DSM Program Procedures Manual Volume I – Industrial Energy Efficiency Program

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Acknowledgements

The *DSM Program Procedures Manual, Volume 1: Industrial Energy Efficiency Programs*, discusses planning and implementation issues based on a work plan that was developed during meetings held at the July 2007 DSM Forum in Beijing. The National Development & Reform Commission (NDRC), which hosted the DSM Forum, was influential in conceiving of and developing this Manual.

The significance of the Manual is that it demonstrates how programmatic implementation of DSM can procure energy resources that are cheaper, faster, and cleaner than traditional utility-scale energy resources. The Manual also reflects an international cooperative effort to share knowledge and experience of how DSM programs can be used to overcome market barriers and expedite the deployment of clean energy technologies.

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1.1 BACKGROUND AND PURPOSE

In the past decades, demand-side management (DSM) activities in China have achieved great success, resulting in significant social and economic benefits. DSM activities have the potential to "raise the ceiling" by stimulating markets to affect energy end users' decisions and consumption patterns. To implement DSM programs in China, it is important to have reliable and long-run support. Persistent DSM activities supported by governments, organizations, foundations and enterprises can capture the opportunities in energy conservation and savings from the demand side and lower the pressure on China's electric utilities to increase energy supply.

1.1.1 Background and History of Manual's Development

In the summer 2007, the National Development and Reform Commission (NDRC) formally launched the project of development of a national DSM Implementation Manual to provide concrete guidance to the nation's DSM efforts. The Natural Resource Defense Council (NRDC) and the China-US Energy Efficiency Alliance assembled a team of top international and domestic experts to take on this important task. Two of the largest utilities in the U.S., Southern California Edison and Pacific Gas and Electric Company, are providing major support for this work.

1.1.2 Relationship of DSM Implementation Manual to DSM Guide

The NDRC and the State Grid Corporation have produced a comprehensive *Electricity Demand-Side Management Working Guide* ("Guide") that was published in 2007. The Guide discusses basic concepts of electricity DSM, reviews DSM history and evolution in China and other countries, introduces a series of laws and regulations relating to DSM, and discusses the methodologies of calculating avoid costs and DSM related cost-benefit analysis.

The Guide also discusses issues related to DSM implementation including energy efficiency labeling, the Clean Development Mechanism's treatment of energy efficiency, energy contract management, and DSM program implementation and administration. The Guide also discusses a wide variety of applications, ranging from load control and management for both electricity suppliers and end users to energy saving technologies for lighting, high efficient motors, transformers, home appliances, efficient electric heating, building, heat pumps, central AC, SVC, and combined cooling heating and power.

For industrial applications, the Guide discusses electricity saving applications in different sectors including iron and steel, electrolytic aluminum, metallurgy, cement, chlor-alkali, synthetic ammonia, and power generation.

Unlike the Guide, which covers a much wider scope, this volume of the DSM Implementation Manual focuses particularly on one of the most important areas, *DSM implementation procedures*, including issues to consider at both program and project levels.

1.1.3 Purpose of this Manual

This Manual provides detailed methods of *how* DSM can be implemented. The Manual provides practical implementation guidelines that demonstrate how DSM can act as a resource comparable to traditional energy supply resources to address growing energy demands resulting from economic development.

Because China's industrial sector is the country's largest consumer of electricity, this Manual primarily focuses on industrial retrofit efforts to help decision makers better understand in detail how DSM can be implemented in the industrial sector. Future implementation manuals will address other market sectors.

This Manual will provide users with practical guidelines on how to implement DSM at both program and project levels, help them to identify energy saving opportunities in industrial retrofit process, provide least-cost options for energy saving investment, and guide the users to carry out these options step by step. DSM program administrators can use this manual to learn the practical activities to plan and implement energy-efficiency programs, set priorities for energy efficiency work, determine needed funding, and coordinate activities with other parties. Policy makers can utilize this manual to design DSM policies and develop both short- and long-term governmental strategies for energy conservation, environment protection and economic development.

1.1.4 Intended Audience

This DSM Implementation Manual is written primarily for senior policymakers and senior managers who are responsible for establishing public and organizational policies and determining how much to spend, what kinds of programs to offer, and what levels of risks are acceptable.

This manual is also for DSM program planners, who—in *addition* to being responsible for developing program plans and procedures—will be responsible for coordinating interdepartmental support including planning for:

- *Customer contact, answering and forwarding questions.* Projects are typically contracted between customers and ESCOs, who will necessarily interact with the people responsible for DSM portfolio management, program design and delivery, monitoring and verification, and technical support.
- *Market research and market promotion activities.* To implement DSM programs successfully, it is highly recommended that they be designed to suit local geography and market conditions after careful and thoughtful market investigation.
- *Revenue impact analyses.*
- *General office support (staffing, printing, IT services, etc.).*
- *Business transactions (special billing, credits, or financial assistance).*
- *Engineering and technical support.* Provide customers engineering and technical support; help customers receive more benefits from their DSM program.
- *Purchasing and contract administration.*

This Manual is also intended to serve as a reference for DSM market participants, including energy service companies (ESCOs), providers of monitoring and verification (M&V) services, energy consultants, and other energy professionals.

1.2 ORGANIZATION OF DSM MANUAL

This manual is organized into the following sections:

Section 1: Introduction and Summary

This section lays out the groundwork for the manual. It coves the purpose of the manual, the background and development history of DSM, the relationships of the manual to the DSM guidelines, and the intended audience.

Section 2: Institutional Structure for Program Implementation

This section discusses the institutional structure by establishing an administrative framework that specifies roles and responsibilities, especially those of the government for overseeing the energy efficiency portfolio, programs and projects. As such, this section assumes that the government will establish and fund at least one program to intervene in the existing DSM market with the intention of accelerating and expanding the naturally-occurring level of adoption for DSM technologies and practices.

Section 3: Portfolio Composition and Program Design

This section provides more detailed information on programs and projects that could be included in industrial retrofit portfolios and on program design. However, since this volume of the DSM Manual is intended to focus almost exclusively on the administration and implementation of an Industrial Energy Efficiency Retrofit program, this section will address portfolio composition only in relation to that specific program design.

Section 4: Program Implementation Process Flow and Procedures

This section describes step-by-step processes and procedures undertaken by program administrators and project implementers to fulfill their roles. Program design options that are discussed in Section 3 are addressed in this section.

Section 5: Evaluation, Measurement and Verification of Savings

This section outlines the basic process and technical guidance on program evaluation, project measurement and verification (M&V) issues and requirements for industrial efficiency retrofit projects. This section does not provide enough details to be sufficient on its own to conduct evaluations of programs, or M&V of projects. Rather it provides high-level guidance, identifies issues, and describes best practices. It describes approaches for calculating program savings and project savings. It also describes approaches for conducting process evaluations and will provide some suggestions for decision-making. For project M&V it will reference and utilize material in the International Performance Measurement and Verification Protocol (IPMVP).

Section 6: DSM Cost-effectiveness

International best practices regarding the calculation and comparison of DSM benefits and costs are discussed in this section. It provides guidance in comparing and contrasting different perspectives for determining cost-effectiveness of DSM programs as an alternative to conventional power supplies. This section also describes the key analytical steps required for identifying and assembling DSM programs and portfolios that maximize the net economic benefits to the grid and to society.

Section 7: Program Data Tracking and Reporting

This section discusses typical data collection during the operation of an industrial efficiency program. It also describes the typical requirements for a database and tracking systems and representative reports that are provided about programs and projects.

Appendices

The appendices provide program and project case studies, as well as tools to be used to perform cost-effectiveness analysis and matrix to measure and verify energy savings. They also include case studies on the best practices in promoting DSM in China. In addition, an appendix provides direct references to best practices by U.S. program administrators documenting technology costs and performance characteristics, including energy and demand savings and technology life expectancy.

In summary, this manual will help different stakeholders implement DSM programs aimed at promoting greater energy savings that are beneficial to society, the economy, and the environment in China.

Section 2 Institutional Structure for Program Implementation

2.1 THE DSM ADMINISTRATIVE FRAMEWORK

This manual describes methods for industrial DSM program implementation in the context of an institutional framework that is capable of planning and administering multiple programs.

In general, the administrative structure includes the following functions:

- Policy Oversight, which sets DSM policy goals
- Program Choice, which chooses the portfolio of programs
- Portfolio Administration, which supervises the implementation of a portfolio of programs
- Program Implementation, including marketing, customer recruitment, and project site activities
- Evaluation, Measurement, and Verification, which quantifies achievements and provides quality assurance through program evaluation
- Financing, which provides funding for program administrative functions and financial assistance to program participants
- Advisory Committee Guidance, which provides advice on how to improve program implementation to achieve policy goals

> *DSM Implementation Concepts*
>
> The terminology used to describe implementation activities and the administrative framework begins—at the highest level—with a *portfolio* of carefully planned DSM market interventions, which are defined as *programs*. Programs are focused activities that encourage energy consumers to implement energy efficiency *projects* in their facilities. DSM projects are implemented at the consumer level and include the individual energy efficiency *measures* implemented by a particular customer. A project can include one or more than one measure. Section 3 describes these concepts in more detail.

Appendix A presents and discusses examples drawn from the States of New York, Vermont, and California that represent administration of energy efficiency programs by different institutional entities:

- State agency administration (New York)
- Third party administration (Vermont)
- Utility company administration (California)

This section discusses roles and responsibilities of the DSM program *portfolio* administrator, followed by a brief listing of the roles of *program* managers and *project* implementers.

2.2 ROLES AND RESPONSIBILITIES OF THE PORTFOLIO ADMINISTRATOR

The Portfolio Administrator is responsible for both creating the plan for a portfolio of programs and then supervising its implementation. The roles and responsibilities associated with portfolio administration are discussed below.

2.2.1 Portfolio Composition

The portfolio is a comprehensive set of programs that seek to maximize cost-effective energy savings and provide social fairness by providing savings opportunities to all classes of customers. By offering a comprehensive set of programs, a broad portfolio also reduces financial risks (e.g., the risk of one market sector not achieving its savings goals) by increasing the ability to adapt quickly to changing market conditions.

2.2.1.1 Policy Goals

A DSM portfolio should be designed to meet clearly stated policy goals in terms of energy savings, demand response, economic development goals, and environmental objectives. The portfolio should consider budget constraints and satisfy cost-effectiveness criteria. To meet these goals, the portfolio should be a product of the close cooperation between the Policy Oversight entity, an Advisory Committee (for stakeholder and other public inputs), and the Administrator.

2.2.1.2 Diversity and Risk Management

The diversity of programs in a comprehensive portfolio addresses two goals: it provides financial risk management while achieving cost-effective energy savings.

Portfolio and program design can address three types of risks:

- Performance risk due to design or implementation flaws
- Technology risk that energy-efficiency technologies do not deliver expected savings
- Market risk of customers who might not respond to programs as predicted

Administrators have several ways to address risk. The first way to reduce risk is to invest more heavily in proven programs with a low variability in performance than in new programs with a much higher uncertainty. Investing in long-term programs (e.g., new construction) or in technology development programs that will increase program and technology diversity in the future years will help to diversify future savings and reduce long-term risk. A central feature of a portfolio should be a set of core programs that can be ramped up and down quickly. (This point is addressed in the "Adaptability" section below.)

Resource acquisition (short-term implementation of demonstrated savings) and market transformation (long-term changes in consumer behavior) are two main objectives in energy efficiency program design. To increase probability of long-term success, a balanced portfolio should include—in addition to programs focused on short-term energy savings objectives—educational and informational programs that promote market transformation.

Typically, programs that target large scale industrial facilities are highly cost-effective. Conversely, programs that target smaller market segments are generally less cost-effective, primarily because of the additional marketing and administrative efforts required to influence diverse groups of energy consumers, including "hard-to-reach" markets. Portfolio diversification and social objectives, however, can both be supported by inclusion of programs designed for smaller market segments and hard-to-reach customers.

2.2.1.3 Adaptability

Because some programs might not meet initial expectations (and some might out-perform expectations), an optimal portfolio should be balanced to adapt flexibly to market conditions. To avoid financial losses or to seize opportunities when a program performs better than expected, a portfolio of programs should be chosen and designed to be scaled up or down easily to adapt to market conditions. Accordingly, the Policy Oversight entity should establish portfolio rules that are flexible enough to give the Administrator the ability to quickly transfer funds from programs that don't perform to others that do well.

2.2.1.4 Cost-Effectiveness

The portfolio selection criteria should include a financial screening process that tests programs' cost-effectiveness before they can be included in the portfolio. Such tests typically examine cost-effectiveness from multiple perspectives to ensure economic efficiency, as well as fairness to market participants. Section 6 discusses portfolio and program cost-effectiveness in more detail.

2.2.2 Program Design

The Program design process must address many considerations, including target market, program goals, budget, marketing process, and market transformation objectives. Section 3 presents a thorough discussion of program design issues.

2.2.3 Portfolio and Program Management

Successful portfolio and program management is one part good design, two parts good implementation. This section describes typical tasks and responsibilities that are associated with successfully administering a portfolio.

2.2.3.1 Strategy and Analysis

The Administrator is responsible for monitoring the portfolio's energy savings and cost-effectiveness. These analyses should be performed on an ongoing basis in order to adapt quickly to program progress and make the right strategic decisions regarding allocation of portfolio resources. Over time, the Administrator knowledge of customer behavior will gradually increase and increase the effectiveness of portfolio development.

2.2.3.2 Planning

In most cases, detailed final program designs will be developed by the parties implementing the programs, subject to Administrator review and approval. The Administrator will, however, typically develop and analyze initial program concepts, including technical and financial aspects, for consistency with portfolio objectives, market needs, and budgets, which are then reviewed by the Policy Oversight entity.

2.2.3.3 Program Implementation

For program implementation, the Administrator has the choice to implement the program with its own personnel, hire implementation contractors, or a combination of the two approaches. If the Administrator chooses implementation with its own personnel, it will be responsible for developing the detailed implementation plans. If it decides to hire contractors to implement programs, the Administrator can choose to provide general guidelines only, rather than detailed instructions. In this case the contractor retains flexibility to develop its own detailed program plans. Section 3 and Section 4 provide more detail regarding program implementation responsibilities and processes.

2.2.3.4 Coordination

The Administrator should have regular discussions with staff from the Policy Oversight entity staff and EM&V contractors to facilitate coordination among the portfolio's program teams. The Administrator should also establish develop cooperative efforts among different programs within the portfolio to harness economies of scale and cost-effectively encourage broad market participation.

2.2.3.5 Administrative Support

The Administrator's day-to-day portfolio management responsibilities include hiring and managing the contractors responsible for implementation, as well as providing additional administrative services. The process for selecting implementation support contractors should be done in a competitive and unbiased solicitation to encourage innovative and optimally cost-effective programs. After implementation contracts are awarded, the Administrator becomes responsible for managing contracts, identifying requirements for customer relationship management, paying any financial incentives, monitoring program performance, and reporting program performance to the Program Oversight entity. (Section 7 presents information on functional requirements of centralized tracking and reporting systems.)

2.2.3.6 Budget

The first of the two tasks related to the budget is daily budget management, which consists of setting program budgets, tracking costs against budgets, and timely processing of invoices and payments. The second task is budget analysis, which should provide a regularly updated assessment of each program's cost-effectiveness using monitored performance metrics.

2.2.3.7 Communications

Two types of communications are involved in the process of managing a portfolio: external communication, which includes program marketing and other communications directed towards energy consumers, and internal communication, which includes routine contacts with implementation contractors and reports directed towards the Policy Oversight entity.

The Administrator will typically determine the strategy and scope of broad marketing campaigns. The marketing strategy will be aimed at coordinating the development of the overall portfolio messaging and ensuring standards are met by each program implementer. The program administrator will gather data on the full range of benefits the program delivers to the public and make this information available for the communication campaign.

To keep the Policy Oversight entity fully knowledgeable of program developments, the Administrator will provide detailed reports, including both technical and financial data, on a regular basis.

2.2.3.8 Evaluation

Evaluation is of paramount importance to successful portfolio management. The Administrator will establish performance metrics related to savings acquisition, cost-effectiveness, quality control, and customer service, and will adjust implementation activities in accordance with evaluation results. Section 5 presents a detailed discussion of the evaluation process.

Depending on the choice of administrative model, program evaluators may report either to the Administrator or to the Policy Oversight entity. In either case, the Administrator will fully cooperate with the Evaluation entity and provide it with all required program documentation to facilitate the evaluation process.

2.3 ROLES AND RESPONSIBILITIES OF THE PROGRAM MANAGER

The roles and responsibilities of program managers are outlined above, and are discussed in more detail in Section 4, which describes program processes in more detail.

2.4 ROLES AND RESPONSIBILITIES OF THE PROJECT IMPLEMENTER

A project implementer is the entity that develops and manages an energy efficiency project in a customer facility. The implementer also interacts with the demand side management program manager to fulfill program requirements, report savings, and receive incentive money or services. In this section we present a high level view of the roles and responsibilities of project implementers. Section 5 provides more information regarding typical steps and procedures in typical implementation, including details on the interactions that occur between program managers and implementers during the project lifecycle.

An implementer can be a facility, an enterprise, government agency, ESCO, specialty contractor, engineering firm, or other qualified entity designated by the program manager. Demand side management programs determine the eligibility requirements for implementers so that only those organizations that support program goals are authorized to implement projects and report savings. Section 4 and Section 5 provide more detail on eligibility and different implementer types.

The implementer’s roles and responsibilities can be grouped into planning, construction, and measurement and verification phases, which are common to all energy efficiency projects. The following is a brief overview of the activities undertaken by an implementer during these three phases:

- **Planning**. During the planning phase, the implementer develops and schedules the procurement and installation of the energy efficiency project. The implementer may also be responsible for obtaining project financing. The development process includes conducting a rigorous analysis of the energy savings and demand reductions that can be expected from the project. The estimated energy cost savings plus any expected financial incentives from demand side management programs are included in the project financial analysis. When applying for program incentives, the implementer is responsible for submitting a planning package to the program manager in a format and schedule specified by the program rules. The implementer is also responsible for developing a measurement and verification plan during the planning stage, if one is required by the administrator.

- **Construction**. The implementer is responsible for all phases of construction, and assumes all responsibility for completing the project as specified during the planning phase. Demand side management programs usually have requirements for milestone reports, and the implementer is responsible for preparing such milestones in order to maintain eligibility for any program incentives that were reserved during the planning phase. The milestone reports may involve on-site inspections conducted by the program manager or its representatives, and the implementer is also responsible for ensuring that the inspectors have access to the equipment and information they need to complete their reviews. The implementer is responsible for commissioning the project at the end of construction (including any special metering that may be required to report energy savings) to ensure that the project was built and operates as specified.
- **Measurement and Verification**. After the project installation is complete, the implementer begins any measurement and verification (M&V) activities required by the program to quantify and validate energy and demand savings. The M&V data and analyses are subject to review by the program manager if program incentives are contingent upon verified savings, as is usually the case for industrial customer projects. Upon the program manager's approval of the M&V report and the completion of the verification phase, the administrator awards the implementer any remaining incentive as specified in the project agreement.

In summary, in a demand side management program framework the project implementer is responsible both for the planning and construction of the project, and for verifying the resulting savings. The program manager is independent of the project and assumes no responsibility for its performance. The program manager's role is limited to providing financial assistance and information in the form of financing or technical guidance, as specified in program procedures.

2.5 ROLE OF ESCOS

Energy service companies (ESCOs) are an important class of implementers that warrant additional discussion. A market for ESCOs developed in the United States in response to the OPEC oil embargo and energy crisis of the late 1970's, when consumers were highly motivated to control soaring energy costs. A central element of the ESCO business model is the concept of performance contracting, in which an ESCO's payment is contingent upon achieving the energy efficiency performance that is forecast during the project development process and is specified in an agreement between the ESCO and a host facility (the customer) where the project is to be installed.

Energy efficiency projects, particularly retrofits of existing facilities, often require a significant capital investment with a long economic payback period if traditionally financed by the facility owner. In a performance contract, however, the ESCO typically finances the energy efficiency project and offers to allow the facility owner to pay for the project over a contract term of several years. The terms of the contract typically allow the facility owner to pay the ESCO based on the energy savings performance of the project.

The pay-for-performance feature of the ESCO business model has led the industry to emphasize the role of measurement and verification of savings in energy efficiency projects. The objective of ESCO project M&V is to quantify savings in a process that follows accepted technical standards and is transparent to the customer. The ESCO model places a high value on good energy engineering, cost control, and knowledge about energy-efficient equipment and strategies—all of which help mitigate the risk that the contracted savings may not be achieved.

Performance contracts are typically long term, typically from five to ten years (and sometimes longer). Long terms and significant capital outlays tend to favor large projects where economies of scale can absorb the fixed costs associated with maintaining M&V activities over many years and with securing financing. In the United States, the ESCO industry is well established and has demonstrated both the viability of performance contracting and of the market's need for ESCO services. To date, U.S. ESCOs have installed approximately $20 billion worth of projects.

This section introduces the theory of demand side management (DSM), placing it in the broad framework of resource planning. The focus is on descriptions of the main components of a demand side management program. To understand the set of activities that are required to successfully design, operate, and promote a demand side management program—and to quantify the resultant savings—it is first necessary to understand the resource planning context. Thus we begin with an overview of the utility planning process.

3.1 THE RESOURCE PLANNING CONTEXT

Government agency and utility resource planners ensure that supply will be sufficient to satisfy expected demand over a forecast planning period. Faced with projected shortfalls in energy and capacity (or both), system planners have traditionally balanced the supply and demand equation by focusing on the supply side, usually by building new power plants, upgrading transmission and distribution systems, and/or purchasing additional energy. However, the balance can also be achieved by reducing demand imposed on a system by energy consumers. DSM is the practice of shaping demand patterns and energy usage in order to control load growth, address supply shortages, or mitigate the environmental impacts associated with energy use. Demand side management planning is an alternative to solutions that focus exclusively on the supply side.

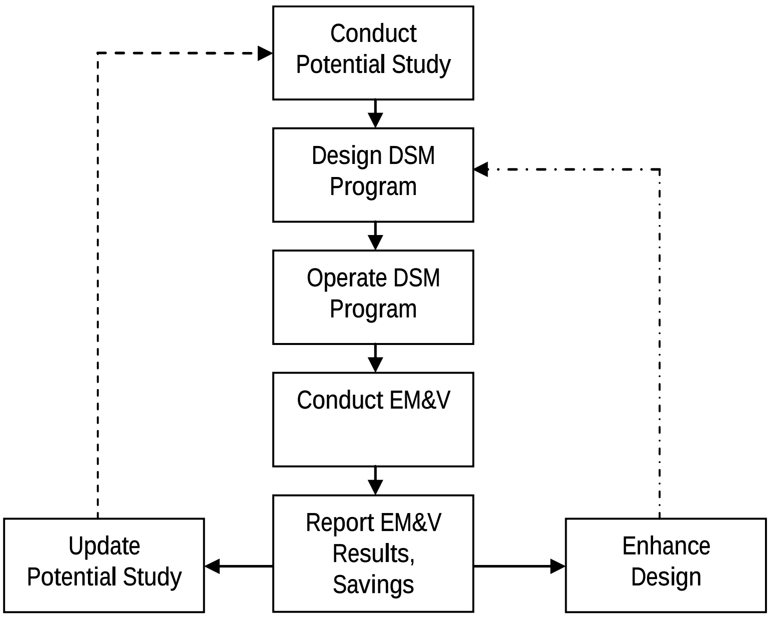
DSM resources are both measurable and well-documented; they are directly comparable to supply side resources, and planners can always weigh the advantages and disadvantages of both supply and demand options. While resource planning is beyond the scope of this manual, an understanding the fundamental mechanisms will provide the groundwork for understanding the design of energy efficiency program portfolios.

Resource planning is the process of determining the optimum mix of supply (energy and capacity) and demand side management in a least cost solution that balances the supply/demand equation at an acceptable reliability level. Supply side costs, which consist of fuel and energy purchases plus infrastructure investments, are generally well understood. Demand side management costs and benefits are less familiar, but can be quantified using standard methods. Their gross costs are the installation of energy efficiency or demand reduction equipment in customer facilities plus energy efficiency program administration costs less the energy provider's lost revenue (due to the avoided energy use). Demand side management net benefits are the avoided energy costs due to improved efficiency, less the gross costs.

In most systems, some level of investment in demand side resources will almost always be cost-effective when weighed against the supply side alternative. This is true even if the system is not facing an energy shortfall or capacity constraint. Investing in some amount of demand side management will result in a positive economic return for nearly all systems. To maximize economic and social benefits, public policy planners often develop long term strategic plans to establish public objectives, clarify institutional roles and policies, and create a framework for coordinating energy initiatives.[1]

In the planning process, estimates of available demand side resources are obtained by conducting studies of potential savings that quantify achievable efficiency and demand savings under different economic and programmatic scenarios.[2] If the decision is made to pursue any of the resources identified in a market potential study, the administrative agency in charge would design a program, or more likely a portfolio consisting of multiple programs, to reach the target customers and motivate them, usually with incentive payments and information campaigns, to install efficient and demand controlling equipment and strategies. After the DSM initiative begins operations, a separate evaluation, measurement and verification (EM&V) review is launched to objectively assess how well it is meeting its stated goals, and to quantify the resulting savings impacts. The EM&V review results are used to modify the design to improve progress towards goals, and to update the initial potential study. Figure 3-1 depicts the planning, operational, and evaluation phases of the demand side management process.

Figure 3-1 Demand Side Management Overview



Theory is of course always modified in practice, and the resource planning process is no exception. The orderly flow of activities described above is frequently circumvented in practice, often due to the need to reduce demand in the face of immediate supply shortfalls. But regardless of the path taken to the decision to invest in demand side resources, the need for clear goals (based on a realistic estimate of savings potential), a detailed plan to achieve them, a management structure that delineates roles and responsibilities, an understanding of the economic costs and benefits of the savings goals, and the requirement for an independent EM&V

1 See, for example, California's series of Energy Action Plans and its Long Term Energy Efficiency Strategic Plan. Documentation is available at www.californiaenergyefficiency.com

2 Market potential studies can be conducted separately or in conjunction with the resource planning process. In either case, they provide information about the cost-effective demand side resources available in a geographic region, consumer population, or equipment grouping.

process are necessary ingredients if a DSM resource plan is to succeed. The balance of this section discusses these components in the context of China's energy markets.

3.2 PORTFOLIO COMPOSITION

If, as part of the resource planning process, a decision is made to acquire achievable demand side resources then an extensive design process is started so that the anticipated demand and energy savings can be acquired on schedule and in budget. Demand side resources are typically diffuse and distributed among many different customer classes and types of energy using equipment. It is quite common that an initial step in the design process is to assign percentages of the savings goal to different sub-populations of customers and equipment types. After the customer classes have been segregated, each with its own energy savings goal, then DSM planners can develop programs, where a program is a coordinated set of activities designed to achieve a specific goal.

A DSM portfolio is a collection of individual programs, each of which focuses on specific customer classes and technologies. A portfolio has overarching goals such as a quantity of MWh/year electricity savings or therms/year of fuel reductions; programs are the mechanisms created to achieve the goals. Within a portfolio, each program can target a unique customer class such as textile mills, petrochemical refining facilities, or other groups identified through a market potential study or otherwise known to portfolio administrators. Programs can also promote specific technologies such as efficient motors and variable speed drives, high efficiency space conditioning equipment, or high efficiency lighting equipment.

