NRDC) China	China
Paolo Bertoldi	European Commission	European Union
Eoin Lees	Regulatory Assistance Project	European Union
Alexandre Jeandel	GDF Suez, Paris, France	European Union
Inge Pierre	Svensk Energi, Stockholm, Sweden	European Union
Harry Vreuls	Senternovem, Netherlands	European Union
Natasha Bhan	Shakti Foundation	India
Jayanta Chatterjee	Tata Power	India
Koshy Cherail	Alliance for an Energy Efficient Economy	India
Mahesh Patankar	Regulatory Assistance Project	India
Daljit Singh	None	India
Kevin Cooney	Navigant	United States
Marvin Horowitz	Demand Research	United States
Steve Nadel	American Council for an Energy Efficient Economy	United States
Steve Schiller	EVO Board Member	United States
Frank Stern	Navigant	United States
Dan Violette	Navigant	United States

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