DSM initiatives can begin with a single program, a portfolio of one, and then launch additional programs as the administrators and markets mature. With time, administrators of new programs may learn that some classes of facilities have significant energy and demand reduction potentials and yet do not respond to a particular program, or they may identify an underutilized technology that can yield additional, cost-effective savings. Launching separate programs designed to better serve non-responsive customers and market niches is a natural development for any DSM initiative and the resulting mix of programs will constitute a portfolio.

Using the portfolio approach for comprehensive demand side management offers administrators several advantages over the single program model. These include:

- Incentives and program support tailored for specialized groups of energy users
- Improved risk management that spreads the savings goals over multiple targets
- Improved pricing of program offerings where incentives are customized for particular markets rather than for an average mix of customer classes
- Avoided lost opportunities during new construction, major renovation, or equipment failure by targeting customers during the short periods when investment decisions are made for equipment that will be placed in service for many years, if not decades.

3.3 PROGRAM DESCRIPTION

A program is an organized, coordinated and planned set of activities that seeks to acquire the demand side resources identified during its planning period for a particular customer or technology grouping. The resources are acquired through energy efficiency or demand reduction projects that are developed by customers or specialty contractors in response to the program's marketing activities. Each project is comprised of a set of related measures—the individual activities taken at a project site that result in a measurable reduction in energy and/or demand requirements. Some examples of common measures are:

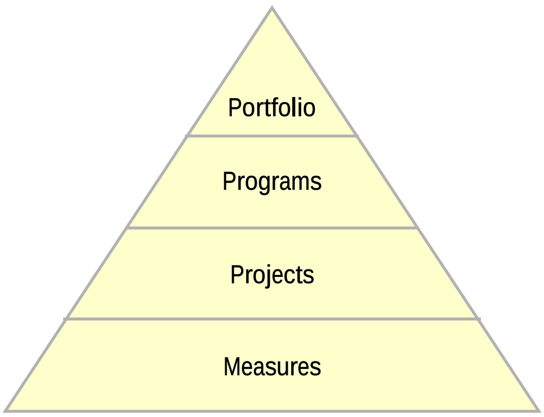
- Instituting a compressed air system leak detection and repair procedure for a manufacturing plant
- Installing high efficiency air compressors instead of standard efficiency units when building a new industrial facility

Measures are the fundamental units that make up a DSM program. A measure, as seen in the examples above, is a particular action or piece of equipment that results in less energy use than would have occurred if the pre-existing (or "baseline") operation or equipment had remained in place. Energy and demand savings are the difference between the consumption of the baseline and the efficient devices, implying that a fundamental characteristic of a measure is that its savings must be quantifiable and measurable.[3]

A project is a group of measures installed at a facility, or at a group of related facilities. A project is typically implemented as a coordinated activity with a budget and timeline. Thus in an industrial facility, a project may include several measures such as lighting retrofits, an air compressor leak detection procedure, and motor replacements. Collectively, all the projects implemented in a program deliver the savings, or demand side resources, that are counted towards program's goals that were set at the design stage.

Figure 3-2 depicts the relationships and hierarchy of the building blocks that result in savings for a demand side management program.

Figure 3-2: Hierarchy of Demand Side Management Building Blocks



The sections above have defined the measure, project, and program building blocks that work together to achieve the demand side resource goals that are set for each program. The following sections describe a few design and operational details that are generally encountered during a program's life cycle.

[3] The discipline of quantifying savings due to measures and projects is termed measurement and verification, M&V, which is discussed in detail in Section 5.

3.4 PROGRAM OBJECTIVES

DSM program investment planning starts with a clearly-defined set of desired outcomes. These objectives can be defined by utility managers or state or provincial government authorities. In China, government authorities will most likely be responsible for setting and balancing these objectives for program investment by DSM administrators.

The majority of key DSM program objectives are readily quantifiable and therefore subject to measurement by program administrators and verification by state or provincial authorities. Some objectives (e.g., social concerns) are not quantifiable and therefore must be taken into account and dealt with qualitatively in DSM program planning and decision-making.

3.4.1 Quantitative Objectives

In well-planned programs, DSM investment objectives are typically defined in terms of energy (electric and thermal) and monetary savings. Other resource savings and environmental benefits are also recognized as secondary objectives, typically in quantification of emissions reductions and the monetary valuation of resource savings. Usually these objectives are stated over a planning and implementation period of three to five years.

Electricity Savings

China's power plants provide electric energy constantly. They also provide energy during periods of highest demand on the electricity grid, which constitutes peak capacity. Energy reductions due to DSM programs therefore save electric energy and avoid electricity generation whenever the more-efficient load of the DSM project operates. Depending on the timing of the underlying load, DSM efficiency investments also contribute to reducing peak capacity investments by reducing load during peak periods.

In typical practices, planners include explicit electric energy and peak demand savings in their stated program objectives.

Thermal Energy Savings

Because coal is the primary fuel source for new power plants being built to serve growing electric energy demand, electricity savings from DSM programs will reduce coal consumption. Thus, DSM program savings contribute directly to national and provincial priorities on reducing the coal content of China's economic output.

Non-Energy Resource Savings

In addition to electricity savings, most industrial facilities also offer potential for saving other energy resources. Water is the most prominent non-energy resource valued in international best practices in DSM investment planning. Where potable or usable water sources are scarce, some industrial efficiency investments in China can free up water supply that would be wasted otherwise. Its value is most often reflected indirectly in measuring success in monetary objectives. Reductions in the contribution of industrial facilities to waste streams, both hazardous and non-hazardous, are often the by-product of industrial efficiency investments and these reductions can be included as an explicit objective of industrial DSM programs.

3.4.1.1 Economic Objectives

The DSM program planning process establishes economic outcomes as a primary objective In the DSM context, authorities would require utilities and provincial governments to provide high service quality at the lowest reasonable life-cycle cost . Section 6 discusses cost-effectiveness and resource economics, including direct and indirect economic effects of DSM, in more detail

3.4.1.2 Environmental Objectives

Coal-fired power plants are the predominant source of new electric energy to supply China's growing economy. They emit harmful pollutants into the air due to incomplete fuel combustion to fire steam boilers for electricity generation. Lowering the amount of electricity consumed by industrial end uses therefore reduces coal-fired generation and its pollutant emissions. DSM programs will reduce coal-fired emissions of carbon dioxide, oxides of sulfur and nitrogen, particulates, and mercury.

Environmental benefits from DSM may warrant their selection as a significant quantitative objective for DSM programs. They vary directly with the amount of electric energy savings achieved. Peak demand reductions do not produce comparably large amounts of emission reductions due to the small number of hours during the year that peaking generating facilities operate.

3.4.2 Qualitative Objectives

North American policy-makers have identified a variety of objectives that are hard to quantify, but are nonetheless important DSM program objectives. Some of these qualitative objectives include market transformation effects that seek to increase prospects for longer-term success of DSM programs.

3.4.2.1 Infrastructure Capacity Building

Developing a durable energy efficiency infrastructure is perhaps the single most crucial need for the long-term success for DSM in China. To reach a major share of China's industrial efficiency potential, programs will need access to technologies and skills on a large scale. It is therefore an important objective for DSM programs in China to build the institutional capacity that is necessary to deliver industrial DSM programs successfully. Capacity building will include training of industrial efficiency experts to recognize, quantify, and qualify potential efficiency retrofits. To stimulate this increase in capability, DSM programs may need to contribute to training at universities and other technical institutions in the province. This may increase the costs of DSM program investment in the near term.

3.4.2.2 Demonstrate DSM Viability

Another important objective of industrial DSM in the next few years will to demonstrate the practical viability of expanding DSM investment to other markets and sectors of provincial economies. It is therefore necessary that initial industrial DSM successes be documented convincingly and publicized widely. It may be necessary to devote additional funding to ensure the success of early projects in producing the desired outcomes and therefore meeting the objectives set for DSM programs.

For DSM programs to prove viable in the long run, program managers also need to find out where improvements in program design and process can be made based on lessons learned during the first few years of program operation. A key objective of initial DSM program planning should therefore be to establish the monitoring, verification, and reporting mechanisms to demonstrate successful implementation.

3.4.3 Balancing Competing Objectives

North American best practices in establishing DSM program objectives include the pursuit of all economically achievable potential for electricity savings. In practical terms, this has meant investing in all efficiency opportunities that save electricity for less than the cost of producing and delivering it. This least-cost approach balances two key DSM program objectives: electricity resource savings and monetary value. It ensures that the grid does not waste money on supply that could have been avoided by DSM programs that cost less money. It also discourages uneconomic DSM investment (i.e., investments that cost more than the monetary value of their resource savings). This section concludes with an example of how one state uses a combination of success indicators to balance multiple DSM program objectives.

3.5 INDICATORS OF PROGRAM SUCCESS

3.5.1 Criteria for Measuring Program Success

DSM programs typically produce multiple outcomes, which are jointly produced by individual projects. For example, most energy-efficiency measures save both electrical energy (kWh) and peak demand (kW). Both are important and valuable for electricity resource planning. Least-cost resource planning objectives introduce economic value into the mix of outcomes that determine successful DSM investment. Energy savings also reduce pollution, and can help China to meet its environmental goals.

The challenge for DSM program planning is to

- Specify the quantitative criteria to use for measuring program success based on objectives established in advance for the DSM program portfolio
- Set performance goals that define successful outcomes for each criterion over the planning horizon
- Decide how much weight to place on success under each criterion, based on the relative importance established for each program objective
- Allocate program resources to achieve the performance balance sought by the set of success indicators

Success indicators that can be observed and counted provide an essential ingredient for successful DSM program management. Typical success criteria are listed below in a commonly used order of priority

- Energy savings
  - Electric energy—typically expressed on annual basis to indicate incremental savings in each program year and cumulative savings over a longer program planning period

  - Thermal energy—also expressed on annual basis to indicate incremental savings in each program year and cumulative savings over a longer program planning period
- Peak Demand Savings—expressed in units of avoided peak electricity capacity
- Economic Value
  - Net Electric Benefits
  - Net Thermal Energy Benefits
  - Tradable Carbon Emission Reductions
  - Other Resource Savings
- Environmental Savings
  - Avoided SO_2, NO_x, CO_2, PM_{10}, Hg, etc.—expressed in units of weight
- Other Success Indicators—often qualitative indicators (e.g., consumer satisfaction) or, in early stages of program implementation, indirect quantitative measure of success (e.g., numbers of participating customers or projects)

3.5.2 Balancing Success Indicators

Table 3-1 below offers an example of how to balance multiple success indicators to pursue multiple DSM portfolio investment objectives. The table lists the success indicators that Vermont's regulators adopted for its State's DSM portfolio administration for 2006-2008. The table indicates exactly how much value the State places on each of several types of success indicators, including electric energy and peak capacity savings, economic value, and several indicators of market transformation.

Table 3-1 Illustrative Success Indicators—Performance Metrics

PI#	Title	Performance Indicator	Target	Period	Incentive Weight	Form of Verification	Entity Responsible	Incentive Amount (100%)
1	Electricity Savings	Annual incremental net MWh savings	270,000 MWh (See Note 1)	2006-2008 cumulative	30%	Annual Verification Process	CA and DPS	$598,500
2	Total Resource Benefits	Present worth of lifetime electric, fossil, and water benefits	$184,000,000 (See Note 2)	2006-2008 cumulative	24%	Annual Verification Process	CA and DPS	$478,800
3	Summer Peak Demand Savings	Cumulative summer net peak demand savings	40,000 kW (See Note 3)	2006-2008 cumulative	7%	Annual Verification Process	CA and DPS	$139,650
4	Winter Peak Demand Savings	Cumulative winter net peak demand savings	40,000 kW (See Note 4)	2006-2008 cumulative	5%	Annual Verification Process	CA and DPS	$99,750
5	Summer Peak Demand Savings in Geographic Areas	Cumulative summer net peak demand savings in designated summer peak geographic areas	10,750 kW (See Note 5)	2006-2008 cumulative	10%	Annual Verification Process	CA and DPS	$199,500
6	Winter Peak Demand Savings in Geographic Areas	Cumulative winter net peak demand savings in designated winter peak geographic areas	10,750 kW (See Note 5)	2006-2008 cumulative	10%	Annual Verification Process	CA and DPS	$199,500
7	Compact Fluorescent Lightbulb Stocking by Grocery Stores	Number of grocery stores with 25 or more employees participating in buy downs, mark downs or coupons for Compact Fluorescent Lightbulbs in part of both 2007and 2008	40 stores, all with sales between 8/1/08 and 12/31/08, and at least one agreement for each of the three grocery store chains - Hannaford, Price Chopper and Shaw's. (See Note 6)	Year 2007 and 2008	7%	Signed Participation Agreements with Large Grocery Stores & Documented CFL sales between 8/1/08 and 12/31/08	CA	$139,650
8	Community Awareness	Completion of community-based projects with over 35% participation in each community and agreed-upon percent reduction in community-wide electrical energy use	2 communities with 35% participation, at least one of which demonstrates a *3%* reduction in community-wide electrical energy use (See Note 7)	2006-2008 cumulative	7%	Tracking System	CA	$139,650
				TOTALS	**<u>100%</u>**			**$1,995,000**

CA = Contract Administrator; DPS = Department of Public Service

<u>Notes</u>

Note 1 The award is scaled as follows. Below 216,000 MWh (80% of the *100% Target Level*) , *Contractor* earns no incentive. At 216,000 MWh *Contractor* earns 50% of the total incentive. The award shall be scaled linearly between 50% and 100% of the incentive amount for performance between 216,000 and 270,000 MWh. For performance greater than 270,000 MWh, Contractor can earn a set amount per MWh as provided for in Table C-3. However, the Contractor's total performance incentive payment may not exceed $2,347,000.

Note 2 The award is scaled as follows. Below $138,000,000 (75% of the *100% Target Level*) of TRB, *Contractor* earns no incentive. At $138,000,000 of TRB *Contractor* earns 50% of the total incentive. The award shall be scaled linearly between 50% and 100% of the incentive amount for performance between $138,000,000 and $184,000,000 of TRB. For performance greater than $184,000,000 of TRB, Contractor can earn a set amount per $ of TRB as provided for in Table C-3. However, the Contractor's total performance incentive payment may not exceed $2,347,000.

Note 3 The award is scaled as follows. Below 30,000 KW (75% of the *100% Target Level*), *Contractor* earns no incentive. At 30,000 KW *Contractor* earns 50% of the total incentive. The award shall be scaled linearly between 50% and 100% of the incentive amount for performance between 30,000 and 40,000 KW. For performance greater than 40,000 KW, Contractor can earn a set amount per KW as provided for in Table C-3. However, the *Contractor's* total performance incentive payment may not exceed $2,347,000.

Note 4 The award is scaled as follows. Below 30,000 KW (75% of the *100% Target Level*), *Contractor* earns no incentive. At 30,000 KW *Contractor* earns 50% of the total incentive. The award shall be scaled linearly between 50% and 100% of the incentive amount for performance between 30,000 and 40,000 KW. For performance greater than 40,000 KW, Contractor can earn a set amount per KW as provided for in Table C-3. However, the *Contractor's* total performance incentive payment may not exceed $2,347,000.

Note 5 The award for each of these performance indicators is scaled as follows. Below 5,375 kW (50% of the *100% Target Level)*, Contractor earns no incentive. At 5,375 kW *Contractor* earns 50% of the total incentive. The award shall be scaled linearly between 5,375 kW and 10,750 kW. For performance greater than 10,750 kW *Contractor* can earn a set amount per KW as provided for in Table C-3. However, the *Contractor's* total performance incentive payment may not exceed $2,347,000.

Note 6 There is no scaling for this performance indicator. However, if the *Contractor* meets all the requirements for the *100% Target Level* except that it only obtains participation agreements for two grocery store chains the Contractor shall earn $83,790 (60% of the *100% Target Level*).

Note 7 The award is scaled as follows. Below two communities, *Contractor* earns no incentive. At two communities with 35% participation and one of which achieves a minimum 1 percent reduction in electrical energy, Contractor earns 50% of the total incentive. The award shall be scaled linearly between 50% and 100% of the incentive amount for energy savings between the 1 percent minimum and the *100% Target* Level *of three* percent.

3.6 TARGETED MARKETS AND TECHNOLOGIES

The market potential study was introduced earlier in this chapter as a tool for identifying cost-effective demand side management resources in a region or end-use customer group. The section continues with a discussion of the methodologies used in conducting market potential studies, different measure types and their implications for program design, and then examines some of these topics as they relate to a typical DSM program.

Market potential studies involve a series of logical steps, each building on the preceding, according to the following process:

- Disaggregate the baseline forecast into customer groups (residential, commercial, industrial) and end-use equipment or systems (lighting, motors, space conditioning, etc). Utilities and energy suppliers will have forecasts of future requirements that reflect both historical usage and expected change in usage, usually growth. By examining future demand at the end-use level, the research focuses on the high energy use technologies, which will suggest possible measures to slow the rate of the projected load growth. The disaggregated forecast is also the basis for a model to estimate future savings.
- Identify and characterize efficiency and demand reduction measures. A list of measures will be developed based on the disaggregated baseline forecast, local knowledge about customers and their equipment, and other market potential studies. Each measure represents the replacement of a standard efficiency piece of equipment with a more efficient model (or the implementation of an energy management or co-generation strategy) and is characterized by energy and demand savings, useful life, installation cost, and avoided energy cost. Measures for which installation costs exceed energy cost savings are excluded from further consideration.
- Organize cost-effective measures into proto-typical programs, and estimate the savings effect on the baseline forecast. The measures are organized into logical groupings that target similar customers (e.g., an industrial motor efficiency program, a commercial lighting retrofit program, etc.). Analysts will need to estimate installation rates, and conduct a net present value economic analysis over the forecast period, usually at least ten years.

The disaggregation step involves both bottom-up and top-down analysis. In bottom-up analysis, the typical energy use of a device is multiplied by the number of installed devices (motors, for example), with the step repeated for all devices until the utility or service provider's baseline forecast is accounted for. In the top-down approach, the forecast is disaggregated into increasingly smaller units until all the baseline usage is assigned to system or equipment levels by customer groupings. Disaggregation is always limited by available data and the end results always include some uncertainty. This uncertainty carries through to the energy, peak demand, and economic savings estimates that are the result of the market potential study.

The practice of conducting market potential studies is considerably more complex than described here, and depends on experienced and professional judgment to achieve reliable results. However, this brief overview demonstrates is a logical procedure to identify cost-effective energy efficiency measures that have the potential to reduce energy usage within specific groups of customers or markets; these measures and markets are the targets for a demand side management program. The remainder of this section discusses some of the common measure classification schemes, and a review of simple versus comprehensive measures. In each case, there are implications that should be considered during the program design phase.

Energy efficiency measures can be categorized as follows:

- *Retrofit or early replacement measures* target operational equipment with the intent of replacing it with equivalent but more efficient equipment. As an example, replacing T-12, magnetic ballast fluorescent lighting with T-8, electronic ballast technology is a common retrofit measure. The savings derive from the assumption that without the program intervention (the retrofit) the old equipment would have remained in place.
- *Replace on failure measures* target the momentary opportunity that occurs when a piece of energy using equipment fails and needs to be immediately replaced. A DSM program offers the customer an alternative to buying a standard unit by promoting a more efficient option, usually with a financial incentive. The savings is the difference in the life cycle consumption between the standard and efficient units.
- *New construction measures* target the momentary opportunity that exists during the design phase or major renovation of a new building or industrial facility when energy using equipment is being specified. A demand side management program can intervene at the design stage to offer the developer better-than-standard-efficiency equipment, again usually with a financial incentive equal to some or all of the incremental cost difference between the standard and efficient units.

Standard efficiency equipment that is installed in new construction or upon failure of an old unit in an existing building or industrial plant represents a “lost opportunity” for a demand side management program. Replace on failure and new construction measures need to be available to the customer at the time of selection, otherwise the standard equipment option will be installed and the savings opportunity will be lost until it fails or is replaced, often ten or twenty years later. Programs that address the lost opportunity problem need to educate decision makers about the efficiency options prior to the selection point, at which time the program needs to react quickly to supply the high efficiency alternative when the selection is made. Programs that promote replace on failure and new construction measures work with vendors to make sure that suppliers stock the efficient option, train engineers and architects to consider efficiency as part of the design process, and educate operators and owners about the life-cycle cost savings potential for efficient equipment. Careful planning needs to occur at the design stage of any demand side management in order to effectively target measures that address the lost opportunity problem.

For the DSM program designer, retrofit measures require a simpler operational framework than those addressing the lost opportunity problem. Retrofits can potentially occur at any point during a piece of equipment’s lifetime, thus removing the time-critical element of a new construction or replace on failure measure. Programs that promote retrofit measures typically offer assistance or financial incentive for a variety of pre-approved measures (usually with a fixed incentive rate), and custom measures proposed by the customer with an incentive rate based on a life cycle cost savings analysis. To target retrofit measures, program designers typically plan outreach activities to inform potential customers of the benefits and availability of the measures and that there are equipment and trained installers available to perform the retrofit.

Measures can also be classified by their degree of complexity and financial risk. While it may be tempting to only target simple measures, doing so usually leaves untouched a considerable pool of additional savings that are available from more complicated measures. A standard simple measure is replacing T-12, magnetic ballast lighting equipment with T-8, electronic ballast equipment. The technology is proven, the savings are well understood and easily quantified, and the opportunity is widely available (at least in the United States.) Complex measures usually involve a comprehensive improvement of a system or a process, often with consideration given to the interactions between pieces of equipment, their scheduling, and their set points. An example of a complex measure is the retrocommissioning of buildings, which involves a methodical investigation of the operation of energy using equipment to implement small but incremental improvements in the system's components. Retrocommissioning savings can be surprisingly large; they average five to ten percent of building energy use, and the measure can represent a significant savings potential.

Demand side management planners often refer to the low cost, low risk measures as "low hanging fruit," an image that conveys both the relative ease with which their savings are harvested and the untouched savings that remain harder but are more difficult to achieve. In the examples just given, lighting would be considered low hanging fruit while retrocommissioning would require greater planning and administrative support to succeed. Good program design will include provisions for targeting both simple and comprehensive measures.

DSM programs can have the objective of reducing energy intensity, offsetting projected load growth, or achieving a fixed goal of MWh per year. Programs can further specify the customer classes, geographic region, technology or other design condition for their target. While these objectives are ideally the outcome of a market potential study and resource planning process, many of the techniques discussed in this section will be useful even in the absence of such earlier research, particularly with regards to targeting both facilities (or plant types) and measures. Whether or not a potential study precedes the decision to launch a DSM program, designers will likely perform most of the following activities:[4]

- Develop a classification scheme for the population of the target facilities, in which each category represents an industry or customer class sharing similar processes, load profiles, operating characteristics, or products. Examples of likely categories are chemical facilities, petroleum refineries, steel mills, cement plants, pharmaceutical plants, office buildings, multi-family buildings. These categories are potential targets for a large-customer DSM program.
- For each facility category, disaggregate the existing energy consumption into major end-use categories or processes, and equipment types. This step will require collecting historical energy usage, both at the main meters and at available sub-meters or systems, for a sample of facilities in each category. It may also require short term monitoring of high use systems, and walk-through energy analyses in representative facilities.

[4] This is not meant to be a complete list but a starting point for the process.

- Develop load growth estimates so that the disaggregated historical record can be projected over the planning period as the baseline forecast. This is the future consumption and demand expected in the absence of a demand side management program, often referred to as business as usual. The forecast may be highly uncertain due to existing and expected future supply constraints, but these should be accounted for using the best estimates available. In addition to annual average usage, the projections should include usage for patterns that vary from the average. These usage pattern variations could be weather-driven (e.g., winter and summer seasons), production driven (plastics plants may have one or more seasonal peaks), or due to other variables.
- Develop a forecast of energy costs for each of facility or building category for the planning period. The forecasts should include both demand and energy components.
- Develop lists of measures for each facility category. The list should be guided by the results of the disaggregation step and the walk through audits. A quick way to begin this task is to use measure lists developed for other demand side management programs.

Using the results of these steps, program planners can perform iterative scenario analyses to select groups of measures for each facility category that offer the greatest cost-effective savings or return on investment. The measures can then be packaged into the design of a DSM program.

3.7 PROGRAM ELIGIBILITY CRITERIA

An outcome of any program design, and of any market and measure target selection process, is a set of expected characteristics for participants and projects. Participants and projects that match these criteria will support the program goals and increase the likelihood of successfully achieving them. Conversely, allowing participants that do not fit the expected profile for the program, or enrolling projects with measures that do not conform to program requirements, will diminish the potential for success. This section explores how eligibility criteria are developed and used.

> *Eligibility Rules Focus the Program*
>
> As an example of participant eligibility criteria consider how to prioritize industrial DSM program marketing. Eligible participants could be defined as large industrial facilities or as belonging to a class of energy-intensive industries. Lists of eligible and target industries would be prepared as part of the program design activities so that there is no doubt about eligibility. Note that within the eligible population there could be facilities that are not able to support program goals; for example, industrial plants that operate seasonally, or plants that self-generate their own electric power. Part of any DSM program design effort is to anticipate and consider these exceptions so that the program marketing *focuses on customers that can provide economically beneficial impacts*.

Eligibility criteria are applied to two elements of a demand side management program; participants and projects. Participants always include energy consumers, and they can be defined at any level of precision; for example, broad eligibility criteria might allow all industrial facilities to submit a project to an industrial program. A more restrictive eligibility screen might limit participants to only cement plants that have more than two megawatts of electric demand and are located, for example, within two hundred fifty kilometers of Beijing.

Projects, which are collections of measures and may include multiple sites, are also screened to ensure that they are consistent with program goals.

Participant eligibility criteria will vary from program to program, and by administrative model. Some common criteria include:

- A customer who hosts the proposed project must receive service from the energy provider that sponsors the demand side management program
- A customer or facility must meet a minimum annual energy usage or demand threshold
- A customer must be located within a specified geographic region
- A customer must belong to a specified class, often a billing rate class but could be as general as "industrial"
- A facility where the project will be installed must remain in operation for a minimum number of years
- A lending agency must demonstrate sufficient financial resources and experience with financing energy efficiency projects to support program goals
- A contractor or installer must demonstrate sufficient experience, financing, and resources to complete project

Projects are eligible if the underlying measures are eligible, if the projects conform to administrative requirements, and the project sponsors are eligible participants. Typical administrative requirements are discussed later in Section 5 (participant eligibility has already been discussed above). The balance of this section focuses on measure eligibility.

Demand side management programs commonly define measure eligibility criteria in three ways; specifying ineligible measures, providing a list of pre-approved measures, and setting guidelines for developing custom measures (defined as measures that may be eligible but are not pre-approved.)

Programs develop lists of ineligible measure attributes to reduce the number of applications that do not meet program goals, and to communicate to potential applicants the types of measures that are acceptable. Example criteria for defining ineligible measures for industrial demand side management programs may include:

- Useful life must exceed a specified number of years, commonly five to ten years
- Performance must meet or exceed legal minimum standards for efficiency or any other required criterion
- Savings cannot be a result of the reduction in the level of existing service, for example, reducing the number of shifts at an industrial plant
- Measures cannot be funded through another program
- Simple economic payback must be greater than some specified period, commonly one to two years

- Electric measures must reduce demand during system peak periods
- Measures cannot result in an increase in environmental or public health risks

It is also common for demand side management programs to develop lists of pre-approved measures. By including these in the program guidelines and application materials, designers guide potential participants to consider the list when planning for an energy efficiency project. Pre-approved measures in a project are usually processed in a streamlined fashion, and the measurement and verification of their savings is often simplified. Some common pre-approved measures used in industrial demand side management programs include:

- High efficiency lighting, for example T-5 or T-8 fluorescent lamps with electronic ballast that replace T-12 lamps with magnetic ballast
- Lighting occupancy and daylight dimming controls (in place of on-off switches)
- Premium efficiency motors that replace standard efficiency models
- Variable speed drives installed on variably loaded motors that replace an on-off switch
- High efficiency air compressors that replace standard efficiency equipment
- High efficiency chillers that replace standard efficiency equipment
- High efficiency boilers that replace standard efficiency models
- Stack economizers that recover exhausted thermal energy to perform useful work

In an actual demand side management program, each of these pre-approved measures would be fully specified as part of the program design process. So for example, a high-efficiency chiller would be defined as one that meets or exceeds an explicit minimum efficiency level; definitions for standard and premium efficiency electric motors would similarly be specified, usually by motor size in horsepower.

Demand side management programs will commonly stipulate savings and incentive levels for a subset of the pre-approved measures. Measures that fall into this category typically involve mature and well-understood technologies, such as lighting, that deliver savings with a small level of risk. Because of the low risk nature of these measures, applications and processing procedures for them are simplified and measurement and verification is based on earlier studies or the results from other programs.

Finally, programs frequently allow customers and contractors to propose custom measures for consideration. Custom measures are neither excluded by the ineligible list nor included in the pre-approved group. Allowing custom measures is a powerful strategy for allowing good engineers and business and facility mangers to develop unique solutions that fit a particular building or industrial process. Demand side management programs review custom measures to determine whether they will deliver reliable savings, are cost-effective, and will most likely be installed only if the program supplies financial or other substantial support. If these criteria are met, then the measure is accepted by the program.

Participant and project eligibility criteria are necessary controls imposed by program designers to ensure that the savings delivered by anticipated projects will be reliable, will support the program's overarching goals, and would only occur with the program's support.

3.8 KEY PROGRAM DESIGN OPTIONS

After a decision has been made to proceed with an energy-efficiency or demand-reduction program, then planners will need to select a delivery mechanism to acquire the demand side resources. This section introduces common delivery models, summarizes their key features, and weighs their strengths and weaknesses. These options can be deployed under any of the three administrative or institutional models that were discussed in Section 2. The fundamental program operations are the same for all deployment models, whether the administrator is a government agency, an independent organization, or an energy utility.

Regardless of the design option ultimately selected, successful programs share a core set of practices. These practices are independent of the delivery models, and adopting them can help increase the potential for a successful outcome. Many of these have been touched on earlier in this section and others will be addressed in later sections. Following is list of best practices that can be incorporated into whatever design option is selected:

- Set clear, achievable goals based on a realistic assessment of the target market
- Plan for the evaluation, measurement and verification of program results, primarily the savings impacts, during the design stage
- Specify the data needed to calculate the program's savings, require all participants to collect those data, and build a database to archive those data
- Actively reach out to the target audience and inform it about the program's benefits
- Minimize the administrative burden so that it does not become a barrier to participation
- Staff the program with a technically trained workforce of engineers, economists, and social scientists
- Prepare periodic reports on program impacts and participation, communicate the results to program staff, and use them to identify potential improvements
- Offer a comprehensive mix of cost-effective measures and application options so that energy consumers in the target market will find solutions for each of their individual facilities
- Adopt pricing and review practices that reduce project enrollments that would have occurred even in the absence of the program

All demand side management programs have the overall goal of acquiring demand side resources—that is, energy and peak demand savings. Different administrative, outreach, and financing mechanisms are used to achieve the desired savings, and these mechanisms constitute the program types or design options that are the focus of this section. Following is summary of these options:

Rebate programs operate by offering cash to offset the purchase of a high-efficiency device such as a motor or refrigerator. The cash is usually paid directly to the purchaser, who submits a proof-of-purchase receipt. The cash can also be paid to wholesalers and distribution centers, typically requiring proof-of-sale to a retail customer. Rebate programs are simple to deploy and operate, and their immediate availability helps to address the lost-opportunity problem for simple technologies. Rebate programs generally target the “low hanging fruit,” and do not result in comprehensive projects. They are often one element in a portfolio that provides multiple paths and opportunities for customers to improve energy efficiency.

Direct-install programs use utility or contractors to directly install low-cost, quick pay-back energy efficiency measures in customer facilities. While direct-install programs have limited application in an industrial sector efficiency program where the solutions and measures tend to be complex and large, and where plant operators are reluctant to allow outside contractors access to equipment used in the plant’s production, there are successful examples using such an approach. One example is a compressed direct install the program in which the administrator arranges for qualified technicians to work with industrial plants to identify and install low-cost compressed air measures. The technicians can be utility employees, or they can be contractors that are hired for their expertise. The technicians are trained experts who can quickly assess a plant’s operations and take advantage of compressed air savings opportunities. Typical measures include leak detection and repair, installing time clocks on compressors, adding small air compressors to serve a localized high pressure load that is then isolated from the lower pressure system, and piping cooler outside air to compressor intakes. Plant managers and the program administrator agree that the technicians will have access to the plant and will be allowed to install measures provided there is no interference with production. In a direct-install program measures are installed at little or no cost to the customer; in exchange the DSM program is able to achieve reliable and highly cost-effective energy savings.

Bid programs solicit private contractors to submit proposals to improve energy efficiency levels within a targeted group of customers. The programs set broad goals such as location and measure and facility types, and then rely on the bidders to propose projects. Proposals include estimated savings and price. Bid programs can rely on a few contractors that selected to develop projects over a period of years, or they can use an open enrollment policy that solicits contractors and facility owners to develop individual projects with measures that have been identified. Bid programs rely on contractors and customers to leverage their knowledge about facilities and markets with which they are familiar, improving the likelihood of projects that support the business of the host facility.

Standard offer programs offer to purchase energy savings from a list of pre-approved measures at a fixed price for each avoided kWh or therm. Contractors and facility owners can develop projects that conform to any program requirements that are itemized in the offer. The offer price can vary by measure type, region, size of project, or any other parameter that helps to improve the program’s potential to succeed. Standard offer programs can also accept custom measures not on the pre-approved list; project developers submit a description of the measure with estimated savings and costs, and the program manager calculates an offer price unique to the proposal. Like bid programs, standard offer programs leverage existing contractor or distributor relationships and facility owners’ knowledge about their own operations.

Energy audit programs provide technical experts to assess energy efficiency opportunities at facilities within a target market. The audit results in a report submitted to the investigated facility that describes how energy is currently being used, investigates promising energy efficiency measures, and recommends measures that will result in cost-effective savings while maintaining or improving service levels. Audit programs are usually linked to an implementation program (rebate, standard offer, etc.) so that the recommended measures can be installed. Audit programs also serve to educate the facility operations staff and increase awareness of the demand side management portfolio.

Upstream or mid-market programs provide incentives and other support (such as training and marketing materials) to encourage manufacturers and distributors to promote energy efficient equipment. The savings from an upstream program are achieved indirectly when a customer purchases and installs one of the promoted products.

The design options summarized above are delivery mechanisms that convert demand side management goals into actions, and ultimately savings. Each option has strengths and weaknesses, and in most cases is complemented by other design options—for example, the pairing of audit and standard offer programs, or of rebate and standard offer programs. Planners will ultimately select program types based on overall goals, the target market, and the target measures.

In addition to the design options, planners classify programs according to overall their objectives as follows:

- Resource acquisition
- Market transformation
- Strengthened codes and standards
- Education and training

In a capacity-constrained market such as that experienced by China's energy-intensive industries, demand side management programs usually have the acquisition of energy savings as a primary objective. In other circumstances, the program objective might be to transform how energy efficiency markets operate and help build the infrastructure (e.g., energy service companies and architects who design energy efficient buildings) so that energy efficiency becomes a standard option. These macro goals are used to classify demand side management portfolios as having resource acquisition or market transformation objectives. In practice, the distinction is often difficult to discern as all demand-side programs seek to acquire energy savings; if they also seek to develop a societal awareness and capacity for efficiency then they become resource acquisition programs with market transformation objectives. Planners consider these program categories when translating program goals into action, and progress towards goals is measured slightly differently in each case, but the same delivery mechanisms are used regardless of the classification.

Energy efficiency can also be improved by mandating minimum efficiency levels through codes and standards. Since the mandates occur as the result of regulatory or legislative action, the concept of a program design option is moot; savings are achieved as equipment is replaced and as new industrial plants, manufacturing facilities and buildings are constructed. Savings from codes and standards mandates can be significant; a recent California study estimated that they would contribute more than 15 percent of energy savings goals in the State in 2006.[5] China has already embarked on the codes and standards path with a series of initiatives in recent years such as the equipment standards issued by China's Appliance Standard Committee.

Energy efficiency can also be promoted through education campaigns and training sessions. An education and training initiative seeks to provide customers with the information they need to make rational decisions about energy use and purchases, and is therefore a market transformational activity. Education and training initiatives are often deployed in conjunction with other more focused delivery mechanisms such as rebate and standard offer programs.

There are numerous additional planning decisions to be made when designing a demand side management program, including the level of the evaluation, measurement and verification of program impacts; selecting a framework for presenting program economics; and identifying financing mechanisms. These topics are addressed later in this manual either as stand-alone subjects, or in the context of related topics.

3.9 PROCEDURES MANUALS

Regardless of the types of program selected by planners for inclusion in a DSM initiative or portfolio, each program will need a procedures manual that sets out the operational details of all aspects of any project that may enroll. A procedures manual is a practical guide that delineates the roles and responsibilities of the administrators, the participants or customers, the contractors who perform the work, the rules for payment, as well as specifications for project and customer eligibility. Procedures manuals need not be complex but they should provide a roadmap for all parties to understand the program process from initiation to final payment.

Additional details on the contents of procedures manuals are described at the end of Section 4, after first introducing typical elements of a project.

3.10 PLANNING FOR EVALUATIONS

In addition to providing for a DSM program's activities, goals, target markets, administrative structure, and other details, program designers also need to specify how the results will be evaluated. Program evaluation reviews are the actions taken to measure and report a program's benefits, its costs, and its progress towards goals. To accomplish these activities, evaluators will need the program administrators to collect and archive data that capture the baseline conditions, installations, and operations of all of the measures that account for savings impacts. Thus as part of any program design, planners should identify evaluation data needs and require administrators to acquire them.

Evaluation theory, planning and activities are described more fully in Section 5: Evaluation, Measurement, and Verification of Savings

[5] Southern California Edison (2005). *Codes and Standards White Paper on Methods for Estimating Savings*. Prepared by Heshong Mahone Group

Section 4 Program Implementation Process Flow and Procedures

This section describes some of the program management tasks as they relate to the design and operation of a demand side management program. Much of the theory and many of the principles that underlie these tasks were presented in Section 3. These tasks are independent of the administrative models introduced in Section 2 and are applicable to any management structure.

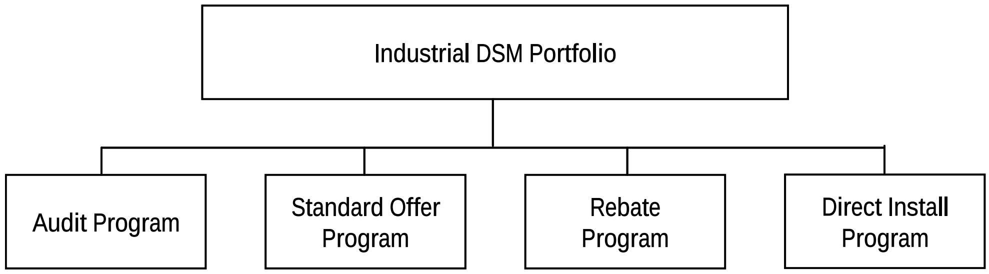
This section begins to apply the concepts, which have been the focus of the manual up to this point, to a typical program. In doing so we discuss the options and choices in terms that are specific to Chinese circumstances, and focus on the industrial market, which accounts for over 60 percent of China's stationary energy consumption. Considering an industrial DSM program is useful because it 1) focuses the discussion on the market and the savings opportunities that offer the greatest reduction in energy intensity and load growth and 2) anchors the explanations of the design and management tasks to the concrete tasks that will be faced by program administrators operating in China.

Given China's stated need to reduce forecast growth in energy consumption, any Chinese DSM program is likely to be a portfolio of programs with resource acquisition goals, and it could reasonably be expected to have a mix of some or all of the following elements or programs:

- Energy audit program. This would be a key approach for recruiting participants, educating facility managers, and developing projects. An audit program helps facilities identify cost effective energy reduction projects that can be built using implementation programs that are part of the portfolio.
- Standard offer program, with a provision for custom measures. This would likely be the main implementation activity of any portfolio of industrial DSM programs, helping facility managers turn the recommendations of the audit reports into projects and savings.
- Rebate program. The rebate program would supplement the standard offer program by offering cash rebates to help buy down the purchase price of simple and easy-to-implement measures recommended in a facility's audit report.
- Direct install program. The direct install program would deploy teams of technicians into factories and facilities to identify and install low cost, low risk measures focused on one or more systems commonly found in industry; for example, compressed air or process cooling.

For the balance of this section, it is assumed that the portfolio of programs includes these components. It is also assumed that the portfolio has limited, but sufficient, funding so that it can offer financial incentives under the rebate and standard offer programs, and to hire energy engineers to conduct facility audits and operate direct install programs. These assumptions would be commonly found in currently operating demand side management programs in many countries around the world. Figure 4-1 below provides a simple illustration of a portfolio of industrial programs. Program performance goals can be established and evaluated at the program level, as well as at the portfolio level.

Figure 4-1 Illustrative DSM Portfolio



4.1 ANALYSIS AND ASSESSMENT OF ENERGY SAVINGS POTENTIAL

The market potential study was described in Section 3.6 as a method for identifying and quantifying the energy and demand reductions that could be achieved by operating a demand side management program. Chinese DSM programs and portfolios will likely borrow concepts from the potential study, as the need to reduce load growth is so pressing that authorities are likely to advocate immediate action. Nonetheless, some form of abbreviated assessment of savings potential will likely be conducted.

An important task for the assessment of savings potential is not only to establish quantifiable program goals, but also to conduct sufficient research so that marketing efforts can be carefully directed toward priority industry types and end uses.

Industrial facilities are not a homogeneous group, and so it is necessary to identify sub-populations of similar facilities that share energy use profiles and that can benefit from similar measures. The first step is to group similar industries, a step that can probably be done by examination of business profiles. The second step is to construct an energy use profile for each of the industry classes, which will allow program administrators to develop strategies and bundles of measures that complement the energy use patterns for each class or sector. The second step can be carried out by using the savings potential study to disaggregate a typical facility energy use and intensity for each class. Data to support this effort will probably come from energy audits, supplemented by additional site visits to representative plants. Energy use profiles for industrial sectors in Europe, the United States, and Asia can be used to validate the results.

As an example, consider the Chinese iron and steel manufacturing industry, which accounts for approximately ten percent of China's primary energy consumption. Because of the sector's size and relatively homogeneous structure, DSM planners will want to profile energy usage for a typical iron and steel plant. One survey of the US steel industry finds that of all the energy used in a steel plant, 38 percent is consumed during initial iron making, 15 percent in steel making electric arc furnace, 12 percent in boilers, and 20 percent in miscellaneous processes such as reheating, rolling and finishing.[6] These four processing groups account for 85 percent of production energy requirements and clearly should be the focus for investigating steel plant energy efficiency opportunities. It is not surprising that waste heat recovery, blast furnace

6 US Department of Energy, Office of Industrial Technologies. 2000. *Energy and Environmental Profile of the US Iron and Steel Industry*. DOE/EE-0229.

controls, and insulation of furnaces are among the measures that represent significant potential for reducing energy use and intensity.

This simple example of the development of an energy use profile would be carried out (with considerably greater rigor and detail) for each energy-intensive industrial sector. The result would be a characterization of potential savings by sector, process, and technology that can enable the program managers to identify readily available opportunities, and to develop measures that achieve the savings needed to meet the goals of the DSM planners.

There are two categories of measures used in the industrial class that deserve special recognition, and should always be considered in assessing industrial savings potentials:

Motors can account for 70 percent or more of industrial electricity use. Motor measures include:

- Installing variable speed drives on motors powering variably-loaded equipment
- Replacing standard efficiency motors with premium efficiency models
- Replacing oversized motors with smaller, load-matched motors

Cogeneration can significantly reduce source energy use if there is a simultaneous and nearly continuous requirement for electric and thermal energy. The thermal requirement should be sufficiently large to use all, or nearly all, of the generator's rejected heat. Because these conditions are common in manufacturing plants, they present an opportunity for reducing energy use and intensity.

The administrators of a portfolio of industrial DSM programs will be responsible for conducting the energy savings potential assessment task. This may require hiring outside consultants and engineers to perform the actual surveys and data analysis, but the work should be specified by the administration so that it is coordinated with the overall goals of the DSM initiative.

4.2 IDENTIFICATION OF TARGET MARKET

As discussed earlier, the identification of target markets is an outcome of the savings potential analysis. In China the target market is likely to be the large industrial energy consumers, and little further study is needed to define its boundaries. Nonetheless, as indicated in the previous section, these facilities constitute a heterogeneous population, and segregating them into sub-classes containing similar facilities such as iron and steel, power, textiles, petroleum and petrochemical, will allow the program administrator to tailor an approach to each industrial category. And because there are additional savings opportunities outside of the industrial sector, for example, in the construction of highly energy efficient office buildings, Chinese DSM programs will also target other sectors.

For a Chinese industrial program or portfolio of DSM programs, the target market identification task is to quantify the savings potential for systems and technologies in each of the energy-intensive industrial facility classes. The process for doing this has been explored in previous discussions of potential studies, and relies on both the top-down (disaggregation) and bottom-up approaches to constructing a baseline forecast, and then conducting parametric analysis by using energy savings measures to replace standard equipment with high-efficiency or co-generation equipment to estimate a revised forecast and potential savings.

The end result of the identification of the target market is an estimate of the realistic savings potential for large industries by plant or facility class, and by end-use technology or system. This information guides the outreach activities for the industrial DSM programs, and allows the program to allocate financing and staffing resources in proportion to savings potential.

The administrators of the portfolio of DSM programs will be the party responsible for conducting the analysis to identify the savings measures by sector, and end use systems and technologies, with support as needed from consultants and engineering concerns.

4.3 SELECTION AND RECRUITMENT OF ENTERPRISES TO PARTICIPATE IN THE PROGRAM

Demand side management programs need to have an active approach in recruiting and enrolling participants to ensure that energy savings projects are implemented. After planners have analyzed the target market and savings goals have been assigned to industry classes and end uses, they will need to create a marketing strategy to persuade decision makers in the key industries to develop and complete projects. Industrial decision makers will certainly include facility and operations managers who have some level of budget control or input into the budget planning process.

DSM programs typically interact with other market players with influence over the strategic decisions on investing in energy efficiency or energy management measures. Some examples of these include:

- Energy service companies (ESCOs) that design, develop and operate energy using systems in the target market. ESCOs seek to reduce or control energy costs through improved efficiency and management. They often provide financing and recover their investment and profits from the industrial consumer’s avoided energy costs, a process termed a performance contract.
- Specialty contractors with expertise in energy use in industrial facilities
- Professional and trade associations that represent managers and operators within the different classes of large industrial enterprises
- Government agencies that plan output and economic performance for groups of industries

Planners and portfolio administrators will need to develop strategies to inform potential participants about operations of all programs in the portfolio, how they can help each of them to improve their services or grow their businesses. One successful approach is to develop a strategy for each market participant and to then convene a focus group made up of members of the target market to test the strategy. The focus group participants provide feedback directly through exit interviews, and indirectly by carefully designed response forms completed during the trial session.

The activities that can be included in a strategy to inform and influence the market participants will vary from group to group, but they will likely include at least some of the following:

- Technical training sessions on energy audits, energy efficiency, energy management, and co-generation, and other technical topics

- Printed and electronic material advertising program initiatives
- Prepared presentations introducing the demand side management program to gatherings of targeted market players
- Public media campaigns to inform the mass market about energy issues and the value of energy efficiency

Administrators and planners will need to develop strategies to encourage decision makers to invest in energy savings projects. The strategies should be specific for each market group and type of decision maker, and should be coordinated with each other to deliver a consistent message.

4.4 INCENTIVE MANAGEMENT

After any portfolio of programs, or an individual program, is designed, launched and operational, a major administrative activity is to operate and manage the program. The fundamental unit of a program is a project, and so managing a program largely means managing projects. Project management; including the handling of incentive payments, their timing, and the triggers that activate payment; are all discussed in more detail below in Section 4.6.

4.5 BEST PRACTICES FOR PROCESS EVALUATION AND CONTINUOUS PROGRAM IMPROVEMENT

Successful demand side management programs evolve over time by continually assessing their own operations and outcomes, and then using the results to modify the program delivery structure to improve overall performance. This continuous improvement mechanism is suggested in Figure 3-1 where the EM&V results provide feedback to the program design.

Formal assessments of program performance are termed process evaluations. A process evaluation provides information on a program's operational efficiency and its ability to meet program goals. It also assesses the program's market segmentation scheme and targeted markets to see if they are correctly characterized and matched.

Best practices for process evaluations and program improvement include the following:

- Clear program goals and indicators for progress towards goals. An example of an indicator is the amount of energy saved to date, which can be compared to a program's savings goal. One method for developing the relationship between goals and indicators is a theory and logic model, a depiction of the operations, and near- and long-term outcomes of a demand side management program. While theory and logic models are often complex, simple versions can provide a great deal of insight into how to evaluate performance.[7]
- Include provisions for a process evaluation as part of program design. It is particularly important during the design phase to specify the information that will be required by the process reviewers to complete their work. Information that is typically required includes lists of program customers and their contact information, lists of

[7] For a detailed discussion of theory and logic models see: *The California Evaluation Framework.* California Public Utilities Group. June 2004.

attendees at training and outreach sessions, all outreach materials, and cycle times for project reviews and other administrative operations.

- Conduct a process evaluation early in a program's life cycle, ideally at the end of the first year of operation, so that opportunities to make design improvements and increase administrative efficiency can be identified and enacted quickly.
- Engage the administration staff in the process evaluation so that they are more likely to accept and implement the recommendations for change. Staff members can be threatened by change, no matter how well-intentioned, because of a natural tendency to interpret suggestions for improvements as criticism of past conduct.
- Engage administration management in the process evaluation outcomes so that they are also more likely to accept the recommendations and manage their implementation.
- Engage trained professionals to design and implement a process evaluation. Process evaluations require judgment and experience if they are to result in actionable recommendations that reflect the operating reality of the programs under review.

Despite the last item on the best practices list, even a simple process review conducted in-house by a program administrator can help correct contradictions between goals and operations, and address administrative inefficiencies. There will inevitably be room for improvement in any new program design, and so careful and early consideration of program operations is important to identify and act on those improvements quickly.

4.6 PROJECT PROCESS FLOW AND PROCEDURES WITHIN PROGRAMS

This section describes the steps in the development, construction and final reporting of a typical demand side program project. Following the scenario laid out at the beginning of Section 4, we examine a hypothetical portfolio of industrial DSM programs that includes audit, standard offer, rebate, and direct install program components.

The components of a project and the operations steps will vary by program type. Because the central operation in an industrial portfolio is likely to be a standard offer or similar program, this section focuses on a typical standard offer program process. Processes for energy audit, rebate, and direct install programs, which follow a simpler operations model, are introduced at the end of this section.

There are several ways to configure the procedures for the life cycle of a typical project in a standard offer program, and the one described here could be modified to fit the particular circumstances of an industrial program. The architecture presented below is probably as complex a scheme as will be encountered among operating programs, and so we highlight steps that could be optional.

Following is a brief summary of the steps in a standard offer project. Note that a program participant can be a facility, an enterprise, a government agency, an energy services company, a specialty contractor, an engineering firm, or other qualified entity designated by the program administrators.

- Initial application. Prepared by the participating facility or representative, and submitted to the program administrator, it outlines the proposed energy savings project, including savings estimates and schedule.
- Agreement. The program manager, after reviewing and approving the initial application, prepares an agreement laying out the terms and conditions for the participating facility to receive payment for the proposed savings.
- Final application. Prepared by the participating facility and submitted to the program manager, the final application contains the engineered plans for the energy savings project; at this point the energy savings estimate is based on sound science and good operating data. The program manager reviews the application (a step that may include a baseline inspection) and approves or requests changes.
- Installation. The participating facility or its contractors install the measures specified in the approved final application, and sends an installation report to the program manager.
- Installation payment. The program manager reviews the installation report, conducts an inspection of the new equipment, and approves or requests changes. Upon final approval, the program manager pays the participant a portion, usually less than half, of the incentive amount in the agreement.
- M&V and savings report. As specified in the agreement, the participating facility conducts M&V according to an M&V plan submitted as part of the final application. This may take a few weeks to a few years depending on the measures, magnitude of savings, program design, and other factors. Participant submits a savings report.
- Performance payment. Administrator reviews the savings report and upon approval issues final payment to the participant.

Figure 4-2 depicts the relationships, the sequences and the responsible parties for the processes for a project enrolled in a standard offer program. Following Figure 4-2, additional information is given on each of the steps.

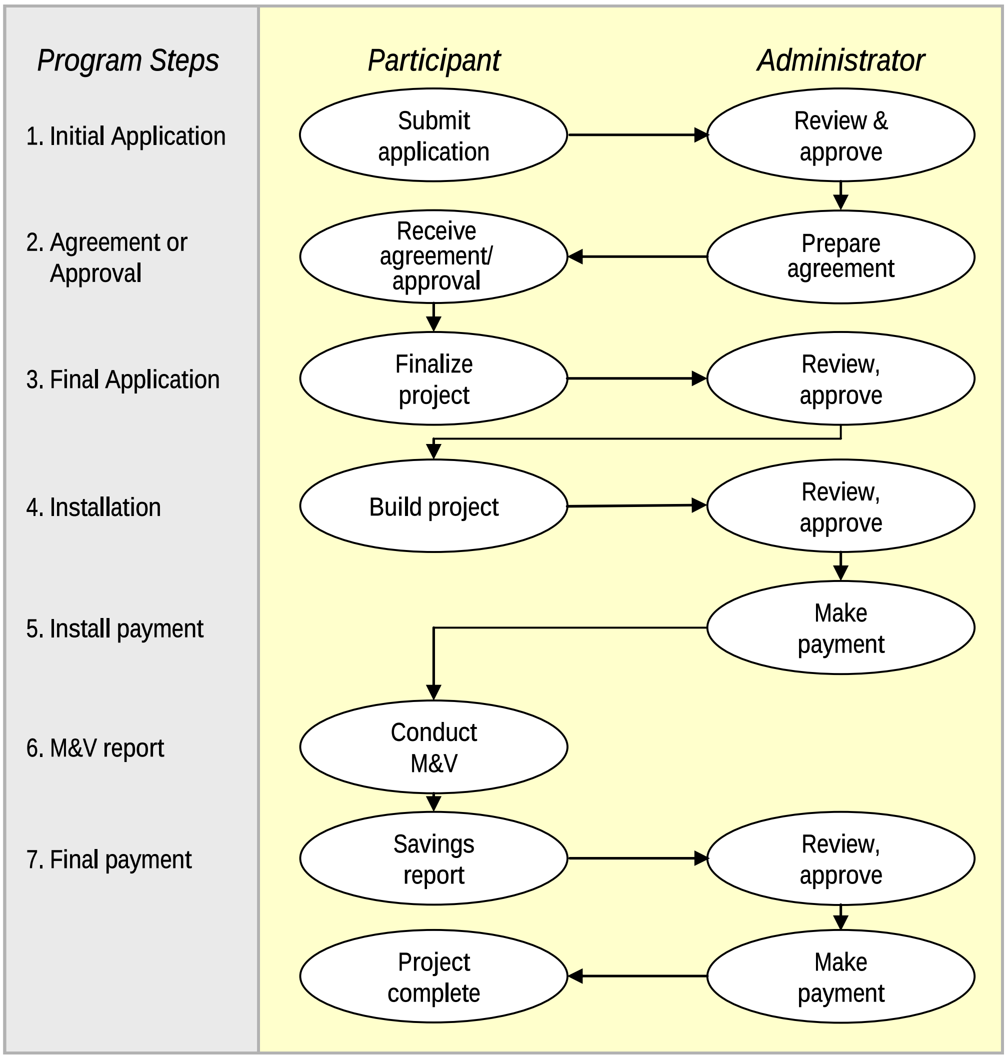


Figure 4-2 Standard Offer Program Process

4.6.1 Initial Application

A project is initiated in a standard performance program when a potential participant submits an application to the administrator to request funding and support. The application is made on forms provided the administrator and it contains information about the applicant, the facility where the proposed project would be installed, the proposed measures with the baseline and proposed energy profiles, and the estimated savings by measure and project.

The administrator reviews the application for conformance with the program's eligibility rules, completeness, and to ensure that the savings estimates are reasonable. The administrator asks the applicant to supply or correct any missing or erroneous information. If at the end of the review, the application is complete and the proposed project and measures are eligible, then the administrator approves the project and prepares an agreement between the participant and the program, which is sent to the applicant for execution. Upon approval, the administrator also reserves the incentive money specified in the agreement.

The savings at this point in the process are still estimated, with some degree of uncertainty. The accuracy of the estimates improves as the project progresses through the program, until at the final stage they are based on M&V activities and are reported with high confidence.

The project application is rejected if it is ineligible, incomplete, or there is not enough information to support the savings estimates.

4.6.2 Agreement

The agreement spells out the terms and conditions under which the administrator will pay the participant. In most cases, the incentive payment is made for the energy savings that result from the project, in which case the agreement is termed a pay-for-performance agreement. Less rigorous terms might pay in exchange for the *installation* of measures, or some simple demonstration of a reduction in energy usage through a bill comparison, but then the program's reported savings would be highly uncertain.

The incentive payment in a pay-for-performance agreement is usually the maximum incentive, and no additional money will be paid for energy savings beyond the amount specified in the contract. However, if the actual savings, as determined by the final savings report, are less than the agreement quantity, then the payment is reduced proportionally, usually on a per kWh or therm basis. A major reason for adopting this approach is that the available funds are limited, and the administrator reserves the agreed amount for each approved application, until the funding limit is reached. If projects are allowed to receive payment above the agreed amount, then the administrator looses control over the budget and claims can exceed available funding.

DSM program administrators in China may not be able to sign a commercial contract, and in most cases are also unable to transfer money directly to a customer. Therefore the energy performance agreements found in other countries may take a different form when employed in China. For example, an approval by a Chinese government authority is generally considered a binding agreement even though the approval or order is not a negotiated contract. As example of handling incentives, in Jiangsu payment is awarded through bill credits with no cash changing hands.

In either Chinese or Western-style agreements, the importance of specifying the terms and conditions of the transaction remains high. Without an explicit understanding, neither the customer (who is selling energy savings) nor the administrator (who is purchasing savings), can be clear about the rules governing the transaction. Thus the approval by a government authority to proceed with an energy efficiency project should have clear terms and conditions under which the bill credit will be awarded, and how the savings are to be demonstrated.

The authority's approval or agreement, which also typically includes an authorization to proceed with the project, is sent to the participant upon approval of the initial application. Appendix E presents a sample agreement.

4.6.3 Final Application

The final application describes the proposed measures, and estimated energy savings and incentive payments based on a detailed engineering analysis using data collected as part of a site audit. There is usually a deadline of a few months after the initial application is approved until the final application must be submitted. The deadline is specified in the agreement.

Some of the information usually required in a final application includes:

- Detailed information about existing and proposed equipment such as counts, efficiencies, operating schedules, size, and nameplate data
- Baseline demand and energy usage, including the raw and processed monitoring and spot measurement data used to create the baseline condition
- Facility operating and production schedules, and both historical and expected trends and variations
- M&V plan describing how participant will measure and verify the projected energy and demand savings
- Estimated project timeline

To ensure that the participant submits the required information, the administrator usually develops forms that must be used as part of the final application submittal. Example forms can be seen in Appendix E.

The administrator reviews the final application using the same criteria and process as the initial application. In most cases, the administrator also conducts a baseline inspection. The baseline inspection verifies the participant's equipment counts, sizes, schedules, efficiencies and other variables that determine the baseline energy use and demand.

The baseline is the energy and demand requirement of the equipment and systems that are to be modified as part of an energy savings project. The savings are the difference between the baseline and the efficient usage. Because it is impossible to measure the baseline condition (energy and demand requirements, temperatures, schedules, flow rates, capacities, load factors, and other variables) after a project is completed, establishing an accurate and supported baseline is arguably the most critical factor in ensuring a successful energy savings project. The most common source of uncertainty in an energy savings project's savings is uncertainty in the baseline.

A key component of the final application is a project-specific M&V plan that describes how the participant will measures and verify the energy savings expected for the project. The M&V plan includes details regarding who will carry out the plan, an inventory of the measures including baseline and new equipment lists, what measurements and monitoring will be conducted after the new equipment is installed, the equations that will be used to calculate the savings, and the schedule for carrying out the plan.[8] Well-planned and thorough M&V is critical to the accuracy of a project's reported savings, and for the sponsoring program. M&V is discussed in depth in Section 5.

An alternative to having separate initial and final application stages is to combine these into a single step. The advantage of a combined application is a reduction in document preparation and

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8 Responsibility for M&V can rest with the participant, the program administrator, or a 3rd party independent agent. Participant conducted M&V is the most common practice in the United States programs.

review time, and possibly a shorter time to project completion. The disadvantage is that participants frequently misunderstand or ignore program requirements and submit applications with missing or erroneous information, which then requires the administrator to work with the participant to correct the initial submittal. Breaking the application into two, with the initial part requiring only basic information, allows the administrator to begin a dialog with the participant to convey the scope and limitations of the program. Two-part applications are the norm for standard offer programs in many countries.

4.6.4 Installation

When the final application is approved, the participant begins to install the energy savings project. After construction is complete, the participant submits an installation report to the administrator. There is usually a maximum allowable time period, from a few months to a year or more, between the final application approval and the installation report. The allowable time period is specified in the agreement.

The form and content of the installation report is similar to the final application, except that it reflects the as-built condition with any changes or modifications to the originally proposed measures, or changes in facility operations and schedules. The savings estimates are also revised based on the actual installation. The M&V plan is updated to match the as-built condition. Like the final application, the participant is required to submit much of the information using forms designed for the program.

The administrator conducts an installation inspection to ensure that the measures are installed and operating as specified in the installation report. The administrator also reviews the calculations used to estimate the project savings. Missing or erroneous information is supplied or corrected by the participant as requested by the administrator.

If the review of the installation report is satisfactory, then the administrator notifies the participant with an approval to begin the M&V activities.

4.6.5 Installation Payment

Upon approval of the installation report, the administrator releases a portion of the reserved incentive amount. There are no rules for the size of the portion, but is typically in the range of 40 percent to 60 percent of the reserved funds, with the actual amount specified in the agreement. The rationale for making an interim payment is to help the participant help pay down some of the costs incurred in implementing the project. The payment also reinforces the value of the program in the participant's mind; the link between payment and program can be lost if it is delayed until after the M&V period, which can be years after project completion.

The amount of the incentive payment is based on the most recent savings estimate that is approved as part of the installation report. If the agreement specified a 40 percent installation payment then the actual payment would be of 40 percent of the adjusted incentive based on the savings report estimate, but no more than 40 percent of the reserved incentive specified in the agreement.

Payments made before the project savings are measured and verified, as at the installation stage, are called progress payments. Progress payments can be made at any stage during the project implementation. It is not uncommon for a program to allow two progress payments; one upon approval of the final application, and another when the installation report is approved. The decision to make progress payments is based on the administrator's estimate of how much of an early reward participants will need to be persuaded to enroll in the program.

4.6.6 Measurement and Verification

After the installation report is approved by the administrator, the participant (or other responsible party) begins to conduct the activities specified in the M&V plan. The term of the M&V period is specified in the plan, and usually depends on the expected variability of the savings over time. Savings for measures whose performance varies by season or erratic production schedules or for other reasons are subject to longer M&V periods than for steady state or constant load measures that have no fluctuations. Selecting an M&V method and period requires balancing the value of the expected savings against their expected uncertainty. Thus a minor lighting retrofit project in a facility with a fixed operating schedule (where the savings are small and the performance is known with good confidence) would likely use a simplified M&V plan. A large, complex process cooling measure on a manufacturing line that has a variable operating schedule (i.e., a schedule that varies depending on unpredictable market demand) would likely use a detailed M&V plan requiring the monitoring of multiple data points for a year or more.

The administrator may conduct one or more site visits to verify that the approved M&V plan is being implemented as expected and that the supporting data are being collected and archived.

When the data collection phase of the project's M&V activities is completed, the data are analyzed using the equations and algorithms specified in the plan. The participant prepares a savings report summarizing the results, supported by the raw and processed data, and that includes all the calculations used to quantify the savings results.

The administrator reviews the savings report and, as with earlier submittals, requests additional information or corrections as needed. The administrator notifies the participant when the report is approved.

4.6.7 Performance Payment

Upon approval of the M&V report, the administrator makes a final payment based on the actual performance of the project. If the earlier installation payment was 40 percent of the total incentive, then the performance payment is for the remaining 60 percent. As with the installation payment, the value of the total incentive is recalculated using the results from the M&V savings report, with the limitation that the total incentive cannot exceed the agreement amount.

For complex projects that have an extended M&V period and multiple annual savings reports, the performance payment can be distributed over several reporting periods. While multi-year M&V plans can increase the accuracy of the final savings estimates, the increased confidence comes at the cost of additional work, and, from the participant's perspective, delayed reward. In standard performance programs in the United States, the trend has been towards shorter M&V periods using simpler methods.

With the final performance payment, the project is finalized.

4.6.8 Additional Program Types

The preceding discussion presented the administrative and implementation steps for a project submitted to a standard offer program. We assumed earlier that an industrial DSM initiative is likely to be a portfolio with other programs in addition to a standard offer, namely energy audit and rebate programs. While the principles for the basic processing and review steps remain the same for all three program types, the project flow varies somewhat. This section outlines the processes for the energy audit and rebate programs.

4.6.9 Energy Audit

An energy audit program investigates the energy savings opportunities in a facility, and provides the facility managers with a roadmap showing how to acquire those savings. An audit program helps to persuade facility and plant mangers to invest in cost-effective energy efficiency and cogeneration projects, which can then be implemented through an industrial DSM portfolio's standard offer or rebate programs, or both. The value of an energy audit program for any DSM portfolio is that it provides a stream of eligible projects to its implementation programs, and thereby helps achieve savings. By controlling the process, content, and staffing of the audit, the program administrator controls the quality of the final study, which increases the confidence in the savings estimates and costs for the recommended measures.

Following is a brief summary of the steps in an energy audit study. As with the standard offer program, a program participant can be a facility, an enterprise, a government agency, an energy services company, a specialty contractor, an engineering firm, or other qualified entity that is designated by the program administrator.

Application. A DSM program-sponsored energy audit begins with an application from the potential participant. The application contains basic information about the facility site and operations, the current energy usage, and the reasons for wanting to conduct an audit.

Scope of work. The administrator or its technical consultants conducts a site visit for the purpose of performing a scoping study. This step results in a scope of work agreed to by the participant and the administrator that describes the tasks in the energy audit. These tasks typically include:

- Profiling the facility's energy usage, and disaggregating it into systems and processes
- Benchmarking the facility's energy usage against similar facilities.
- Investigating a specified list of potential energy savings measures.
- Preparing a final report.
- Agreement (or approval to proceed). The participant and administrator implement an agreement to conduct the energy audit described in the scope of work. The agreement lists the people who will do the work, sets a schedule, and itemizes the contributions that each party will contribute to the effort. Programs in an industrial DSM portfolio might offer to pay part or all of the costs of the study, or to reimburse the participant's costs (up to a fixed amount) if the recommended measures are implemented.
- Study and report. The study and report phase carry out the scope of work according the terms and conditions laid out in the agreement. The study procedure should follow

a protocol selected by the administrator, or use protocols developed for the program.[9] Because the participant is the primary beneficiary of the audit, facility staff should be engaged in the investigation, the analysis, and its results. When the study is complete and both parties agree to its content and recommendations, it is delivered to the participant, along with any payment specified in the agreement.

- Follow up. Because the purpose of the study for the administrator is to turn recommendations into projects and savings, the program should follow a procedure to work with the participant to enroll in one of the implementation programs.

4.6.10 Rebate Program

A rebate program reimburses a participant for some or all of the cost of a simple measure. Complex measures that require baselining and performance measurement are better suited for a standard offer program. Rebate programs provide a list of eligible measures and their rebate amounts. The rebates are calculated based on average expected savings and avoided energy costs, average equipment lives, and average operating conditions for each measure. A rebate for a measure should result in several years of avoided energy use with a net value that is greater than the rebate. The nature of the program is such that the savings per application are small and relatively reliable; therefore the administrator's role is usually limited to reviewing the materials submitted by the participant.

- Application. The participant submits an application for a completed measure using standard forms provided by the administrator. The participant selects one of the equipment types approved for the program, supplies the equipment counts, and provides facility information. The participant attaches receipts or other proof of purchase for the equipment. The administrator reviews the application for compliance with program rules and equipment eligibility, and either approves or rejects the application.
- Payment. If the application is approved, then the administrator pays the participant the rebate set by the program for the equipment submitted in the application. Both the rebate amount and the savings for each piece of equipment are stipulated and do not vary from application to application. The stipulated savings are credited to the sponsoring program.

4.6.11 Direct Install Program

- A direct install program employs team of technicians who are trained to quickly assess energy savings opportunities and install simple measures, all while conducting a site visit at a facility and at low cost or no cost to the facility or industrial plant. Direct install programs target technologies or systems such as compressed air, or process cooling. Measures are typically simple and have quick paybacks, so that the program administrator can have high confidence in the resulting savings. Typical steps in a direct install program include the following:Application. A representative of the program contacts a facility to introduce the program and to schedule a trip to the facility or plant by the program's technicians.

[9] Some examples of audit protocols are: ASHRAE. *Procedures for Commercial Building Energy Audits.* And Turner. *Energy Management Handbook.* Turner, Wayne. The Fairmount Press, Inc. 2001.

- Installation: On the scheduled day(s) the technicians conduct their survey of the target facility and install measures as appropriate for the opportunities that they find on site for the technology or system they are targeting. The technicians record each of the energy efficiency improvements that they implement and their estimated savings; this record is forwarded to the program administrator who combines it with all other installation reports to calculate the program savings.

4.7 PROCEDURES MANUAL

Procedures manuals were introduced during the discussion of portfolio and program design as a necessary ingredient for a program's success, and a roadmap for all program participants. A procedures manual describes the program rules for a project and the expectations for the participants in applying for and building a project. Typical contents of a procedures manual include the following:

- Program goals
- Program schedule, open and close dates
- Project eligibility requirements
- Participant eligibility requirements
- Measure eligibility requirements
- Incentive rates
- Payment milestones
- Enrollment process
  - Initial application form
  - Final application form
  - Installation report template
  - M&V report template
  - Final payment
- M&V requirements

An example program procedures manual for a United States standard offer program is included in the appendix.

Section 5 Evaluation, Measurement, and Verification of Savings

There are several barriers to the full use of cost-effective energy efficiency. One of these barriers is proving that energy efficiency "provides the claimed savings." This barrier can be addressed by having consistent, complete, accurate and transparent evaluations that document energy savings. Having effective evaluation infrastructures, policies, processes and trained personnel in place to document the benefits of energy-efficiency activities is critical to the success of efficiency programs that must prove their value and their worthiness of continued investment. Thus, by utilizing best practices and consistent, standard procedures, evaluations can support the adoption, continuation, and expansion of efficiency programs.

This section supports the preparation of program rules for determining the energy savings that directly result from implementation of a program. In particular this section describes a structure and several standard approaches for calculating energy, demand, and emissions savings resulting from facility (non-transportation) energy-efficiency programs that are implemented primarily for industrial facilities.[10] This is called "impact evaluation." This chapter also describes some basics of other types of evaluations, including process and market evaluations and cost-effectiveness analyses.

As explained below in Section 5.3, for industrial energy efficiency programs, there are two primary procedures documents that must be prepared for the impact evaluation activities:

- Each individual efficiency project's *Measurement and Verification (M&V) Plan*, prepared by enterprises

Why Conduct Evaluations? Things that are measured tend to improve.

The reasons to do an evaluation can be summarized in two words: improvement and accountability.

Evaluations provide information that can help improve programs and they demonstrate internal and external accountability for the use of resources. Program evaluations provide timely information to improve program implementation, as well as the design of future programs and individual energy efficiency projects. By conducting a program evaluation, entities can answer the following questions:

- Are the program and the projects that make up the program achieving their goals? If so, how and why?
- How well has the program/project worked?
- What changes are needed to improve the program/project?
- What is the program's impact on actual projects and future projects?
- Should the program/project be replicated, adjusted, or cancelled?

An evaluation also indicates if the "resource" can be relied upon. Knowing whether the efficiency program will reliably generate savings (i.e., MWh) is critical to knowing whether existing and future programs can be counted on as an important part of an energy resource portfolio.

An evaluation also provides an understanding of:

- Program approaches that are most and least effective and how to improve future programs.
- Where to focus programs for greater savings.
- Actual values that can be used in future estimates of benefits, for example, estimates of energy savings per motor.

[10] This section is based on the US National Action Plan for Energy Efficiency (2007). Model Energy Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc. www.epa.gov/eeactionplan

participating in the program, that indicates the details of how the savings from each individual project will be determined.

- A *Program Evaluation Plan*, prepared by the Program Administrator, that defines how the Administrator will determine the program's total savings resulting from all the projects in the program, using the results from each individual project's M&V efforts.

Corresponding to these two procedures documents there will be two primary types of reports:

- Each individual efficiency project's savings report prepared by the enterprises and verified by the Administrator.
- The program evaluation report, prepared by the Administrator, describes the overall program savings and other results from the program evaluation effort.

To provide information for preparing these procedures and reporting documents, this section is organized into five major areas:

- Overview of evaluation basics
- Impact evaluation basics
- Planning evaluation and M&V activities
- Minimum requirements and best practices for impact evaluation of industrial energy efficiency programs—including preparing the two primary procedures document
- References

5.1 OVERVIEW OF EVALUATION BASICS

5.1.1 Definitions

To describe the basics of energy efficiency evaluation, this subsection starts with a few definitions:

- *Energy Efficiency Project (project)* is an activity or course of action involving one or multiple energy efficiency measures at a single enterprise. Enterprises are responsible for implementing their own projects.
- *Energy Efficiency Program (program)* is a group of projects, with similar characteristics and installed in similar applications. An example is a program to install energy-efficient motors and systems in industrial facilities in a particular Province. Administrators are responsible for implementing a program.
- *Energy Efficiency Portfolio (portfolio)* is the collection of all the energy efficiency programs that an Administrator operates.
- *Evaluation* is the process of determining and documenting the results, benefits, and lessons learned from a *program or portfolio*. Evaluation involves real time and/or retrospective assessments of the performance and implementation of a program. Evaluation is the responsibility of the Administrator.

- *Measurement and verification (M&V)* is another expression often used when discussing analyses of energy efficiency activities. M&V refers to data collection, monitoring, and analysis associated with the calculation of energy savings from *individual projects*. For industrial programs, M&V is usually the responsibility of the enterprises implementing projects. M&V results, once verified by the Administrator, can be used to evaluate the performance of the entire program (of projects).

Generally speaking, the difference between evaluation and project M&V is that evaluation is associated with programs and M&V with projects. The term "evaluation, measurement, and verification" (EM&V) is also frequently seen in evaluation literature. EM&V is a catchall acronym for determining both program and project impacts.

5.1.2 Evaluation Objectives

There are two key objectives of evaluations:

- Document and measure the outcomes of a program in order to determine how well it has met its goals. This can include retrospectively determining the performance (and incentive payments and/or penalties) of energy service companies (ESCOs) and enterprises that are responsible for implementing efficiency projects.
- Understand why the program's outcomes occurred and identify ways to improve current and future programs.

There are three different types of energy efficiency program evaluations:

1. *Impact evaluations* determine the impacts (usually energy and demand savings) and co-benefits (co-benefits may include avoided emissions, health benefits, job creation, energy security, transmission/distribution benefits, and water savings) that directly result from a program. Impact evaluations also support cost-effectiveness analyses that evaluate and compare program costs and benefits.
2. *Process evaluations* assess program processes, from design to implementation, in order to identify problems, efficiencies, what worked, what did not work, barriers to success, and potential improvements. Timeliness in identifying opportunities for improvement is essential to making corrections during the implementation process.
3. *Market effects evaluations* estimate a program's influence on encouraging future energy-efficiency projects because of changes in the energy marketplace or regulations. These evaluations are primarily, but not-exclusively, used for programs with market transformation elements and/or objectives.

These types of evaluations can have interrelated activities and results and are often conducted at the same time. Table 5-1 compares these three evaluation types plus cost effectiveness analyses.

Table 5-1 Program Evaluation Types

Evaluation Types	Description	Uses
Impact Evaluations	Quantifies direct and indirect benefits of the program	Determines the amount of energy and demand saved, the amount of emissions reductions, and possibly, levels of co-

Evaluation Types	Description	Uses
		benefits
Process Evaluations	Indicates how the program implementation procedures are performing from both administration and enterprise perspectives	Identifies how program processes can be improved
Market Effects Evaluations	Indicates how regulations or the overall supply chain and market have been affected by the program	Determines changes that have occurred in markets and whether they are sustainable with or without the program
Cost-effectiveness Analyses	Quantifies the cost of program implementation and compares with program benefits	Determines whether the energy-efficiency program is a cost-effective investment as compared to other programs and energy supply resources

5.1.3 Impact Evaluations

Impact evaluations determine program-specific induced benefits. These benefits include changes in energy use and/or demand (e.g., kWh, kW) and avoided air emissions that can be directly attributed to an energy-efficiency program. Following the brief summaries of process and market effect evaluations, the remainder of this section focuses on impact evaluations

> *Evaluation and Measurement and Verification*
>
> The term measurement and verification (M&V) is another term often used when discussing analyses of energy-efficiency activities. M&V refers to data collection, monitoring and analysis activities associated with the calculation of savings from individual sites or projects. M&V can be a subset of program impact evaluation. Thus, generally speaking, the difference between evaluation and project M&V is that evaluation is associated with programs and M&V with projects. The term evaluation, measurement and verification, EM&V, is also often seen in evaluation literature. EM&V is a general acronym for determining both program and project impacts.
>
> In this context, a project is a single activity at one location, for example a set of energy-efficient motor retrofits in a factory. A program is a group of projects with similar characteristics that are installed in similar applications, such as a program to encourage installation of energy-efficient motors in many factories

5.1.4 Process Evaluations

The goal of process evaluations is to produce improved and more cost-effective programs. Thus, process evaluations examine the efficiency and effectiveness of program implementation procedures and systems. These evaluations usually consist of asking questions of personnel involved in the program, analyzing their answers, and comparing results to established best practices.

Process evaluations are particularly valuable when:

- The program is new or has many changes
- Benefits are being achieved more slowly than expected
- There is limited program participation or energy users (enterprises) are slow to begin participating
- Participants are reporting problems
- The program appears not to be cost-effective

Typical process evaluation results involve recommendations for changing a program’s structure, implementation approaches, or program design, delivery, and goals.

The primary mechanism of process evaluations is data collection (e.g., surveys, questionnaires, and interviews) from administrators, designers, participants (such as facility operators), implementation staff (including contractors, ESCOs, and field staff), and energy officials. Other elements of a process evaluation can include workflow and productivity measurements; reviews, assessments and testing of records, databases, program-related materials, and tools; and possibly collection and analysis of relevant data from third-party sources (e.g., equipment vendors, trade allies).

5.1.5 Market Effects Evaluations

Program-induced changes that affect non-participants in a program or the way a market operates are addressed in market effects evaluations. One way that market effects evaluations can be viewed is that they estimate the effect a program has on future energy-efficiency activities.

> *Market Potential Studies*
>
> Another form of market study is called a market potential study. Prior to a program implementation, these studies are conducted to assess market baselines and savings potentials for different technologies and customer markets. These studies can also assess customer needs and barriers to the adoption of energy efficiency and how best to address these barriers through program design. Potential is often defined in terms of technical potential (what is technically feasible given commercially available products and services), economic potential (which is the level of savings that can be achieved assuming a certain level of participant and/or societal cost-effectiveness is required) and market potential (what the market can provide, which is almost always less than market potential). Findings also help managers decide who constitutes the program's key markets and clients and how to best serve the intended customers.

Market effects evaluations often involve a significant undertaking because they are designed to determine whether the market is changing. For example, a market effects study could evaluate increases in the adoption of the products or services that are being promoted by the energy-efficiency program (or more likely, a portfolio of programs) or whether new energy efficiency regulations are being implemented as a result of the programs. Such an evaluation might answer a question such as—are distributors of equipment stocking and promoting more energy-efficient motors for industrial enterprise customers as a result of the program? Market effects are sometimes called the ultimate test of a program's success, answering the question—will efficiency best practices continue in the marketplace or through regulation even after the current program ends?

Market effects evaluations usually consist of surveys, reviews of market data, and analysis of the survey results and collected data. Some possible results from a market assessment include:

- Total market effects
- Estimate of how much of the market effect is due to the program being evaluated
- Estimate of whether the market effect is sustainable

Market effects studies are not always conducted. For example, in the United States, several states do not conduct market effects studies for their energy efficiency programs. However, for the UNFCCC Clean Development Mechanism (CDM), evaluating market effects may be an option or requirement for obtaining CDM Certified Emission Reductions.

5.1.6 Cost-effectiveness Analyses

Data from the impact evaluation are used to help determine the cost-effectiveness of programs. Section 6 provides information on the cost-effectiveness indicators and the data needed to calculate them.

5.2 IMPACT EVALUATION BASICS

The primary purpose of this sub-section is to provide basic information on how to conduct impact evaluations.

The basic steps in the impact evaluation process are:

- Setting the evaluation objectives in the context of the program's overall policy objectives.
- Selecting an evaluation approach and preparing a program evaluation plan that takes into account the critical evaluation issues. This is the second procedures document mentioned at the beginning of this section.
- Implementing the evaluation and determining program benefits, such as energy and demand savings and avoided emissions.
- Reporting the evaluation results and, as appropriate, recommendations for current or future program improvements.
- Continuing the evaluation process to determine the persistence of savings and benefits.

> *Basic Impact Evaluation Concepts*
>
> - Impact evaluations are used for determining directly achieved program benefits (e.g., energy savings and avoided emissions).
> - Savings cannot be directly measured, only indirectly determined by comparing energy use and demand after a program is implemented to what they would have been had the program not been implemented (i.e., baseline).
> - Successful evaluations harmonize the costs of evaluation with the value of the information received (i.e., appropriately balancing risk management, uncertainty, and cost considerations)

The three impact evaluation results that are typically reported are:

- Estimates of total savings. Total energy (or demand) savings refer to the change in energy consumption and/or demand that results directly from program-promoted actions taken by program participants (e.g., installing energy efficient motors), regardless of the extent or nature of program influence in causing their actions.
- Estimates of net savings. Net energy savings refer to the portion of total savings that is attributable to the program. This involves separating out the impacts that are a result of other influences, such as enterprise owner self-motivation. Given the range of influences on enterprises' energy consumption, attributing changes to one cause (program) or another can be difficult.
- Estimates of co-benefits. A co-benefit commonly documented and reported is avoided air emissions. Avoided emissions refer to the air pollution that would have been emitted if more energy had been consumed in the absence of the energy-efficiency program. These emissions can be from combustion of fuels at an electrical power

plant or from combustion of heating fuels, such as natural gas and fuel oil, at a project site. Other co-benefits can be positive or negative; examples are comfort and productivity improvements, job creation, and increased maintenance costs due to unfamiliarity with new energy efficient equipment.

Energy savings cannot be directly measured. Instead, savings are determined by comparing energy use after a program is implemented (the reporting period) to what would have occurred had the program not been implemented (the baseline). The baseline and reporting period energy use and demand are compared using a common set of conditions (e.g., weather, factory operating hours, product being manufactured, etc.) through adjustments so that only program effects are considered when determining savings. Avoided emissions and other co-benefits can then be calculated using the energy savings values and/or other needed information.

Note that each of the items above defines an *estimate*. This is because the nature of efficiency evaluation involves estimation of the difference between (a) actual energy consumption and (b) what energy consumption would have occurred—during the same time—had the efficiency projects not been installed. The energy consumption that *would have occurred* during that same time *didn't* actually occur, and so must be estimated rather than measured.

An objective of program evaluation is to determine energy and demand savings estimates (and, as desired, associated co-benefits) with some reasonable level of accuracy. However, the value of the estimates as a basis for decision-making can be called into question if the sources and the level of accuracy of reported savings estimates are not analyzed and described. Thus, evaluation results, as with any estimate, should be reported as expected values with a level of uncertainty. Minimizing uncertainty and balancing evaluation costs with the value of the evaluation information are at the heart of the evaluation process. This is discussed more in Section 5.4.4.

When implementing an impact evaluation, the process for determining energy and demand savings and avoided emissions involves determining total program savings using one of the following approaches (these are illustrated in Figure 5-1 below, and each is described in the following sub-sections):

- One or more measurement and verification (M&V) methods, from the IPMVP , are used to determine the savings from all or just a sample of projects; and these savings are then applied to all of the projects in the program.[11]
- Deemed savings that are based on historical and verified data applied to conventional energy-efficiency measures implemented in the program.
- Statistical analyses of large volumes of metered energy usage data conducted on all the facilities where projects are implemented and compared with facilities where projects were not implemented and compared (energy consumption data analyses).

In some situations combinations of these approaches are utilized, particularly the deemed savings and M&V approaches. For industrial energy efficiency projects, the first approach listed above, M&V, is the most common approach. Deemed savings are occasionally used for industrial

[11] Measurement and verification is the process of using measurements to reliably determine actual savings created within an individual facility. IPMVP is the International Performance Measurement and Verification Protocol (available at www.evo-world.org)

projects but statistical analyses of large volumes of data are usually used for just residential programs.

In addition, if desired, the following evaluation activities may also take place:

- Total program savings are converted to net energy savings using a number of considerations. The primary, but not exclusive, considerations that account for the difference between net and total savings are free riders (those who would have implemented the same or similar efficiency projects without the program now or in the near future) and participant and non-participant spillover. Non-participant spillover comes from efficiency projects implemented by those who did not directly participate in a program, but which nonetheless occurred due to the influence of the program. Participant spillover is defined as additional energy efficiency actions taken by program participants as a result of program influence, but actions that go beyond those directly subsidized or required by the program. Net savings calculations are optional and not required if the only interest is total energy savings.
- Avoided emissions are calculated by applying emission factors (e.g., kilograms of CO_2 per MWh) to net energy savings[12]. A variety of approaches can be used to calculate emission factors ranging from just using annual average emission factor values to preparing detailed hourly calculations of displaced energy sources. However, whether emissions are actually avoided depends on whether the energy savings are truly additional to what would have occurred without the program's influences, whether all significant emissions sources associated with a program were taken into account, and the scheme under which any affected emission sources may be regulated.

12 An alternative method for calculating avoided emissions involves using emissions scenario analyses (e.g., using computer models to estimate the difference in emissions from grid-connected power plants with and without the reduced electricity consumption associated with an efficiency program).

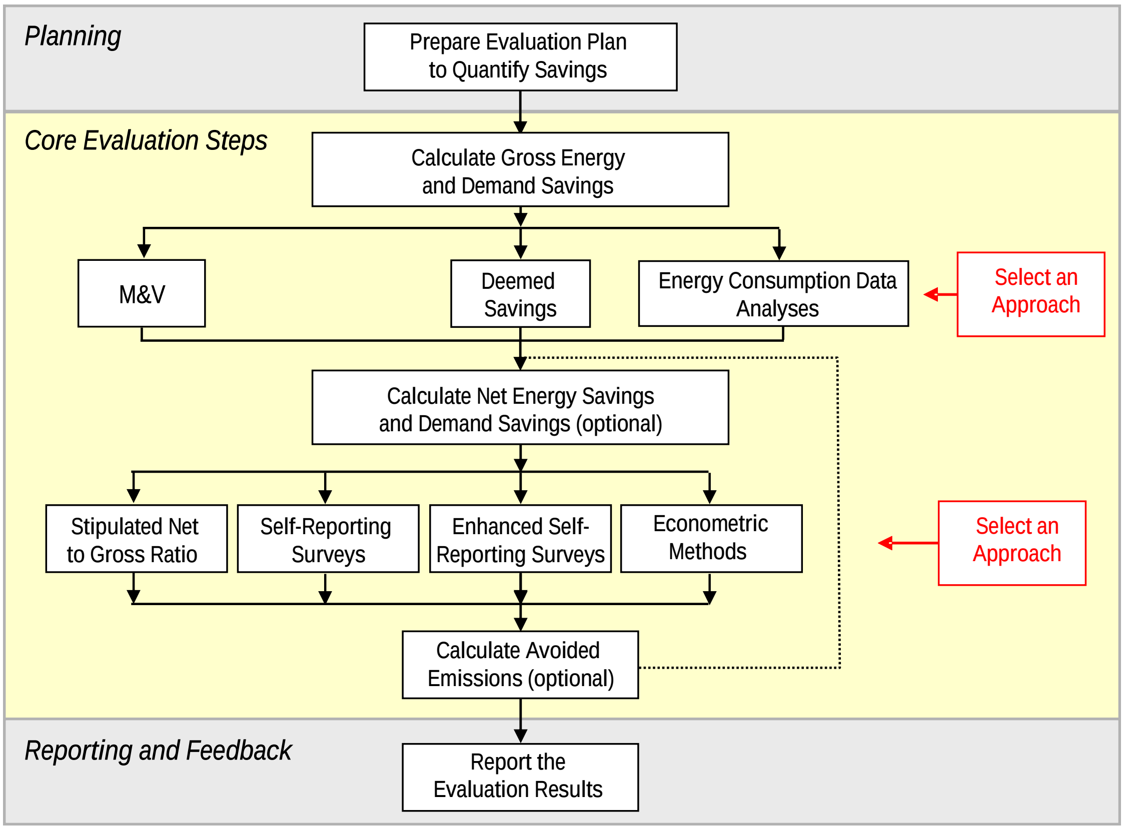

Figure 5-1 Impact Evaluation Process

Figure 5-2 summarizes a simplified version of the process where the M&V approach is used for industrial programs without considering net savings or avoided emissions.

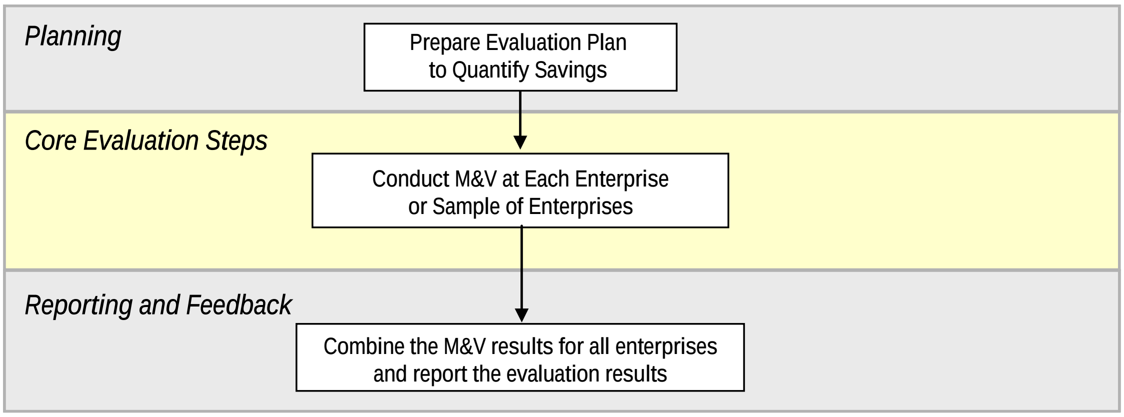

Figure 5-2 Simplified Impact Evaluation Process

5.2.1 Determining Total Energy Savings

The absence of energy use—that is, total energy savings—can be estimated by comparing energy use before and after implementation of a program. Thus, in general, the following equation applies:

Energy savings = (baseline energy use) – (reporting period energy use) ± (adjustments) (eq 6.1)

Where:

- "Baseline energy use" is the energy consumption that is estimated to have occurred before the program was implemented and is chosen as representative of normal operations. It is sometimes referred to as "business-as-usual" (BAU) energy use. When discussed in terms of specific projects, it is sometimes called the pre-installation energy use.
- "Reporting period energy use" is the energy consumption that occurs after the program is implemented. When discussed in terms of specific projects, it is sometimes called the post-installation energy use.
- "Adjustments" distinguishes properly determined savings from a simple comparison of energy usage before and after implementation of a program. By accounting for factors (independent variables) that are beyond the control of the program implementer or energy consumer, the adjustments term brings energy use in the two time periods to the same set of conditions. Common examples of adjustment are:
  - Weather corrections—for example, if the program involves heating or air-conditioning systems in factory buildings.
  - Occupancy levels and hours—for example, if the program involves lighting retrofits or conveyor belt in a factory where the production hours vary from one time period to another.
  - Production volumes and manufactured product characteristics—for example, if the program involves energy efficiency improvements to factory motors or air compressors whose operation varies by volume of product produced or the type of product produced.

> *Weather Adjustments*
>
> The most common adjustment for comparing baseline and reporting period energy use in buildings is weather. This is because often weather is the primary independent variable for energy use in buildings. Weather is typically described in terms of ambient dry bulb temperature, the outdoor air temperature most people are familiar with seeing reported. It is reported in and described in terms of ˚C or in cooling degree days (CDD) or heating degree days (HDD). CDD and HDD are common indicators of how space cooling or heating is required in a building, as a function of standard thermostat set points and outdoor air temperature. Other weather parameters that might be important include solar insolation and wet bulb temperature, which is an indication of ambient air temperature and humidity

The basic approach to evaluation is shown in Figure 5-3. It involves projecting energy use patterns of the baseline period into the reporting period. Such a projection requires adjustment of baseline energy use to reporting period conditions (weather, production level, occupancy, etc.). Therefore, the evaluation effort will involve defining the baseline energy use, the reporting period energy use, and any adjustments made to the baseline energy use.

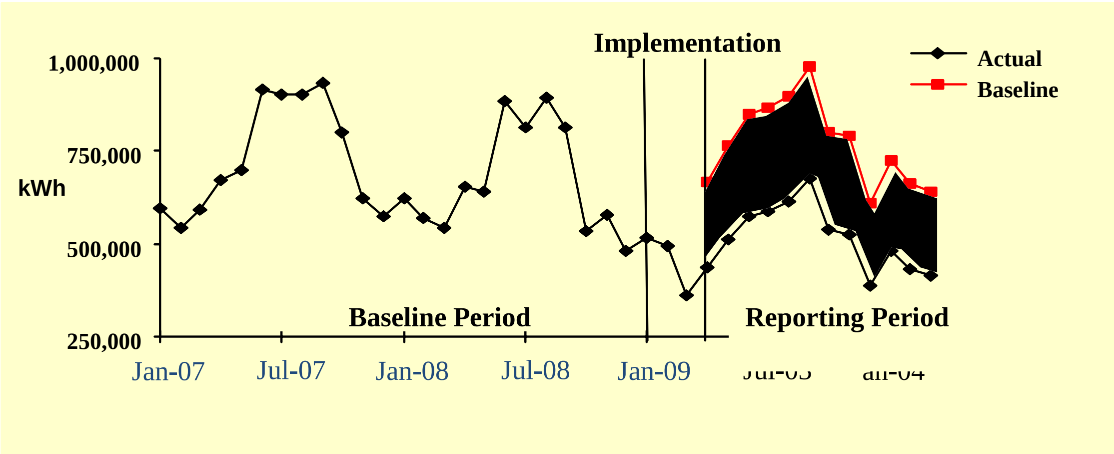

Figure 5-3 Comparison of Energy Use before and after a Program is Implemented

5.2.1.1 Measurement and Verification Approach

M&V is a very common approach for determining savings from industrial energy efficiency projects. M&V is the process of using measurements to reliably determine actual savings created within an individual enterprise's facility. This includes data collection as well as monitoring and analysis associated with the calculation of total energy and demand savings. M&V covers all field activities dedicated to collecting site information, such as equipment counts, observations of field conditions, building occupant or operator interviews, measurements of parameters, and metering and monitoring.

For program evaluations that uses the M&V approach at individual enterprises, total energy and/or demand savings are determined by:

- Selecting a representative sample of projects. This could be 100 percent of the projects or a smaller percentage. Typically for industrial programs the sample size is a census of projects (i.e., 100 percent).
- Determining the savings of each project in the sample, using one or more of the M&V Options defined in the IPMVP.
- Applying the sample projects' savings to the entire population, (i.e., the program).

The four IPMVP Options provide a flexible set of methods (Options A, B, C, and D) for evaluating energy savings in facilities. Having four options provides a range of approaches to determine energy savings with varying levels of savings certainty and cost. A particular Option is chosen based on the specific features of each project, including:

- Type and complexity.
- Uncertainty of the project savings.
- Potential for changes in key factors between the baseline and reporting period.

- Value of project savings.

The Options differ in their approach to the level, duration, and type of baseline and reporting period measurements. For example, in terms of the level of measurements:

- M&V evaluations using Options A and B are made at the end-use system level (e.g., lighting, motor system).
- Option C evaluations are conducted at the whole-building or whole-facility level.
- Option D evaluations, which involve computer simulation modeling, are also made at the system or the whole-building level. Neither Option C nor Option D is commonly used for industrial measures.

In terms of type of measurement:

- Option A involves using a combination of both stipulations and measurements of the key factors needed to calculate savings in engineering models.
- Options B and C involve using data collected from spot, short-term, and/or continuous measurements in engineering models (Option B) or regression analyses (Option C).
- Option D may include spot, short-term, or continuous measurement data to calibrate computer simulation models.

The four generic M&V options are summarized in Table 5-2.

Table 5-2 IPMVP Options (as Indicated in the 2007 IPMVP)

M&V Option	How Savings Are Calculated	Cost per Project (Not from IPMVP)	Typical Applications
A. Retrofit Isolation: Key Parameter Measurement Savings are determined by field measurement of the key performance parameter(s) that define the energy use of the affected system(s) and/or the success of the project. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimates can be based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required. The plausible savings error arising from estimation rather than measurement is evaluated.	Engineering models of baseline and reporting period energy from short-term or continuous measurements of key operating parameter(s). Estimated values. Routine and non-routine adjustments as required.	Dependent on number of measurement points. Approximately 1% to 5% of project construction cost of items subject to M&V.	A lighting retrofit where power draw is the key performance parameter that is measured periodically. Estimate operating hours of the lights based on building schedules, occupant behavior, and/or prior studies.

M&V Option	How Savings Are Calculated	Cost per Project (Not from IPMVP)	Typical Applications
B. Retrofit Isolation: All Parameter Measurement Savings are determined by field measurement of the energy use of the affected system. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period.	Short-term or continuous measurements of baseline and reporting-period energy, and/or engineering models using measurements of proxies of energy use. Routine and non-routine adjustments as required.	Dependent on number and type of systems measured and the term of analysis/metering. Typically 3% to 10% of project construction cost of items subject to M&V.	Adjustment of pump flow by means of a variable-speed drive and motor controls. Measure electric power with a meter installed on the electrical supply to the motor, which reads the power every minute. In the baseline period this meter is in place for a week to verify constant loading. The meter is in place throughout the reporting period to track variations in power use.
C. Whole Facility Savings are determined by measuring energy use at the whole-facility or sub-facility level. Continuous measurements of the entire facility's energy use are taken throughout the reporting period.	Analysis of whole-facility baseline and reporting period (utility) meter data. Routine adjustments as required, using techniques such as simple comparison or regression analysis. Non-routine adjustments as required.	Dependent on number and complexity of parameters in analysis and number of meters. Typically 1% to 5% of project construction cost of items subject to M&V.	Multifaceted energy management program affecting many systems in a facility. Measure energy use with the gas and electric utility meters for a 12-month baseline period and throughout the reporting period.
D. Calibrated Simulation Savings are determined through simulation of the energy use of the whole facility or a sub-facility. Simulation routines are demonstrated to adequately model actual energy performance measured in the facility. *Not common for industrial energy efficiency projects.*	Energy use simulation, calibrated with hourly or monthly utility billing data. (Energy end-use metering may be used to help refine input data.)	Dependent on number and complexity of systems evaluated. Typically 3% to 10% of project construction cost of items subject to M&V.	Multifaceted new construction energy management program affecting many systems in a facility—where no meter existed in the baseline period. Energy use measurements, after installation of gas and electric meters, are used to calibrate a simulation. Baseline energy use, determined using the calibrated simulation, is compared to a simulation of reporting period energy use.

Source: EVO,2007

One of the key aspects of M&V is defining a measurement boundary. The measurement boundary might be a single piece of equipment (e.g., the replaced motor in a factory), a system (e.g., all the motors in a factory's production line) or the whole facility (e.g., for a factory that has undergone a complete retrofit). Any energy effects occurring beyond the measurement boundary are called "interactive effects." A typical interactive effect is the decrease in air-conditioning requirements or increase in space heating requirements that can result from a lighting retrofit (which by its nature reduces the amount of heat produced by a lighting system).The magnitude of such interactive effects, if significant, should be considered and a method developed to estimate them as part of the savings determination process.

M&V Option A—Retrofit Isolation—Key Parameter Measurement

Option A involves project- or system-level M&V assessments in which the savings associated with a particular project can be isolated. With this Option, key performance parameters or operational parameters can be spot or short-term measured during the baseline and reporting periods. However, some parameters are stipulated rather than measured. This level of verification may suffice for certain types of projects in which a single parameter represents a significant portion of the savings uncertainty.

Under Option A, energy and demand savings are calculated using "engineering models." These models (essentially groups of equations defining energy use as a function of various inputs—often simple spreadsheet models) involve developing estimates of energy and demand savings based on:

- Assumptions concerning operating characteristics of the equipment or facilities in which the equipment is installed, which are informed by measurements (from spot to continuous). Examples are power draws (wattage) of motors and boiler efficiencies (kJ out/kJ in).
- Assumptions about how often the equipment is operated or what load it serves. Examples are operating hours of motors or boiler consumption rates (kJ/hour).

> *Field Inspections of Energy Efficiency Measures*
>
> Not all of the evaluation approaches described in this section require field inspections, but it is recommended that there be some physical assessment of at least a sample of the individual projects in a program (i.e., field activities). This is to ensure that the measures installed are to specification and thus the projects included in a program have the potential to generate savings. This potential to generate savings can be verified through observation, inspections, and spot or short-term metering conducted immediately before and after installation. These field activities can also be conducted at regular intervals, during the reporting period, to verify a project's continued potential to generate savings. The field activities are an inherent part of the data collection aspects of the M&V approach, though they may be considered "add-ons" to the other approaches.

The most straightforward application of engineering models involves the use of savings algorithms that describe energy use as a function of certain variables or parameters. Savings are then estimated by changing the values for the variables or parameters that are affected by program participation. With Option A, at least one of the key model parameters must be measured. The parameters not measured are stipulated based on assumptions or analysis of historical or manufacturer's data. Using a stipulated factor is appropriate only if supporting data demonstrate that its value is not subject to fluctuation over the term of analysis.

This Option and Option B are best applied to programs that involve retrofitting equipment or replacing failed equipment with efficient models. All end-use technologies can be verified using Option A or B; however, the difficulty of applying these Options is inversely proportional to the complexity of the measure and the number of independent variables significantly affecting the results. Thus, the savings from a simple motor retrofit (less complex) may be more easily determined with Option A or B than the savings from an industrial process modification.

Also true with Options A and B is that measurement of all end-use equipment or systems may not be required if statistically valid sampling is used. For example, the operating hours for a selected group of representative constant-load motors may be metered, rather than metering all of motors in a factory.

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

M&V Option B—Retrofit Isolation—All Parameter Measurement

Option B, like Option A, involves project- or system-level M&V assessments with performance and operational parameters measured at the component or system level. In addition, savings calculations, as with Option A, involve the use of engineering models. However, unlike Option A, Option B does not allow stipulations of major parameters such as motor operating hours.

Thus, Option B requires additional and often longer-term measurements compared to Option A. These include measurements of both equipment operating characteristics, (as measured with Option A) and relevant performance factors. Commonly measured parameters include operating hours for lighting and motor equipment, line flows and pressure for various compressed air applications, and wattage for motors.

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

Retrofit Isolation and Measurement Boundaries Example

A factory's boiler, used for process steam production, is replaced with a more efficient boiler of about the same capacity. The measurement boundary is defined to include the boiler only, whether the baseline boiler (before it is replaced) or the more efficient boiler (once installed). With this boundary, the analyses of baseline and efficient boilers are not affected by variations in the factory's process steam load, although the actual savings depend on the total steam consumption. Meters for fuel consumption and boiler steam output are all that is needed to assess the efficiencies of the baseline and efficient boilers over their full range of operations. Under Option A, savings are reported for the boiler retrofit by applying the measured annual average efficiency improvement to an estimated annual boiler load, and the boiler efficiency test is repeated annually during the reporting period. Under Option B, the annual boiler load may be determined by first measuring the boiler load over several weeks (to prepare typical hourly and daily load profiles) and then making a more accurate savings estimate based on matching typical hourly load profiles to partial and full steam load boiler efficiency profiles, rather than just using annual average efficiency values and average annual steam consumption.

All end-use technologies can be verified with Option B, but the difficulty and cost increase as measurement complexity increases. Measuring or determining energy savings using Option B can be more difficult than doing so with Option A. The results, however, are typically more reliable. In addition, the use of longer-term measurements can help identify under-performing efficiency projects—which in turn can lead to improvements in their performance.

M&V Option C—Whole-Facility Analysis

Option C involves use of whole-facility meters or sub-meters to assess the energy savings at single building or factory facility. These meters are typically the ones used for utility billing, although other meters, if properly calibrated, can also be used. Use of Option C is very common for commercial building projects, although somewhat less so for industrial facilities unless the energy savings due to he project are very large compared to the total energy consumption at the factory. With this option, energy consumption from the baseline period is compared with energy consumption meter data from the reporting period.

Whole-building or facility-level metered data are evaluated using techniques ranging from simple comparisons of utility billing data to multivariate regression analysis. Option C regression methods can be very powerful tools for determining savings. However, simple bill comparison methods are strongly discouraged for estimating energy savings because they do not account for independent variables, such as weather and changes in production schedules at a factory.

For the regression analyses to be accurate, all explanatory (independent) variables that affect energy consumption need to be monitored during the performance period. Critical variables may include weather, occupancy schedules, throughput, control set points, and operating schedules. Most applications of Option C require at least 9 to 12 months of continuous baseline (pre-installation) meter data and at least 9 to 12 months of continuous data from the reporting period (post-installation).

> *Caution against Just Comparing Energy Use*
>
> It is very important to note that simple comparison of meter data—say subtracting this year's utility bills from the utility bills from before the measure installations—is not a valid evaluation approach (equation 5.1 above shows that the baseline data are corrected for the changes in independent variables).Simple comparison of reporting period energy use with baseline energy use does not differentiate between the effects of a program and the effects of other factors, such as weather. For example, even a more efficient motor may consume more electricity after its installation if the moor is operated more hours during the reporting period than it was before installation. To isolate the effects of the evaluated program, the influence of these complicating factors must be addressed through the use of regression analyses.

All end-use technologies can be verified with Option C. However, this option is intended for projects in which savings are expected to be large enough that they can be distinguished from the random or unexplained energy consumption variations normally found at the level of the whole-facility meter. The larger the savings, or the smaller the unexplained variations in the baseline consumption, the easier it will be to identify savings. In addition, the longer the period of savings analysis after project installation, the less significant the impact of short-term unexplained variations. Typically, savings should be more than 10% to 15% of the baseline energy use, if they are to be separated from the minor random variations in baseline data.[13]

M&V Option D—Calibrated Simulation

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

Any end-use technology can be verified with Option D if the drop in consumption is larger than the associated simulation modeling error. Option D can be used in cases where there is a high degree of interaction among installed energy systems, or where the measurement of individual component savings is difficult. Option D is commonly used with new construction energy-efficiency programs. Although Option D is not commonly used for the M&V of industrial energy programs, if it is used for industrial energy projects, a process model of the factory can be used to assess energy use with and without the efficiency measures.

5.2.1.2 Deemed Savings Approach

Deemed savings are used to stipulate savings values for projects with well-known and documented savings values. (Examples are energy-efficient appliances, such as washing machines, computer equipment and refrigerators, and lighting retrofit projects with well-understood operating hours.) *Deemed savings are not common for process industrial energy efficiency projects because each factory tends to be unique with regard to its energy efficiency measures.*

The use of deemed values in a savings calculation is essentially an agreement between the enterprise and Administrator to accept a stipulated value, or a set of assumptions, for use in determining the baseline or reporting period energy consumption. With the deemed savings approach, it is common to hold the stipulated value constant regardless of what the actual value is during the term of the evaluation. If certain requirements are met (e.g., verification of installation, satisfactory commissioning results, annual verification of equipment performance, and/or regular maintenance), the project savings are considered to be confirmed. The stipulated savings for each verified installed project are then summed to generate a program savings value. Installation might be verified by physical inspection of a sample of projects or perhaps just an audit of receipts.

Deemed values, if used, should be based on reliable, traceable, and documented sources of information, such as:

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[13] Option C should not be confused with the evaluation approach for determining total energy savings where statistical analyses of large volumes of metered energy usage data are conducted on all the facilities where projects are implemented and compared with facilities where projects were not implemented and compared. Option C involves analyzing one facility at a time and comparing the subject facility's energy use during the reporting period with the baseline period not a "comparison facility"

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

When using deemed values, it is important to realize that technologies alone do not save energy; it is how they are used that saves energy. Therefore, a deemed energy savings value depends on how and where a technology is placed into use. For example, the savings resulting from installing a low-wattage lamp are totally dependent on its operating hours. Such a lamp installed in a storage room will save much less energy than one installed in a factory production area.

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

- The most certain, predictable parameters can be estimated and stipulated without significantly reducing the quality of the evaluation results.
- Stipulating parameters that represent a small degree of uncertainty in the predicted result and a small amount of savings will not produce significant uncertainty concerns.
- Parameters could be measured when savings and prediction uncertainty are both large.
- Even if savings are high, but the uncertainty of predicted savings is low, full measurement may not be necessary for M&V purposes.

5.2.1.3 Large-Scale Meter Data Analysis Approach

Large-scale data analysis requires the application of a variety of statistical methods to measured facility energy consumption meter data (almost always whole-facility utility meter billing data) and independent variable data to estimate total energy and demand impacts. Unlike the M&V whole-facility analysis option (IPMVP Option C) described above, the meter analysis approach usually does not involve onsite data collection for model calibration. However, inspection of a sample of projects to confirm proper operation of installed measures is still recommended. This approach is not typically used for industrial programs.

Most analyses of meter data involve the use of comparison groups (which can be hard to find in areas with a long history of program offerings). In assessing the impacts of programs, evaluators have traditionally used quasi-experimental design. They compare the behavior of the participants to that of a similar group of non-participants—the comparison group—to estimate what would have happened in the absence of the program. The two groups need to be similar. The only difference should be the fact that one participated in an energy-efficiency program and the other did not. The observed change in consumption in the comparison group can be assumed to resemble the change in consumption that would have been observed in the participant group had it not been through a program.

5.2.2 Determining Net Energy Savings

Total savings indicate the savings that result when the participants in a program install energy efficiency measures instead of *not* installing them. Net savings are the savings "net" of *what would have occurred in the absence of the program*. The difference between total and net savings is defined as the net-to-total ratio, NTR. Calculating net energy savings is not always done and it is important to understand that calculating net energy savings can be more of an art than a science. Essentially, one is attempting to separate out the influence of a particular energy-efficiency program from all the other influences that determine program participant and non-participant behavior and decisions.

> *Free ridership issues*
>
> There are three categories of participants:
>
> - Total free rider—would have installed the same energy-efficiency measures at the same time whether or not the program existed.
> - Partial or deferred free rider—would have installed less-efficient (but still more efficient than baseline) measures or would have installed the same energy-efficiency measure but at a later time and would have installed fewer of the energy-efficiency products.
> - Non-free rider—would not have installed the baseline energy-efficiency measure without the influence of the program.
>
> It should be noted that a participant's free ridership status can vary from one measure to the next and also vary over time.

The three primary factors that differentiate total and net savings are free ridership, spillover, and rebound. In addition, for programs that include projects that save electricity from grid-connected power plants, transmission and distribution losses can also be considered in an NTR calculation. The objectives of the evaluation determine which, if any, of these is included in an NTR analysis. Generally speaking, free ridership is the most commonly evaluated NTR factor, followed by spillover and then rebound analyses.

- ***Free ridership.*** Free riders are program participants who would have implemented the program measure or practice in the absence of the program. The program can also affect when a participant implements an efficiency measure (e.g., because of the program a participant installs the equipment sooner than he or she otherwise would have), the level of efficiency of the efficient equipment installed (when they say they would have installed the same efficient equipment without the program), and how many units of efficiency equipment they install.
- ***Spillover effects.*** Spillover occurs when there are reductions in energy consumption and/or demand influenced by the presence of the energy-efficiency program, but which the program does not directly cause. Customer behavioral changes stemming from participation in programs are a positive program spillover, increasing the program effect.
- ***Rebound effects.*** Rebound is a change in energy-using behavior that increases the level of energy consumption as a result of an energy-efficiency action. The most

common form considered is “take back,” which can occur if consumers increase energy use as a result of new devices’ improved efficiency. For example, factories may use more ventilation with their new efficient fan motors because it is less expense to operate the fans with the new motors.

- ***Electricity transmission and distribution losses.*** When an efficiency project reduces electricity consumption at a facility, the amount of electricity that no longer has to be generated at a power plant is actually greater than the onsite reduction. This is because of electricity transmission and distribution (T&D) losses between the facility and the power plants. Most energy savings evaluations only report onsite energy savings. Therefore an evaluator needs to decide whether to include T&D losses in the net savings calculation.

The following four approaches for determining the NTR are typical of best practices:

- *Self-reporting surveys*. Information is reported by participants and non-participants without independent verification or review.
- *Enhanced self-reporting surveys*. The self-reporting surveys are combined with interviews and documentation review and analysis.
- *Econometric methods*. Statistical models are used to compare participant and non-participant energy and demand patterns.
- *Stipulated net-to-total ratios*. Ratios that are multiplied by the total savings to obtain an estimate of net savings and are based on historical studies of similar programs.

5.2.3 Determining Avoided Emissions

For all types of energy efficiency programs, the avoided air emissions are determined by comparing the emissions occurring after the program is implemented to an estimate of what the emissions would have been in the absence of the program (i.e. a comparison of post-implementation emissions to a baseline scenario). Conceptually, avoided emissions are determined by multiplying the program’s net energy savings by emissions factors (e.g. kilograms of CO_2 per MWh) representing the characteristics of displaced emission sources to compute hourly, monthly, or annual avoided emission values (e.g., metric tons of NO_x or CO_2 per year). The basic equation for this approach is:

$$\text{Avoided Emissions}_t = (\text{Energy Savings})_t \times (\text{Emission Factor})_t \quad \text{(eq 5.2)}$$

The emission factor can be for facility equipment (e.g. boilers) or for the electricity grid (for avoided electricity consumption at the facility).One important consideration for both of these approaches is that it the energy savings calculated for the purposes of an energy resource program *may* be different from the savings that need to be calculated to meet the requirements of an avoided emissions program, such as the UNFCCC Clean Development Mechanism. Three potential causes of the difference may be:

- Different definitions of additionality
- Different definitions of boundary areas
- The characteristics of emissions control mechanisms/regulations that may be in place.

5.3 IMPACT EVALUATION PLANNING

For each Program there will be evaluation and M&V activities that are the responsibility of either the Administrator of the program or the enterprises implementing the projects. For most industrial efficiency programs the Administrator will require the enterprises to conduct M&V activities on every energy project and the Administrator will review and approve the M&V results. The Administrator would then use the results from each M&V effort to determine the savings from all of the industrial projects in a program. Thus, for industrial energy efficiency programs, there are two primary types of procedures documents that must be prepared for the impact evaluation activities:

- Each individual efficiency project's *Measurement and Verification (M&V) Plan* - prepared by enterprises participating in the program – that indicate the details of how the savings from each individual project will be determined. For example, if there are 100 projects in an industrial program there would be 100 M&V plans, one for each project – although many would be very similar. Typically Administrators will need to help the enterprise prepare the Plan and may in some cases prepare the Plan for the enterprise.
- *Program Evaluation Plan*, prepared by the Program Administrator, that defines (1) how the Administrator will determine the program's total savings resulting from all the projects in the program – using the results from each individual project's M&V efforts, (2) the requirements for M&V plans and reports, and (3) how the Administrator will conduct reviews of the M&V Plan and the results provided by the enterprises in the M&V report. There would be one Program Evaluation Plan for each program.

Corresponding to these two types of procedures documents there will be two primary types of reports:

- Each individual efficiency project's savings report – the M&V report. These are prepared by the enterprises and verified by the Administrator. I some cases the Administrators will need to help the enterprise prepare the report and may in some cases prepare the report for the enterprise.
- The program evaluation report, prepared by the Administrator, that describes the overall program savings and other results as well as recommendations from the program evaluation effort.

Table 5-3 summarizes these documents.

Table 5-3 Summary of EM&V Documents and Who Prepares Them for Industrial Programs

Administrator Prepares	Enterprise Prepares
▪ Requirements for M&V plans and reports ▪ How M&V plans and M&V reports are approved ▪ How results from M&V reports are used to determine total program energy savings	▪ Meets requirements of Evaluation Plan ▪ Approved by Administrator
	▪ Meets requirements of Evaluation Plan Approved by Administrator

The following two sub-sections provide considerations for preparing an Evaluation Plan for an entire program and then considerations for preparing project specific M&V plans.

5.3.1 Evaluation Plans

Timely and well thought out evaluation planning is critical to the success of efficiency programs. This section can be used to initiate and support the evaluation planning process at the same time that the efficiency program itself is being developed. Working in parallel helps those who are implementing the program understand the parameters under which they will be evaluated and what information they are expected to provide, and receive from, the evaluation.

The evaluation planning process is integral to what is typically a cyclical planning-implementation-evaluation process. These cycles can be one or two years, or even longer, and in most cases are consistent with program funding and contracting schedules. In the program cycle, the evaluation planning process needs to begin while programs are being designed. This is primarily so that the program budget, schedule, and resources can properly take into account evaluation requirements. It is also a way to ensure that the data required to support evaluation efforts are collected at the time of implementation.

Completing evaluations within a program cycle is recommended for four reasons: to ensure that evaluation results can document the operations and effects of the program in a timely manner, to provide feedback for ongoing program improvement, to provide information to support energy-efficiency portfolio assessments, and to help support the planning for future program cycles. In particular, for impact evaluations that examine energy savings of certain measures and program mechanisms, the evaluation information can also be used to inform future savings estimates and reduce future evaluation requirements and costs.

Figure 5-4 shows the energy-efficiency program implementation cycle, focusing on evaluation activities, as well as feedback to the current and future programs.

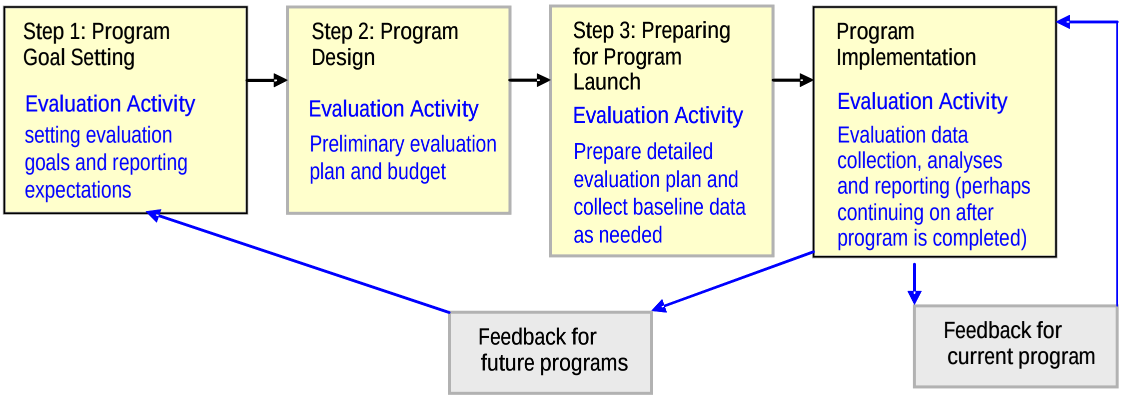

Figure 5-4 Program Implementation Cycle – with High-Level Evaluation Activities

The evaluation planning and implementation steps, displayed in Figure 5-3, are further described as:

- *Goal setting*: Program goals and evaluation goals should be considered when a program is first envisioned, often as part of a portfolio of programs. A simple example would be that if the program (or portfolio) goal is to save electricity during peak usage periods, then the evaluation goal can be set to document accurately how much electricity was saved during the peak (total impact) and how much of these savings can be attributed to the program (net impact).
- *Program design*: While the program is being designed is also when the evaluation design effort should begin. The objective should be a preliminary evaluation plan and budget. The seven issues listed below should be raised, although not necessarily fully addressed, at this time. Whereas a complete program design is usually completed at this stage, it is likely that the evaluation plan will not be fully defined. This is typically because of the iterative nature of integrating the program design and evaluation process. In any event though, specific evaluation goals and objectives should be set and priorities established based on, in addition to other factors, perceived risks to achieving the savings objectives.
- *Preparing for program launch*: Program launch is when activities, program materials, and timing strategies are finalized and made ready, contracts (if needed) are negotiated, trade allies and key stakeholders are notified, and materials and internal processes are developed to prepare for program introduction and implementation. Preferably the detailed evaluation plan is prepared before the program is launched, or soon after it is launched. An outline of such a plan is presented in Section 6.3.2.

  This is also the time when some baseline data collection can take place. Although for industrial programs that use the M&V approach the baseline data are collected as one of the M&V activities. Further, data collection needs to begin early enough in the program cycle to provide feedback and corrective recommendations to program implementers in time for the program to benefit from those recommendations. In addition, impact evaluation activities can support program progress tracking, such as measure installation tracking and verification.

- *Program implementation:* This is when the evaluation actually occurs. Some baseline and all the reporting period data are collected, the analysis is done, and the reporting is completed. For industrial programs, this consists of the M&V activities at individual sites. Given the often-retrospective nature of evaluation, the evaluation activities (completing analyses, preparing a report, determining persistence of savings, etc.) often carry on after the program implementation is completed.

  In terms of reporting, evaluation information can be summarized and provided on any time cycle. The criterion is to get the information needed by the Administrators in a timely manner in order to adjust existing programs and design new ones using current and relevant information. And, of course, the evaluation activities may be conducted with oversight bodies providing review and approval, and these organizations may have specific reporting requirements.

  In terms of providing feedback for future program designs, adjustments to savings estimates can be made based on program evaluation results. Thus, assumptions underlying the efficiency potential analysis used for planning purposes at the beginning of the program cycle can then be updated based on the full net impact analysis. These data then feed back into the goal setting and potential analysis activities, and the cycle repeats to allow for an integrated planning process for future programs.

5.3.1.1 Evaluation Planning Characteristics and Considerations

There are several general characteristics of program evaluation that Administrators should ensure are part of the evaluation process. These are:

- The evaluation process is integral to what is typically a cyclic planning-implementation-evaluation process. Evaluation planning should be part of program planning so that the evaluation effort can support the program's implementation by aligning the budgets and schedules and having evaluation results available within a timely manner to support existing and future programs.
- Evaluation budgets and resources must be adequate to support, over the entire evaluation time period, the evaluation goals and the level of quality (certainty) expected in the evaluation results.
- Evaluations must be complete, transparent, relevant, consistent, and balanced in terms of certainty of results and costs to achieve the results.

With these characteristics in mind, the program evaluation requirements can be defined. These requirements are defined by the program objectives, government mandates, if any, expectations for quality of the evaluation results, intended uses of the evaluation results, and other factors. Seven of these standard requirements are:

1. Defining evaluation goals and scale, including deciding which program benefits to evaluate
2. Setting time frame for evaluation and reporting expectations
3. Establishing a budget in the context of expectations for the quality of reported results

4. Selecting impact evaluation approaches for total and net savings calculations and avoided emissions calculations
5. Selecting who (or which type of organization) will conduct the evaluation and/or M&V activities

And for the M&V plans:

1. Setting spatial boundary for evaluation (what energy uses, emission sources, etc. will be included in the analyses)
2. Defining baseline, baseline adjustments, and data collection requirements

These issues are listed above in what can be considered a sequential process. Many, however, are interrelated, and the overall planning process is iterative. The end result of addressing the above seven issues is preparation of an evaluation plan.

5.3.1.2 Evaluation Plan Outline Requirements

With consideration of the above information the Evaluation Plan can be prepared. The program evaluation plan should be a formal document that clearly presents the evaluation efforts and details the activities to be undertaken during the evaluation. The evaluation plan is a stand-alone decision document, meaning it needs to contain the information needed by the Administrator and enterprises (and others) to understand what is to be undertaken and how. The plan is also an important "historical" document in that it is not unusual for programs with long life cycles to undergo staff changes.

Below is an outline for the contents of a program impact evaluation plan for an industrial program that uses a M&V approach and only involves the calculation of total energy savings (not net energy savings, market assessments, cost-effectiveness, nor process evaluations). Evaluation planning checklists and an evaluation report outline are shown in Section 5.4.

- Program Background
  - Short description of the program(s) being evaluated (market, approach, technologies, budget, objectives, etc.) and expected outcomes
  - Presentation of how the program will save energy and demand and avoid emissions
  - List of the technologies offered by the program
  - Program schedule
  - Program numerical savings and avoided emission goals
- Evaluation Overview
  - Listing of evaluation objectives and how they support program goals
  - Listing of which indicators will be reported (e.g. annual MWh, monthly peak kW, etc.)
- Evaluation Approach – how energy savings and other indicators will be determined

  - Total energy savings analyses description - description of the analysis activities and M&V approach including which IPMVP Option is to be used and why
  - Which independent variables will be considered in analysis of total (e.g. weather, occupancy, industrial production rates)
  - Data sources
  - Uncertainty of results - presentation and discussion of the threats to validity, potential biases, methods used to minimize bias, and the level of precision and confidence associated with the sample selection methods and the evaluation approaches; include quality control information.
  - Evaluation staffing plan - indication of who will do the evaluation analyses and prepare evaluation report
  - Evaluation Report outline
- Evaluation Budget
- Evaluation Schedule - evaluation activities timeline with project deliverable dates
- Detailed site-specific M&V plan requirements to be met by each enterprise (see below) including who will do the M&V work
- Detailed site-specific M&V results reporting requirements to be met by each enterprise (M&V Report)
- Administrator due-diligence review requirements for M&V Plans and results as provided by enterprises

5.3.2 Project M&V Requirements

If the M&V total impact evaluation approach is selected, as is typically done for industrial programs, then an M&V plan needs to be prepared that is *applicable to each project that is selected for analysis*. A project specific M&V plan should describe in detail what will be done to document the savings from a project. It can be a plan for each energy-efficiency measure included in the project, for example, when a retrofit isolation approach (Option A or B) is used. Or, it can cover the entire project —for example, when the whole-facility analysis approach (Option C) is used. The M&V plan will consider the type of energy-efficiency measures involved and the desired level of accuracy.

M&V activities fall into the following five areas.

1. Selecting one of the four IPMVP Options for the project. The Options define general approaches to documenting savings.
2. Preparing a project-specific M&V plan that outlines the details of what will be done to document savings.
3. Defining the pre-installation baseline, including (a) equipment and systems, (b) baseline energy use, or (c) factors that influence baseline energy use.
4. Defining the reporting period information required, including (a) equipment and systems characteristics, (b) post-installation energy use, and (c) factors that influence

post-installation energy use. Site surveys; spot, short-term, or long-term metering; and/or analysis of billing data can also be used for determining the reporting period information.

5. Conducting periodic (typically annual) M&V activities to (a) verify the continued operation of the installed equipment or system, (b) determine current year savings, (c) identify factors that may adversely affect savings in the future, and (d) estimate savings for subsequent years.

The M&V plan should include a project description, facility equipment inventories, descriptions of the proposed measures, energy savings estimates, an M&V budget, and proposed construction and M&V schedules. In addition, it should demonstrate that any metering and analysis will be done in a consistent and logical manner and with a level of accuracy acceptable to the Administrator.

The following is a project M&V plan outline recommendation:

- Description of project, measures to be installed and project objectives
- Selected IPMVP Option and measurement boundary
- Description of base year conditions, data collection and analyses
- Identification of any changes to base year conditions and how they will be determined
- Description of reporting period conditions, data collection and analyses methods
- Basis for adjustments that may be made to any measurements and how this will be done
- Specification of exact analysis procedures
- Specification of metering, metering schedule, and metering specifications
- Description of expected accuracy and how it will be determined
- Description of quality assurance procedures
- Description of budget and schedule for conducting the M&V
- Description of who will conduct M&V

5.4 BEST PRACTICES FOR IMPACT EVALUATION OF INDUSTRIAL ENERGY EFFICIENCY PROGRAMS

The information provided in the following subsections is intended to provide best practices information and guidance during the planning phase of a program's evaluation on:

- Evaluation approaches
- Baselines
- Persistence of savings
- Accuracy of results
- Planning checklists and a sample evaluation report outline are also provided.

5.4.1 Evaluation Approaches for Estimating Total Savings

Selection of a total savings evaluation approach is tied to objectives of the program being evaluated, the scale of the program, evaluation budget and resources, and specific aspects of the energy efficiency measures and the participants in the program. The following are descriptions of situations where deemed savings or M&V approaches are applicable for industrial energy efficiency programs. (Note that the large-scale data analysis approach is not used for industrial programs.)

Deemed savings approaches are most commonly used for programs that involve very simple (a) retrofit energy-efficiency measures or (b) new construction or facility expansion projects with well-defined applications. An example might be replacement of constant-load, continuously operating motors. In this example, an assumption would be made about the average wattage savings and the average hours of operation (8760 hours per year) combined with an effort of verifying that the motors were installed correctly. Deemed values would be based on historical evaluations of other similar programs.

In general, the deemed savings approach is most applicable when all or at least most of the following are true:

- There are limited evaluation resources (time, money, people)
- The projects involve simple energy-efficiency measures with well understood savings mechanisms, and are not subject to significant variation is savings due to changes in independent variables
- The uncertainty associated with savings estimates is low and/or the risk of under-estimating (or over-estimating) savings is low
- Documented per-measure stipulated values are available and applicable to the measure installation circumstances
- With deemed savings the primary goal of the evaluation is to conduct field inspections for all, or a sample of projects, to make sure they are properly installed and have the potential to generate savings (rather than attempting to rigorously determine the energy savings)

> **M&V Costs**
>
> Because the costs for the M&V approach is contingent on which of the four M&V Options is selected, the following are some comments on factors that affect M&V costs for Options A and B, which are the ones typically used for industrial projects.
>
> Option A
>
> - Number of measurement points
> - Complexity of deriving the stipulation
> - Frequency of post-retrofit inspections
>
> Option B
>
> - Number of points and independent variables measured
> - Complexity of measurement systems
> - Length of time measurement system maintained
>
> Frequency of post-retrofit inspections

Unlike the deemed savings approach, the M&V approach is used for almost any type of program that involves retrofits or new construction projects. In addition, while just a sample of projects can be used with the M&V approach, generally it is applied to all of the projects that participate in an industrial program because of the typically large volume of savings associated with each industrial project and because each industrial project is typically unique. It should be noted though that the expenses associated with the M&V approach are higher than with the use of deemed savings.

5.4.2 Establishing Baselines

As mentioned before, a major impact evaluation decision is defining the baseline. The baseline defines the conditions, including energy consumption, which would have occurred without implementing the subject program. When defining the baseline it is also important to consider when in the life-cycle of the existing equipment or systems the new equipment was installed. The options are (a) "early-replacement" of equipment that had not reached the end of its useful life, (b) replacement of failed equipment, or (c) new construction. For each of these options the two generic approaches to defining baselines are the *project-specific* and the *performance standard* procedure. Both can be applied to industrial energy-efficiency programs.

5.4.2.1 Project-Specific Baseline

Under the project-specific procedure, the baseline is defined by a specific technology or practice that either (a) exists or (b) would have been pursued, at the site of individual projects if the program had not been implemented. With retrofit energy-efficiency projects the common way this is accomplished is by assessing the consumption rate of the existing, pre-retrofit equipment, based on measurements or historic data.

For new construction or expansion projects the baseline can be determined by evaluating a control-group's energy equipment. Most enterprises, when calculating their own savings, define baseline as what the new equipment actually replaces, i.e. the baseline is related to actual historical base year energy consumption or demand.

> *New Construction and Industrial Expansion Baselines*
>
> "New construction" projects are efficiency projects that take place as part of the construction of a new facility (new construction), or as part of a facility expansion, and involve using more efficient equipment than what would have been installed without the influence of the efficiency program. New construction and expansion projects can be complicated with respect to defining baselines and additionality. Obviously there are no existing systems to which the reporting period energy consumption and demand can be compared. However, the concepts of project and performance standard baseline definitions can still be used. Thus the common ways in which new construction baselines are defined are:
>
> - What would have been built or installed without the program at the specific site of each of project? This might be evaluated by standard practice or plans and specifications prepared prior to the program being introduced
> - Building codes and/or equipment standards
> - The performance of equipment, buildings, etc. in a comparison group of similar program non-participants.

5.4.2.2 *Performance Standard Baseline*

The second approach to determining baselines is done by developing a performance standard, which provides an estimate of baseline energy and demand for all the projects in a program. Performance standards are sometimes referred to as "multi-project baselines" because they can be used to estimate baseline emissions for multiple project activities of the same type.

Under the performance standard procedure, baseline energy and demand are estimated by calculating an average (or better-than-average) consumption rate (or efficiency) for a blend of alternative technologies or practices. These standards are used in large-scale retrofit (early replacement) programs when the range of equipment being replaced and how it is operated cannot be individually determined. This would be the case, for example, in an industrial compressed air retrofit program, where what types of air compressors are being replaced and how many hours they operate cannot be determined for each factory. Instead, studies are used to determine typical conditions.

Another common use of performance standards is to define a baseline as the minimum efficiency standard for that piece of equipment as defined by a law, code, or standard industry practice (often used for new construction or equipment that replaces failed equipment).

5.4.2.3 *Defining Adjustment Factors*

As indicated in equation 6.1, *adjustments* distinguish properly determined savings from a simple comparison of energy usage before and after implementation of a program. By accounting for factors (independent variables) that are beyond the control of the program implementer or energy consumer, the adjustments allow meaningful comparisons to be made. Common examples of adjustment are:

- Weather corrections - for example if the program involves space heating or air-conditioning systems in factories
- Production operating hours – for example if the program involves retrofits in a factory with changing numbers of production hours
- Production levels - for example if the program involves energy-efficiency improvements in factories.

> *Defining Data Collection Requirements*
>
> Deciding baseline and adjustment issues in the planning stage is important for deciding data collection and budgeting requirements. The goal is to avoid discovering at the analysis stage of an evaluation that critical pieces of information either have not been collected at all or were not collected with a reliable level of quality. Without specific instruction to collect the information, it may not be collected. This is because evaluation information needed for calculating benefits is not necessarily useful to program administrators for their tasks of managing and tracking program progress.
>
> Planning for data collection is necessary to give notice and justification for collecting data not ordinarily collected.

The decision as to what independent variables should be considered can be a major effort that involves testing to determine which variables are meaningful. This would typically be done during the implementation phase as part of the data analysis efforts. However, at the planning phase, significant variables should be identified based on intuition and experience.

5.4.3 Establishing Persistence of Savings Requirements

One important evaluation issue is how long energy savings are expected to last (persist) once an energy efficiency activity has taken place. A persistence study measures changes in the net impacts over time. These changes are primarily due to retention and performance degradation, although in some instances changes in codes or standards or the impact of “market progression" may also reduce net savings. Effective useful life (EUL) is a term often used to describe persistence. EUL is an estimate of the median number of years that the measures installed (activities implemented) under a program are still in place and operable (retained).[14]

Persistence studies can be expensive undertakings. Past experience indicates that a long period of time is needed for conducting these studies, so that larger samples of failures are available, and so that technology failure and removal rates can be better documented and used to make more accurate assessments of failure rates. The selection of what to measure, when the measurements should be launched, and how often they should be conducted are critical study planning considerations.

It is also important to note that the energy savings achieved over time is a “difference” rather than a straight measurement of the installed equipment or changed behavior. For example, the efficiency of both standard and high efficiency equipment often decreases over time. Thus, savings are the difference over time, between the energy usage of the efficient equipment/behavior and the standard equipment/behavior it replaced.

The basic approaches for assessing persistence for industrial programs are:

- Use of historical and documented persistence data, such as manufacturer’s data as to the lifetime or warranty lifetime of specific pieces of equipment, such as motors, pumps, fans, and compressors.
- Field inspections, over multiple numbers of years, of the efficiency measures to ensure that they are still in place, still operating, and still operating correctly and delivering savings.
- Non-site methods such as telephone surveys/interviews, analysis of consumption data, or use of other data, e.g. from a facility’s energy management system.

5.4.4 Establishing Accuracy and Precision Requirements

Perhaps the biggest challenge in conducting evaluations of energy-efficiency programs is the impossibility of *direct* measurement of the primary end result—energy savings. Energy savings are the reduction from a level of energy use that did not happen. What can be measured is actual energy consumption after, and sometimes before, the energy efficiency actions. Consequently, the difference between (a) actual energy consumption and (b) what energy consumption would have been had the efficiency measures not been installed is an *estimate* of energy (and demand) savings.

[14] Market progression is when the rate of naturally occurring investment in efficiency increases and can be considered to erode the persistence of earlier first year savings. An example of a cause of market progression is energy price effects – higher energy costs resulting in higher levels of efficiency.

Because an objective of program evaluation is to reliably determine energy and demand savings with some reasonable level of accuracy, the value of the estimates as a basis for decision making can be called into question if the sources and estimated level of uncertainty of reported savings estimates are not fully understood and described. While additional investment in the estimation process can lead to reductions in uncertainty, tradeoffs between evaluation costs and reductions in uncertainty are inevitably required.

Thus evaluation results, as with any estimate, should be reported as *expected values* including some level of variability. In other words, true values are not known, only estimates with some level of uncertainty. Uncertainty of savings level estimates is impacted by two types of errors, systematic and random.

- *Systematic errors* are those that are subject to decisions and procedures developed by the evaluator and are not subject to chance. These include:
  - Measurement errors may arise from meter inaccuracy or errors in recording observations made by evaluator
  - Non-coverage errors occur when the evaluator's choice of a sampling frame may exclude some parts of the population
  - Non-response errors occur when some refuse to participate in the data collection effort
  - Modeling errors may occur due to the evaluator's selection of models and adjustments to the data to take into account differences between the baseline and the test period.
- *Random errors*, those occurring by chance, arise due to sampling, rather than taking a census of the population. In other words, even if the systematic errors are all negligible, the fact that only a portion of the population is measured, will lead to some amount of error. Random errors are sometime called sampling errors.

The distinction between systematic and random sources of error is important because different procedures are required to identify and mitigate each. The amount of random error can be estimated using statistical tools. However, in most instances, evaluators simply try (within budget limitations) to prevent systematic errors from occurring, and no explicit systematic error computations are made. Thus, in general, there is a tendency to calculate uncertainty only considering random errors.

If a random sampling procedure was used to select the sample, sampling error can be estimated by using the laws of probability and sampling distributions. In other words, the potential magnitude of the sampling error for any value calculated from a sample can usually be estimated. The common factors for reporting sampling uncertainty are *confidence* and *precision*. Confidence is the likelihood that the evaluation has captured the true impacts of the program within a certain range of values; and this certain range of values is defined as the precision.[15]

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

Sampling can be a particularly important aspect of an evaluation design. Decisions about the sample size are one of the key factors that influence the overall uncertainty of the evaluation outcome measures. In most evaluations, evaluators do not have access to an entire population of interest (e.g., all motors retrofitted in a factory), either because the population is too large or the measurement process is too expensive or time-consuming to allow more than a small segment of the population to be observed. As a result, evaluators make decisions about a population on the basis of a small amount of sample data.

- Examples of impact evaluation sample used for an industrial program are:Factory lighting retrofits– a sample of the "areas" (offices, hallways, production areas, etc.) are selected for inspection, metering, and analysis – as compared to do the same actions for every light fixture in the factory
- Industrial motors retrofit – a sample of the motors that were installed for metering of power draw during a range of operating conditions and time periods.

Evaluation of savings uncertainty is an ongoing process that can consume time and resources. It also requires the services of evaluation experts who are familiar with data collection and analysis techniques. And, of course, reducing errors usually increases evaluation cost. Thus, the need for reduced uncertainty should be justified by the value of the improved information. That is, is the value worth the extra cost?

5.4.4.1 Mitigating Random/Sampling Error

As long as sampling is used, there will be sampling error. The most direct way of reducing random error due to sampling is to increase the sample size. Most researchers are familiar with this underlying principle. For any given population and confidence level, the larger the sample, the more precise estimates will be.

Evaluation research adopts conventions about sample sizes for particular types of projects. Prior research (or in some cases, requirements set by a regulatory authority) should be the first place to turn for appropriate sample sizes. The next question is whether relationships in prior studies seem likely to exist but have not been borne out by research. This might point toward the need to invest in a larger-than-conventional sample size.

The other way to reduce sampling error is to improve the sampling design. In general, the design with the smallest random error is a simple random sample where each population element has an equal probability of being selected. There are important reasons why a deviation from this design represents an overall improvement in results. For example, stratified sampling design divides populations into homogenous strata prior to sampling (for example, defining lighting areas according to use or type of lighting rather than treating all lighting areas as if they were all part of the same "population"); Stratification greatly reduces overall sampling error. Researchers should have a well-reasoned plan for stratification or clustering of the sample that addresses the impact on sampling error.

5.4.4.2 Mitigating Systematic Error

Many evaluation studies do not report any uncertainty measures besides a sampling error-based confidence interval for estimated energy or demand savings values. This is misleading because it suggests that the confidence interval describes the total of all uncertainty sources (which is incorrect) or that these other sources of uncertainty are not important relative to sampling error. Sometimes uncertainty due to measurement and other systematic sources of error can be significant.

Measurement error can result from inaccurate mechanical devices, such as meters or recorders, as well as from inaccurate recording of observations by researchers or inaccurate responses to questions by study participants. Of course, basic human error occurs in taking physical measurements or conducting analyses, surveys, or documentation activities. For mechanical devices such as meters or recorders, it is theoretically possible to perform tests with multiple meters or recorders of the same make and model to indicate the variability in measuring the same value. However, for meters and most devices regularly used in energy-efficiency evaluations, it is more practical to use either manufacturer and industry study information on the likely amount of error for any single piece of equipment or calibration data.

Assessing the level of measurement error for data obtained from evaluators' observations or respondents' reports is usually a subjective exercise, based on a qualitative analysis, because it is often impossible to make objective, quantitative assessments of these processes. It is very difficult, for example, to quantify the effect of the design of recording forms or questionnaires, training and assessment of observers and interviewers, and the process of collecting data from study participants. It is possible, however, to conduct special studies of a participant subsample to validate each of these processes. For example, it is possible to have more than one researcher rate the same set of objects to evaluate the level of agreement between ratings, and it is possible to conduct short-term metering of specific appliances for a subsample to verify information about appliance use. Participants can also be re-interviewed to test the answer to the same question at two different times, and pretests or debriefing interviews can be conducted with participants to determine how they interpreted specific questions and constructed their responses. Such special studies can be used to provide an assessment of the uncertainty potential in evaluation study results.

5.4.5 Checklists

Tables 5-4 through 5-6 present checklists for preparing an impact evaluation plan. They are organized around the decisions associated with the total savings calculation, calculation of avoided emissions, and generic issues.

Table 5-4 Checklist for Total Impact Evaluation

Savings to be Reported	
Energy Savings (annual, seasonal, monthly, hourly, other)	☐
Demand Savings (peak, coincident, average, other)	☐
Selected Total Energy Savings Calculation Approach	
Measurement and Verification (M&V) Approach	☐
Deemed Savings Approach	☐
Large Scale Billing Analysis (Billing Analysis) Approach	☐
Quality Assurance Approach	☐
Measurement and Verification Approach	
IPMVP Option A, B, C or D	☐

Deemed Savings Approach	
Source of deemed savings identified and verified	
Large-Scale Billing Analysis Approach	
Time-series Comparison	
Control Group Comparison	
Control Group, Time-Series Comparison	
Sample Size Criteria Selected	

Table 5-5: Checklist for Avoided Emissions Calculations

Electricity efficiency savings – Grid Connected	
Operating or Build Margin evaluated, or both	
System Average emissions rate	
Hourly Dispatch Model emissions rate	
Middle Ground emissions rate	
Natural Gas, Fuel Oil and Non-Grid Connected Electric Generating Units	
Default emissions factor	
Source testing	

Table 5-6: Generic Evaluation Considerations

	Y/N
Overall goals	
Does the evaluation address the key government policy and oversight needs for evaluation information?	
Will the program success in meeting energy, demand and emissions goals be quantifiably evaluated in the same manner as they are defined for the program?	
Does the evaluation plan represent a reasonable approach to addressing the information needs?	
Are there missing opportunities associated with the evaluation approach that should be added or considered? Are any additional co-benefits being evaluated?	
Does the impact evaluation provide the data needed to inform other evaluations that may be performed, particularly cost-effectiveness analyses?	
Has a balance been reached between evaluation costs, uncertainty of results and value of evaluation results?	
Uncertainty of Evaluation results	
Can the confidence and precision of the evaluation results be quantified and if so how?	
Are there key threats to the validity of the conclusions? Are they being minimized given budget constraints and study tradeoffs? Will they be documented and analyzed?	
Is the evaluation capable of providing reliable conclusions on energy and other impacts?	
Budget, Timing and Resources	
Does the evaluation take advantage of previous evaluations and/or concurrent ones for other programs?	
Does the cost of the study match the methods and approaches planned?	
Is the scheduled start and end times of the evaluation match the need for adequate data gathering, analysis and reporting?	
Are adequate human resources identified?	
Does the evaluation rely on data and project access that are reasonably available?	

Reporting

Are the time frames and scopes of evaluation reported defined? ☐

Does the data collection, analysis and quality control match the reporting needs? ☐

Are the persistence of savings and avoided emissions being evaluated?

Have measurement and impacts (emissions) boundaries been properly set?

Sampling and Accuracy

Is the sampling plan representative of the population served? ☐

Is the sampling plan able to support the evaluation policy objectives? ☐

Are there threats to the validity of the evaluation results that are incorporated into the evaluation design? ☐

5.4.6 Reporting

The product of an evaluation is a report. The following is a sample report outline.[16]

Table of Contents

List of Figures and Tables

Acronyms

Abstract

Acknowledgments

- Executive Summary
  - Include highlights of key recommended improvements to the program, if relevant
- Introduction
  - Program Overview (Program Description, objectives, etc.)
  - Evaluation Objectives and Methods
  - Structure of the Report
- Study Methodology
  - Data Collection Approach(es)
  - Analysis Methods
  - Limitations, Caveats
- Key Evaluation Results (answers for all of the questions specified for the evaluation)
  - Could include several sections on findings. Findings could be presented for each different methods used, by different program components covered, by market segments covered, and so forth, followed by a section on integrated findings or organized and presented by the different observed effects or type of results
- Recommendations (if relevant; depends on type of evaluation)

[16] This outline is from the US Department of Energy document EERE Program Analysis and Evaluation Program Management Guide.

- Clear, actionable, and prioritized recommendations that are supported by the analysis

- Summary and Conclusions
- Appendices (examples):
  - Recommended improvements to the evaluation process, including any lessons learned for future evaluation studies
  - Appendices containing detailed documentation of the research design and assumptions, data collection methods, evaluation analysis methodology, results tables, etc.
  - Survey or interview instrument, coding scheme, and compiled results tables and data
  - Sources and quality (caveats on data) of primary and secondary information
  - Quantitative analysis details: analytical framework, modeling approach, and statistical results
  - Qualifications and extensions
  - Possible sources of overestimation and underestimation
  - Treatment of issues concerning double counting, use of savings factors, synergistic effects
  - How attribution was addressed (for impact evaluation)
  - Sensitivity of energy savings estimates
  - Assumptions and justifications

5.5 EM&V SOURCE DOCUMENTS

The key documents that were used in the development of this section are available via the internet and are listed below. These documents can be considered the current primary resources for efficiency program evaluation and project M&V. They are well-established *project* measurement and verification (M&V) guides and *program* evaluation protocols. The M&V guides are the IPMVP, the Federal Energy Management Program (FEMP) M&V Guideline, and the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) Guideline 14; these documents constitute the core M&V guidance documents used for energy-efficiency projects in the United States and many other countries.

- *2007 US National Action Plan for Energy Efficiency Model Energy Efficiency Program Impact Evaluation Guide*.[17] This guide describes a structure and several industry-standard approaches for calculating energy, demand, and emissions savings resulting from facility (non-transportation) energy-efficiency programs that are implemented by cities, states, utilities, companies, and other similar entities. The Guide primarily covers impact evaluations (determining the energy and demand

[17] Prepared by Steven R. Schiller, Schiller Consulting, Inc. www.epa.gov/eeactionplan

savings and avoided emissions that directly result from a program) and is organized into five parts.

The primary intended audience for the Guide is energy-efficiency program designers and evaluators looking for guidance on the evaluation process and key issues relating to documenting energy and demand savings, documenting avoided emissions, and comparing demand and supply side resources. Portions of the Guide are also intended for policy makers seeking information about the basic principles of efficiency evaluation.

- *2007 International Performance Measurement and Verification Protocol (IPMVP).* The IPMVP provides an overview of current best practice techniques for verifying results of energy efficiency, water and renewable energy projects in commercial and industrial facilities. Internationally, it is the most recognized M&V protocol for demand side energy activities. The IPMVP was developed with sponsorship of DOE and is currently managed by a non-profit organization that continually maintains and updates the Protocol.

  The IPMVP provides a framework and definitions that can help practitioners develop M&V plans for their projects. It includes guidance on best practice for determining savings from efficiency projects. It is not a "cookbook" of how to perform specific project evaluations, but provides guidance and key concepts that are used in the United States and internationally. The IPMVP is probably best known for defining four M&V Options for energy-efficiency projects. These Options (A, B, C and D) differentiate the most common approaches for M&V and are presented above in this section.

- *2008 FEMP M&V Guidelines: Measurement and Verification for Federal Energy Projects.*[18] The purpose of this document is to provide guidelines and methods for measuring and verifying the savings associated with federal agency performance contracts. It contains procedures and guidelines for quantifying the savings resulting from energy-efficiency equipment, water conservation, improved operation and maintenance, renewable energy, and cogeneration projects.

- *2002 ASHRAE Guideline 14: Measurement of Energy and Demand Savings.*[19] ASHRAE is the professional engineering society that has been the most involved in writing guidelines and standards associated with energy efficiency. Compared to the FEMP M&V Guidelines and the IPMVP, Guideline 14 is a more detailed technical document that addresses the analyses, statistics and physical measurement of energy use for determining energy savings.

In addition, in terms of energy-efficiency *program* protocols, two documents are often cited as standards in the United States for energy-efficiency evaluation. These are:

[18] The current version of the FEMP M&V Guidelines is Version 3.0. The FEMP M&V Guidelines and a number of other M&V resource documents, including some on the use of stipulations for determining savings, M&V checklists and M&V resource lists, can be found at the Lawrence Berkeley National Laboratory website http://ateam.lbl.gov/mv/.

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

- *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals* (California Evaluation Protocols)[20]
- *CPUC Evaluation Framework*[21]

  These two documents provide a great deal of information on evaluation options and principles for impact, process, and market evaluations of a wide variety of energy-efficiency program types. They can be considered, in many respects, as a more detailed version of this manual. The California Evaluation Protocols and Framework and many other evaluation reports and guidance documents can be found at two web-accessible databases:

  – California Measurement Advisory Council (CALMAC): http://www.calmac.org

  – Consortium for Energy Efficiency's Market Assessment and Program Evaluation (MAPE) Clearinghouse: http://www.cee1.org/eval/clearinghouse.php3

For those wanting more evaluation examples, in addition to the CALMAC and CEE websites readers can look at the Proceedings of the IEPEC Conference (www.iepec.org) and ACEEE Summer Studies (www.aceee.org), where there are shorter (10-12 page) examples of evaluations (versus the 100 or more pages for a typical evaluation study).

Three other important program guides are:

- *Evaluating Energy Efficiency Policy Measures & DSM Programmes*, prepared by Harry Vreuls, International Energy Agency, December 2006. This report is available from IEA at http://dsm.iea.org
- *EERE Program Analysis and Evaluation Management Guide*, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy (US DOE EERE) 2007. The guide is available at http://www1.eere.energy.gov/ba/prog_mgmt_guide.html
- *Impact Evaluation Framework for Technology Deployment Programs*, by John Reed, Gretchen Jordan, and Edward Vine, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy (US DOE EERE), 2007. The guide is available at http://www.eere.energy.gov/ba/pba/km_portal/docs/pdf/2007/impact_framework_tech_deploy_2007_main.pdf

Another important resource is the Database for Energy Efficient Resources (DEER), a California Energy Commission and CPUC sponsored database designed to provide estimates of energy and peak demand savings values, measure costs, and effective useful life all with one data source. DEER has been has been designated by the CPUC as its source for deemed and impact costs for program planning. The current version (October 2005) has more than 130,000 unique records representing over 360 unique measures within the DEER dataset. The data are presented as a web-based searchable data set, http://www.energy.ca.gov/deer/index.html

For calculating avoided emissions, several publications prepared as part of the Greenhouse Gas Protocol Initiative are valuable:

[20] State of California Public Utilities Commission's (CPUC) April 2006.
[21] State of California Public Utilities Commission's (CPUC) 2004

- *Corporate Accounting and Reporting Standard*. Standards, guidance, and web-based calculation tools to help companies, regulators, and others develop an organizational-wide greenhouse gas emissions inventory.
- *GHG Project Accounting and Reporting Protocol*. Requirements and guidance for quantifying reductions from greenhouse gas mitigation projects, for example, those used to offset emissions or to generate credits in trading programs.
- *GHG Protocol Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects*
- These documents are available at http://www.wri.org/climate/

Another series of greenhouse gas guides is the International Organization for Standardization (ISO) 14064 series. There are three parts to the ISO 14064 standards:

- ISO 14064-1. Part 1 specifies principles and requirements at the organization level for the design, development, management, maintenance, and verification procedures used to establish and document an organization's GHG inventory.
- ISO 14064-2. Part 2 specifies principles and requirements and provides guidance at the project level for quantifying and reporting activities intended to cause GHG emission reductions or removal enhancements.
- ISO 14064-3. Part 3 specifies principles and requirements and provides guidance for those conducting or managing the validation and/or verification of GHG assertions, such as the validation or verification of an organization's GHG inventory emissions claim or a project's GHG emission reduction claim.

  These can be downloaded for a fee at http://www.iso.org/

This section describes the calculation and comparison of the benefits and costs of DSM. It provides guidance and examples to explain and contrast different perspectives for determining the cost-effectiveness of DSM programs as resource alternatives to conventional power supply. It also provides guidance on developing global assumptions for cost-effectiveness analysis, including the economic discount rate for computing the present worth of future benefits and costs. The cost-effectiveness section describes the key analytical steps required for identifying and assembling DSM programs and portfolios that maximize the net economic benefits to the grid and to society.

6.1.1 Cost-Effectiveness Indicators

6.1.2 Economic Perspectives on Cost-Effectiveness

A principle of least-cost resource planning is that the economy will be best off if it acquires all the economically achievable efficiency potential. That is, the optimal allocation of resources will result by acquiring all potential electric efficiency savings that can be achieved for less than the avoided costs of supply. This is the indicator of the societal or total resource cost perspective for DSM cost-effectiveness.

Indicators that measure the perspective of the electric system are not a test of allocative efficiency. It the perspective indicates the cost-effectiveness to the electric system of acquiring economically efficient demand-side electricity resources. It is meaningful insofar as it tells how much an administrator has to spend to acquire electricity savings form various types of DSM investment, compared to the benefits to the system those expenditures produce.

Definitions of the most commonly used perspectives, paraphrased from the California Standard Practice Manual, are provided below. These metrics vary in terms of (a) their applicability to different program types, (b) the cost and benefit elements included in the calculation, (c) the methods by which the cost and benefit elements are computed, and (d) the uses of the results.

- Total Resource Cost Test (TRC). The TRC test measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs. The TRC ratio equals the benefits of the program, in terms of value of energy and demand saved, divided by the consumers' and program administrators' net costs. The ratio is usually calculated on a life-cycle basis considering savings and costs that accrue over the lifetime of installed energy-efficiency equipment, systems, etc. When the TRC test is used, if the ratio is greater than 1.0, then the program is considered cost-effective, with of course proper consideration of uncertainties in the TRC ratio calculation. This is probably the most commonly applied cost-effectiveness test.
- Utility Cost Test (UC). The UC test measures the net costs of a demand-side management program as a utility resource option based on the costs incurred by the administrator of the program (assumed to be a utility, thus the name, but can be any organization), excluding any net costs incurred by the participant. The benefits are the

same as the TRC benefits (energy and demand savings value), but costs are defined more narrowly and do not include consumer costs.

- Participant Test. The participant test assesses cost-effectiveness from the participating consumer's perspective by calculating the quantifiable benefits and costs to the consumer due to participation in a program. Because many consumers do not base their decision to participate in a program entirely on quantifiable variables, this test is not necessarily a complete measure of all the benefits and costs a participant perceives.
- Societal Test. The societal test, a modified version of the TRC, adopts a societal rather than a utility service area perspective. The primary differences between the societal and TRC tests are that to calculate life cycle costs and benefits the societal test accounts for externalities (for example, environmental benefits) and uses a societal discount rate.

While the TRC and societal perspectives are arguably the best indicators of economic efficiency, it is important that DSM programs represent attractive investments from the other perspectives: it is essential that participants' economic interests are satisfied, and it is equally important to utility system planners that the utility system's investments in demand-side resources (which increase the utility's revenue requirement) do not exceed the magnitude by which avoided supply costs reduce revenue requirements.

6.1.3 Cost-Effectiveness Calculations

6.1.3.1 Total Resource Cost Test

The following formulae define the net present value (NPV_{TRC}) the benefit-cost ratio (BCR_{TRC}) and levelized cost of energy savings (LC_{TRC}) for the Total Resource Cost test:[22]

$$NPV_{TRC} = B_{TRC} - C_{TRC}$$

$$BCR_{TRC} = B_{TRC} / C_{TRC}$$

$$LC_{TRC} = LC_{TRC} / IMP$$

Where:

NPV_{TRC} = Net present value of total costs of the resource

BCR_{TRC} = Benefit cost ratio of total costs of the resource

B_{TRC} = Benefits of the program

C_{TRC} = Costs of the program

LC_{TRC} = Total resource costs used for levelizing

IMP = Total discounted load impacts of the program

The B_{TRC}, C_{TRC}, LC_{TRC}, and IMP terms are further defined by the following equations:

22 Levelized costs can be expressed in metrics of cost per unit of energy saved (RMB/kWh) or cost per unit of avoided capacity (RMB/kW-yr).

$$B_{TRC} = \sum_{t=1}^{N} \frac{UAC_t + TC_t}{(1+d)^{t-1}}$$

$$C_{TRC} = \sum_{t=1}^{N} \frac{PRC_t + PCN_t + UIC_t}{(1+d)^{t-1}}$$

$$LC_{TRC} = \sum_{t=1}^{N} \frac{PRC_t + PCN_t}{(1+d)^{t-1}}$$

$$IMP = \frac{\sum_{t=1}^{n} \left[(\sum_{i=1}^{n} \Delta EN_{it}) \ or \ (\Delta DN_{it}) \right]}{(1+d)^{t-1}}$$

Where:

UAC_t = Utility avoided costs in year *t*
TC_t = Tax credits in year *t*
PRC_t = Program costs in year *t*
PCN_t = Net participant costs in year *t*
UIC_t = Increased utility supply costs in year *t*
EN_{it} = Reduction in net energy use in time period *i* in year *t*
DN_{it} = Reduction in net demand in time period *i* in year *t*
d = Interest rate (discount rate)

6.1.3.2 Utility Cost Test

The following formulae define the net present value (NPV_{UC}), benefit-cost ratio (BCR_{UC}), and levelized cost of energy savings (LC_{UC}) for the Utility Cost test:

NPV_{UC} = $B_{UC} – C_{UC}$
BCR_{UC} = B_{UC} / C_{UC}
LC_{UC} = LC_{UC} / IMP

Where:

NPV_{UC} = Net present value of utility costs
BCR_{UC} = Benefit cost ratio of utility costs
B_{UC} = Benefits of the program to the utility
C_{UC} = Costs of the program to the utility
LC_{UC} = Total utility costs used for levelizing
IMP = Total discounted load impacts of the program

The B_{UC}, C_{UC}, LC_{UC}, and IMP terms are further defined by the following equations:

$$B_{UC} = \sum_{t=1}^{N} \frac{UAC_t}{(1+d)^{t-1}}$$

$$C_{UC} = \sum_{t=1}^{N} \frac{PRC_t + INC_t + UIC_t}{(1+d)^{t-1}}$$

$$LC_{UC} = \sum_{t=1}^{N} \frac{PRC_t + INC_t}{(1+d)^{t-1}}$$

Where:

INC_t = Incentives paid to the participant in year *t*

(All other variables have been defined above)

6.1.3.3 Participant Test Formulae

The following formulae define the net present value (NPV_P) and the benefit-cost ratio (BCR_P) for the Participant Test.

NPV_P = $B_P - C_P$

BCR_P = B_P / C_P

Where:

NPV_P = Net present value to all participants

BCR_P = Benefit-cost ratio to participants

The Benefit (B_P) and Cost (C_P) terms are further defined as follows:

$$B_P = \sum_{t=1}^{N} \frac{BR_t + TC_t + INC_t}{(1+d)^{t-1}}$$

$$C_P = \sum_{t=1}^{N} \frac{PC_t}{(1+d)^{t-1}}$$

Where:

BR_t = Bill reductions in year *t*

PC_t = Participant costs in year *t* to include:

- Initial capital costs, including sales tax
- Ongoing operation and maintenance costs include fuel cost
- Removal costs, less salvage value
- Value of the customer's time in arranging for installation

(All other variables have been defined above)

6.1.3.4 Societal Cost Test

The Societal Cost Test is a variant of the Total Resource Cost Test and differs in that it includes the effects of externalities (e.g., environmental, national security), excludes tax credit benefits, and uses a different (societal) discount rate. All other elements are the same as in the TRC test.

6.1.4 Summary of Cost-Effectiveness Perspectives

Figure 6-1 illustrates the components of the most commonly used cost-effectiveness perspectives on DSM benefits and costs.

	Participant	*Utility Costs*	*Total Resource Costs*	*Societal Costs*
Benefits	Financial Incentives Bill Reductions	Avoided T&D Costs Avoided Energy Supply Costs	Avoided T&D Costs Avoided Energy Supply Costs	Environmental Externalities Water & Other Resources Avoided T&D Costs Avoided Energy Supply Costs
Costs	Participant Costs	Increased Energy Supply Costs Administrative Costs Financial Incentives	Increased Energy Supply Costs Administrative Costs Participant Costs	Increased Energy Supply Costs Administrative Costs Participant Costs

Figure 6-1 Cost-Effectiveness Perspectives

The issue of determining optimal levels of energy efficiency investment requires planners to understand the supply curve of available DSM resources. Figure 6-2 illustrates the optimal investment level with an example of energy efficiency supply curves from both the total resource and the electric system perspective. The supply curve as depicted here is an upward-sloping curve indicating the marginal cost of the next unit of savings at increasing output levels. It reflects diminishing marginal returns as efficiency investments increase—the next unit of savings from the next efficiency investment will cost more than the last.

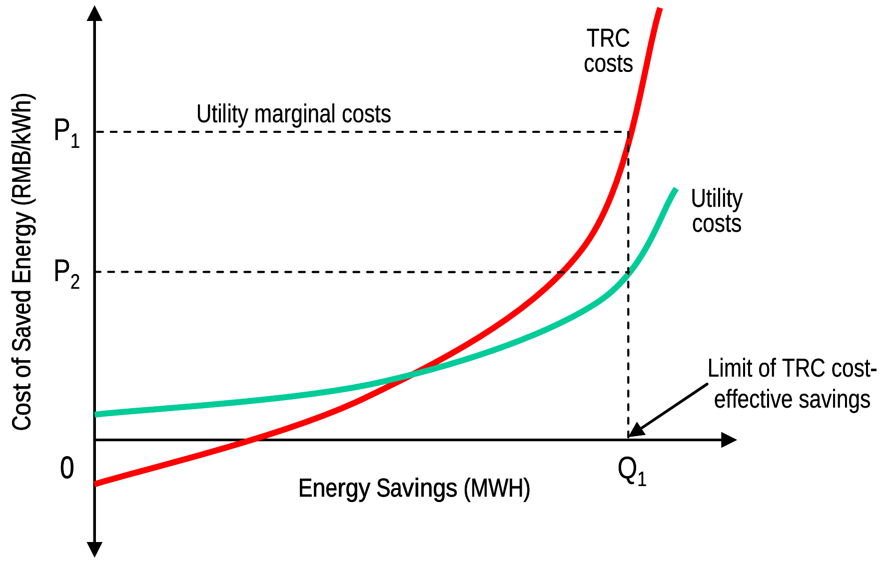

Figure 6-2 TRC and Utility Energy Savings Cost Curves

The red curve in Figure 6-2 represents the marginal resource cost of acquiring efficiency savings; the area under the curve is the total resource cost of DSM savings. The green supply curve is the electric system's marginal cost of acquiring DSM savings at each level of savings. Note that the TRC cost of some DSM resources is less than zero, because non-energy benefits like capacity and customer savings exceed the total cost of the efficiency investment.

The horizontal line at P_1 represents marginal utility costs, which establishes avoided energy supply costs, including avoided capacity costs (i.e., for generation, transmission, and distribution). Notice that at the limits of TRC cost-effective savings (at Q1) the marginal cost of saved energy to the electric system (P_2).

Finally, the graph also illustrates the net monetary value of DSM savings to both the economy and the electric grid. The net economic benefit from acquiring the economically optimal level of DSM savings (Q_1) is the area under the horizontal line at P_1 and above the red line, looking leftward from their point of intersection to the y-axis. The net monetary savings to the electric system is the area under the horizontal line at P_1, again from its point of intersection with the red cost curve, but above the green electric system cost line, again looking leftward to the y-axis.

6.1.5 Principal Economic Indicators

Regardless of economic perspective, indicators of cost-effectiveness are generally expressed in one or more of the three following metrics:

- Net Benefits, which are expressed as the present worth of benefits minus the present worth of costs

  - The expression of net benefits is the primary cost-effectiveness indicator. The objective of a least-cost plan is to maximize net benefits.
  - Net benefits to the TRC or societal test is a measure of the increase in wealth to the economy
- Benefit-to-Cost Ratio, which is expressed as the present worth of benefits divided by the present worth of costs
  - The benefit-to-cost ratio is a secondary indicator of cost-effectiveness and allows for simple comparisons of relative resource attractiveness. For a cost-effective resource, the B/C will be greater than 1.0
  - Because the B/C ratio does not indicate the total value of a resource, it can be a misleading indicator to compare competing investment options
- Cost of Saved Energy, which states the levelized cost of energy (usually in dollars per kWh) and is mathematically expressed as the present worth of costs divided by the present worth of lifetime energy impacts
  - The estimated cost of saved energy allows planners to compare DSM investment costs directly to levelized energy supply costs

The primary indicator is the present value of net benefits. The greater the net benefits, the more cost-effective the investment. If two or more potential investments are competing for funding, the one with the greatest net benefits should be pursued.

The ratio of benefits to costs is another indicator of relative cost-effectiveness of a DSM investment. It is not reliable, however, as a basis for choosing between two competing investments. The investment with the highest benefit/cost ratio (BCR) may not be the one that produces the greatest net benefits. For example, choosing the level of DSM investment that maximizes the BCR would lead one to the mistaken conclusion in the figure above that investment should stop after acquiring only the least-costly (or most cost-effective) DSM. The proper conclusion is that to minimize the total costs of supplying electricity, all DSM resources available for less than the avoided costs of supply are worth pursuing.

The cost of saved electricity is an indicator of DSM cost-effectiveness relative to avoided costs of energy supply. It divides the present worth of DSM costs by the present worth of lifetime electricity savings. All else equal, the lower the cost of saved electricity compared to supply, the more cost-effective it is as an electricity resource. As is the case with the attempting to maximize the BCR of DSM investment, to restrict DSM investment choices only to those with the lowest costs of saved electricity would neglect large amounts of cost-effective savings and lead to a misallocation of resources.

6.2 ESTIMATING AND COMPARING THE MONETARY VALUE OF DSM BENEFITS AND COSTS

This section describes methods for estimating and comparing DSM benefits and costs using the cost-effectiveness perspectives and indicators introduced above, on the basis of best practices in the U.S. and China. Appendix F provides links to various electronic tools for applying these methods to DSM cost-effectiveness analysis.

The discussion that follows includes examples from DSM cost-effectiveness analyses in Jiangsu and Guangdong Provinces. The Jiangsu analysis encompassed cost-effectiveness assessments of individual industrial retrofit projects involving several efficiency technologies, as well as cost-effectiveness analysis of an entire DSM program portfolio.[23] The Guangdong project similarly addressed cost-effectiveness of industrial efficiency retrofits, as well as a $100 million loan portfolio financing numerous individual projects over 25 years.[24]

6.2.1 Global Assumptions

Two basic assumptions are necessary for any valid cost-effectiveness analysis: the discount rate to use for computing the present worth of benefits and costs; and how far into the future the analysis will extend.

6.2.1.1 Discount Rate

A recent Jiangsu analysis of potential energy efficiency investments adopted a real discount rate of 6.4 percent. A real discount rate is net of inflation (as opposed to a nominal discount rate, which includes the rate of inflation in it). This choice was based on the mix and cost of different forms of capital used to finance power supply investment. This same discount rate is used in assessing the economic merits of efficiency investment opportunities for individual industrial facilities.

A recent Guangdong analysis used an economic real discount rate of 12 percent. This higher discount rate was based on capital structure (i.e., mix of debt and equity) to finance most coal-fired power plants. It is higher than the discount rates typically presently used in many other parts of the world. The main reason for this is that the Guangdong economic analysis assumed that the investment funds would otherwise be used to pay for investments carrying greater risks and therefore higher costs of capital.

6.2.1.2 Analysis Horizon

The analysis horizon should extend at least as long as the expected duration of electricity savings produced by the DSM project or program under consideration. For example, the Jiangsu program analysis has an analysis period of 34 years. The Guangdong portfolio analysis has a time horizon of 39 years, for reasons associated with the term of an ADB loan. Both approaches are consistent with international best practices.

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[23] Technical, Economic, and Financial Assessment of Energy Efficiency Investment Options for the Jiangshan Agrichemical and Chemical Co., Prepared for Jiangsu Economic and Trade Commission, Prepared by Stephen Booth, PE (SJB, PC), John Plunkett & Francis Wyatt (Green Energy Economics Group, Inc.), On Behalf of Natural Resources Defense Council, September 2007.

DSM Strategic Plan For Jiangsu Province; Economic, Electric And Environmental Returns From An End-Use Efficiency Investment Portfolio In the Jiangsu Power Sector, Joint Report Prepared In Accordance With The Memorandum of Understanding Between The Jiangsu Provincial Economic and Trade Commission and the Natural Resources Defense Council (USA) on Cooperation in DSM Strategic Planning, Prepared by Optimal Energy, Inc., Green Energy Economics Group and the State Grid Corporation DSM Instruction Center, Updated Report January 20, 2006.

[24] Asian Development Bank TA 4706-PRC, Energy Conservation and Resource Management, Advisory Technical Assistance Report, Part B Phase 2: Pre-feasibility Study for Establishing an Efficiency Power Plant Demonstration Project in Guangdong Province, November 19, 2007.

6.2.2 DSM Benefits

Following are the approaches used to estimate the future value of resources saved by DSM investments in Jiangsu and Guangdong.

6.2.2.1 Avoided Electricity Generation Costs

Both the Jiangsu and Guangdong electricity avoided costs are based on coal generation. Consequently, the analyses presume that reducing electric energy requirements will avoid the full capital and operating costs of new coal plants being built in China. Avoided energy costs have two components: capitalized energy costs and variable operating costs, including fuel. Pollution fees are added to the Jiangsu avoided costs as a relatively small variable cost component.

Capitalized energy costs are associated with the construction cost of a new coal plant and represent an annuity to recover the construction costs, along with a return on un-recovered capital over the over the life of the plant. The rate of return on capital is based on a debt/equity ratio, with assumed real rates of return (i.e., excluding inflation) on both debt and equity. The weighted cost of capital is used to compute the annual payment, which is divided by annual energy output to derive the avoided capitalized energy cost per kWh.

The variable costs are based primarily on the cost of coal. The variable cost is then escalated at the assumed real rate of coal price escalation of 6.8 percent.

Efficiency savings are estimated at the point of use—that is, at the customer level. Avoided generation costs therefore are adjusted upwards to include losses avoided between the point of use and generation.

6.2.2.2 Avoided Electricity T&D Capacity Costs

The reduction of peak demand growth allows the power grid to slow the pace of transmission and distribution (T&D) capacity expansion. The deferral of capital spending avoids annual payments to recover T&D capital, as well as return on that capital over the service life of the assets. To calculate the value of avoided T&D costs, the annualized cost of T&D investment is adjusted upwards for capacity reserve requirements and for losses from generation to end use. Appendix F includes example avoided costs from the Jiangsu and Guangdong studies.

6.2.2.3 Avoided Thermal Energy Costs

Any fossil fuel savings incidental to electric efficiency investments should be valued at the best estimate of future fuel prices. Such projections start with current prices, which are then increased to reflect forecast expectations. For example, in the Guangdong analysis the value of reduced coal consumption started with a current delivered price of 450 RMB per ton, which was then escalated at a real rate of 6.8 percent per year.

6.2.2.4 Environmental Benefits

CDM Proceeds

The TRC and Societal Cost tests may include monetized benefits of environmental assets that are enabled by program savings. Both the Jiangsu and the Guangdong analyses considered the expected value of future Certified Emission Reductions (CERs) under the UN Clean Development Mechanism. The Jiangsu portfolio analysis assumed a CER value of 40 RMB per metric ton of reduced CO_2. This value was below the price in 2005 of EU allowances, which ranged from about €7-9 (RMB 75-95) per ton and UK allowances trading at about RMB 50/ton, and is within the range of average prices reported for compliance-ready project based reductions, which was between $4-5/ton. Furthermore, a team of Chinese and international experts modeled an equilibrium price of $5.2-6.5/ton. The Guangdong analysis used a CER value of 87 RMB per metric ton CO_2 reduction. This was based on the CER value for a large efficiency project in China in March 2007.

Environmental Externalities

The Societal test (but not the TRC) may include environmental externalities—that is, hard to quantify environmental costs associated with traditional energy resources. Impacts of DSM resources that reduce energy consumption also produce direct environmental benefits by reducing air emissions and other pollutants. Only the Guangdong analysis explicitly valued the external environmental costs avoided by DSM. That analysis used the CER value for CO_2 reductions and the values shown in Table 6-1 to represent the environmental costs of the most harmful air pollutants emitted by coal-fired power plants.

Table 6-1 Externality Costs in Guangdong Province (in 2006 RMB/ton)

Year	2006	2007	2008	2009	2008	2009	2010-2026
TSP	3853	3887	3922	3958	3993	4029	4065
SO_2	1634	1649	1663	1678	1694	1709	1724
NO_x	1714	1730	1745	1761	1777	1793	1809

6.2.2.5 Water Savings

The TRC and Societal tests may each include the monetary value of conserved water resources. The two Chinese provincial analyses did not address the value of water savings.

6.2.3 DSM Costs

DSM programs involve two categories of resource costs: the costs of the efficiency technologies installed, and the administrative costs associated with delivering DSM programs.

6.2.3.1 Efficiency Technology Costs

Efficiency technology costs consist primarily of capital costs—one-time costs of equipment or other measures that reduce electricity consumption while providing the same or even higher level and quality of service as less efficient counterparts. The method of measuring the capital cost of most efficiency technologies depends on the setting in which the investment is made.

For DSM technologies installed at the same time that new equipment is purchased or new facilities are built, the capital cost of efficiency technologies is measured as the *incremental* cost of the high-efficiency technology over that of less-efficient technology normally chosen in the marketplace that would be installed in the absence of the DSM program. Ordinarily, the incremental cost of efficient technologies is considered in cost-effectiveness analysis of DSM programs that target new construction and/or new equipment purchases, not the entire cost of the high-efficiency buildings or machines.

In contrast, DSM retrofit programs involve either or both of types of efficiency technologies: supplemental application of technologies to existing buildings or equipment, or early retirement of existing inefficient equipment (i.e., replacement before the end of its normal operating lifetime). An example of the former is the installation of a variable-frequency drive on an existing motor system. An example of the latter is the early removal of an existing inefficient motor halfway through its 20-year life expectancy and replacement by a new, high-efficiency motor. Often, industrial DSM programs promote both types of retrofit applications at once.

Efficiency retrofits consequently involve the full installed costs of supplemental and early-retirement efficiency technologies. Depending on when during its operating lifetime existing equipment is switched out, early retirement retrofit costs must reflect an offsetting cost credit for the high-efficiency technology. This cost credit is due to the permanent postponement of the scheduled replacement cycle, which the early retirement retrofit has interrupted. Using the above example, to retire an existing motor midway through its 20 year expected life means postponing the scheduled purchase of a new motor by 10 years. This *deferral credit* represents the time value of not spending money again on a new replacement for another 10 years after it would have been (if the existing motor had not been replaced 10 years early).

Regardless of the setting, some efficient technologies last longer than the inefficient versions for which they substitute. In such cases, high-efficiency technologies might avoid capital costs that otherwise would have to be incurred for scheduled replacement. For example, compact fluorescent lamps (CFLs) last five or more times as long as incandescent bulbs. Thus, part of the capital cost savings associated with CFLs is the avoidance of purchases of multiple incandescent lamps during the lifetime of the CFLs. In an industrial facility, these cost savings would also include the labor associated with replacing incandescent bulbs when they burn out.

Some efficiency technologies also involve other resource costs beyond initial capital outlays. They can require either more (or less) operation and maintenance (O&M) than their less-efficient counterparts. Such cost increases (or decreases) must also be accounted for in estimating DSM technology costs.

Efficiency technology costs tend to change over time as the volume of installations increases in the future—typically due to the market effects of DSM programs. It is important that such program-driven technology cost reductions be reflected in DSM cost-effectiveness analysis. The effects of pushing the market to higher efficiency levels typically lead to lower incremental costs of high-efficiency equipment (compared to normal market prices) as the market matures.

6.2.3.2 Program Administrator Costs

Program administrator costs include all the costs associated with planning, marketing, managing, and delivering DSM programs. They also include the costs of measuring and verifying DSM project savings, as well as monitoring and evaluating program success. For purposes of cost-effectiveness analysis, these costs are budgeted on an annual basis for as far into the future as the program is expected to operate, usually from five to ten years. Most program administration costs involve administrator staff and contractors. Also included are information technology hardware and software used to track DSM costs and savings.

Typically, program administration costs start out high as programs ramp up, and then level off or even decline in real terms (i.e., net of inflation) over time as programs mature and administrators improve operational efficiency. Also, program administration costs tend to be relatively fixed with respect to the number of participants served or efficiency technologies installed through the program. The exception to this general rule is direct technical assistance provided to participants in industrial retrofit programs.

Program administration costs are counted in the three predominant cost-effectiveness perspectives. They tie up real economic resources and are almost always borne entirely by the program administrator (i.e., not charged directly to program participants).

The other major component of program administrator costs involves financial incentives paid to participants or third parties (such as vendors or wholesalers). These program expenditures depend both on the size of the financial incentive offered for efficiency technologies, and on the market penetration rates expected for various technologies in the future. Financial incentive budgets vary directly with the number of technologies installed throughout the program. Because successful DSM programs are always expected to increase efficiency technology market penetration over time, incentive budgets tend to rise steadily over time. Offsetting this trend is any expectation of future technology cost reductions as program market penetration increases.

6.2.3.3 Participant Costs

North America best practices in DSM program design offer financial incentives to participants that cover some or in some cases all the costs of targeted efficiency technologies. The portion of efficiency technology costs covered by the DSM program becomes a major part of the DSM program budget. The remainder of the efficiency technology capital cost is borne by participants. Participant costs also include the other capital and O&M cost increases or decreases realized on the customer's side of the electricity meter that result from installing efficiency technologies. Participant costs fall outside the electric system cost-effectiveness perspective, but are counted in both the societal and total resource cost perspectives.

6.2.4 Structuring DSM Benefit/Cost Analysis

DSM benefit cost analysis takes place at four progressively higher levels of aggregation.

- Individual efficiency technology or measure
- Individual DSM project, consisting of multiple efficiency technologies or measures
- Individual DSM program, encompassing multiple DSM projects of multiple years in the future
- DSM program portfolio, including all DSM programs.

This analytical structure follows the hierarchy of DSM building blocks depicted in Figure 3-2 (in the discussion of portfolio composition and program design). Best industrial retrofit DSM practice in the US is to perform the first two levels of analysis for individual participating customers on a customized basis as part of program implementation. Best practices also include assessing program cost-effectiveness, for purposes of DSM program and portfolio planning, by analyzing representative or typical efficiency technologies and/or projects.

Appendix F contains links to two cost-effectiveness analysis tools. One is a technology and project analysis tool. The other is a program and portfolio analysis tool.

6.2.4.1 Technology Screening

Efficiency technology screening is the most fundamental level of DSM cost-effectiveness analysis. It projects and compares the benefits and costs associated with individual efficiency technologies. It determines whether a particular measure is cost-effective given its characteristics—cost, resource savings, and life expectancy. It also allows comparison of net benefits between two or more competing technologies within a DSM project or program.

Technology screening is done using the societal or TRC perspective. The electric system test is never used to assess individual technologies because it has no meaning in this context. An individual efficiency technology’s net benefits to society or the economy has no relationship to the level of financial incentive offered by the program. And under no circumstances should an individual technology be assessed for cost-effectiveness by loading on or allocating program administration costs. Doing so could lead to the false and misleading conclusion that an individual technology is not worth pursuing.

6.2.4.2 Project Analysis

Project cost-effectiveness analysis determines whether a collection of efficiency technologies is beneficial to the economy. Using either the societal or the TRC perspective, project cost-effectiveness analysis tells whether the project is good for the economy, regardless of who pays and how much they pay to make it happen.

Some administrators analyze the cost-effectiveness of an individual project to the electric system. This analysis is often used to set a maximum limit on the level of financial incentive that can be offered to the participant and still produce net economic benefits to the electric system.

As in efficiency technology screening, no program or portfolio administration costs are included in project-level analysis.

6.2.4.3 Program Analysis

Program cost-effectiveness analysis aggregates all the efficiency technology characteristics across all the anticipated participants over the entire time horizon of the program plan. It also includes the multi-year program administration budget. Its main purpose is to determine and demonstrate the expected cost-effectiveness of the program under consideration. It is also valuable for examining potential alterations in program design or implementation to see if program cost-effectiveness can be improved.

For example, program cost-effectiveness can often be improved by modifying the program under consideration to increase market penetration of efficiency technologies or projects. This tends to increase resource and monetary savings without proportionally increasing program administration budgets, since in practice these tend to be relatively fixed.

Lastly, the analysis of program cost-effectiveness guides the process of setting program performance goals.

Best practice for DSM program planning is to conduct program cost-effectiveness analysis using the societal, TRC, and electric system perspectives. A multi-year perspective is critical for properly informed decision making. A common mistake in US DSM practice in the 1990s was to consider only the first year or two of program cost-effectiveness. By examining only one or two years when program administration costs are high and market penetration is low, some administrators came to the false conclusion that DSM programs were not cost-effective. When the horizon was expanded to include the full planning period, later years tended to produce more than enough net benefits to offset early economic losses.

6.2.4.4 Portfolio Analysis

The final and perhaps most important cost-effectiveness analysis is to compare costs and benefits from the entire DSM program portfolio over time. This is the point at which DSM portfolio administrators can document and demonstrate how valuable DSM investment will be to the Chinese and provincial economies and to the electricity grid. It is also a valuable tool for examining how raising or lowering the allocation of portfolio budgets between programs could increase the net benefits from the entire portfolio.

Portfolio analysis is conducted from either or both the societal and total resource cost perspectives, and from the electric system perspective.

Section 7 Program Data Tracking and Reporting

Demand side management (DSM) programs need to provide for the collection, storage, and analysis of information relating to their operations as a part of their planning and development phases. The record that is compiled from this information supports two important program functions:

- Reporting program impacts: the quantified savings and other outcomes due to program operations
- Program management: the day-to-day tracking of customer, project, measure, and financial status

Because information needs are driven by these functions, they can, and should, be detailed during the program design stage. When goals (such as savings targets, number of projects per sector, electric peak load reductions, emissions reductions) and project and program structures are in place, the information needed to track goals and support program structures can be precisely specified..

Information tracking systems usually have two components:

- A relational database that can be manipulated to extract quantitative and state information for measures, projects, programs, buildings, customers, or many other possible reporting configurations
- A document management system whereby agreements, written reports, field notes, drawings, photographs and other information can be stored, typically in paper and electronic files

The key ingredients of an adequate information tracking system are well understood. They are the focus of this section. Here we address three issues:

- What basic information and data are needed to substantively report a program's progress toward goals, and to facilitate the day-to-day management of the enrolled projects?
- What reports should the information tracking system generate?
- What are considered best practices for information tracking systems?

One cannot overstate the importance of a well designed information tracking system to the ultimate success of a program. Lack of data, and missing or erroneous data, are often the largest source of uncertainty in evaluating program impacts. Poor record keeping also results in administrative inefficiencies and errors that can undermine a program's effectiveness. With advance planning, program managers and designers can help increase program efficiency and provide the foundation for reporting results with high confidence.

7.1 DATA AND ACCESS REQUIREMENTS

Database structures and contents, which provide the quantitative record of the state of a DSM program, are the topic for the first part of Section 7.1, followed by a discussion of document management.

7.1.1 Database Structure and Content

Relational databases are sophisticated, complex tools that are built and maintained by information technology and software engineering specialists. This overview of the building blocks of a demand side management database will necessarily omit many of the details considered and provided for by these specialists, and is intended only to help program managers help understand and specify data requirements.

Program tracking databases are built up from a relatively few number of tables, each of which contain records relating to one component or actor in a project. The main building blocks are:

- Participant, the entity that interacts with the program to build a project and deliver savings. A participant could be a facility, a private contractor such as an ESCO, a government agency, or other entity that is authorized by the program. A project may involve more than one participant.
- Facility, the building, industrial plant, or operation that is the location of a project. A facility and a participant could be one and the same, a likely scenario under the Top-1000 Program. A facility might also implement more than one project using different parties to perform the work. Thus a facility could be related to multiple participants, and a participant could have activities with multiple facilities.
- Project, the set of energy efficiency and energy management measures submitted to a demand side management program in a scope of work. A project is installed at one or more facilities (think of a school system with multiple buildings). A facility may complete multiple projects, but each project is a unique event.
- Measure, a discrete action or piece of equipment that results in an energy savings for a project. Each project involves one or more measures. In a database, a measure is unique to a project and can only be installed in one project. A measure will involve a measure type such as lighting retrofit or motor replacement, but the action of installing the type in a facility as part of a project is distinct.

- Measure stage, a snapshot of a measure at a submittal stage; initial application, final application, installation completion, M&V reporting. Each measure has multiple measure stages (four in this example,) but a measure stage in a database relates only to one measure.

Figure 7-1 depicts the elements in a typical DSM database. An entry made in an element is a record, and each record contains data in pre-defined fields. Each record has a unique identification number (the ID number) that is used by the database in locating and manipulating records and their data. Each element, and therefore each record within each element, has a relationship with one or more other elements. In Figure 7-1, the relationships are simple and linear, perhaps reciprocal. In an actual program tracking database the relationships would be considerably more complex; they would involve multiple elements and hierarchies of relationships, as well as many more elements.

Each of the elements in Figure 7-1 is associated with fields that contain the data needed to determine a project's status at a given moment in time, identify the measures associated with a project, estimate or report measure and project savings, identify the entity and person responsible for a project, and estimate the project cost. Figure 7-1 is not meant to be a comprehensive design specification, but rather a distillation of the important data required for the management and reporting for most programs.

Database design needs to take into account the needs of the users who will input the data. Most DSM programs have engineering and support personnel based in multiple offices or locations. Many of the staff members will collect or process the data that are to be entered into the tracking system, and a well-designed database will allow data entry from dispersed locations and a number of authorized individuals. This implies the need for network-enabled data systems, or better yet, Web-enabled. While programs in the past have tracked data using simple spreadsheets (one can see from Figure 7-1 how those spreadsheets could be laid out), the limitation of a single point of entry has always conflicted with good data management. With the technology available today, there is no reason not to use a network-based platform for a DSM database.

A data management tool is only as reliable as its contents ("Garbage in, garbage out" is the often-cited observation). All database management plans need to provide for quality control. The need is probably even greater with multiple individuals keying in the data and information. Quality control starts by building in error checking or out-of-range checking routines into the database itself; these features can prohibit the most egregious data entry errors and prompt the user to resubmit. Quality assurance continues with periodic reviews of the data themselves conducted by staff familiar with the program, the units (kWh, kW, etc), and the likely orders of magnitude. As the size of the data record increases, reviewers can develop automated routines to filter out suspect data and to randomly spot check recent entries. *But the best insurance for data* *quality is to allow only qualified, informed staff to enter the data;* this practice is supported by the network based model, where the program managers and engineers key in the data.

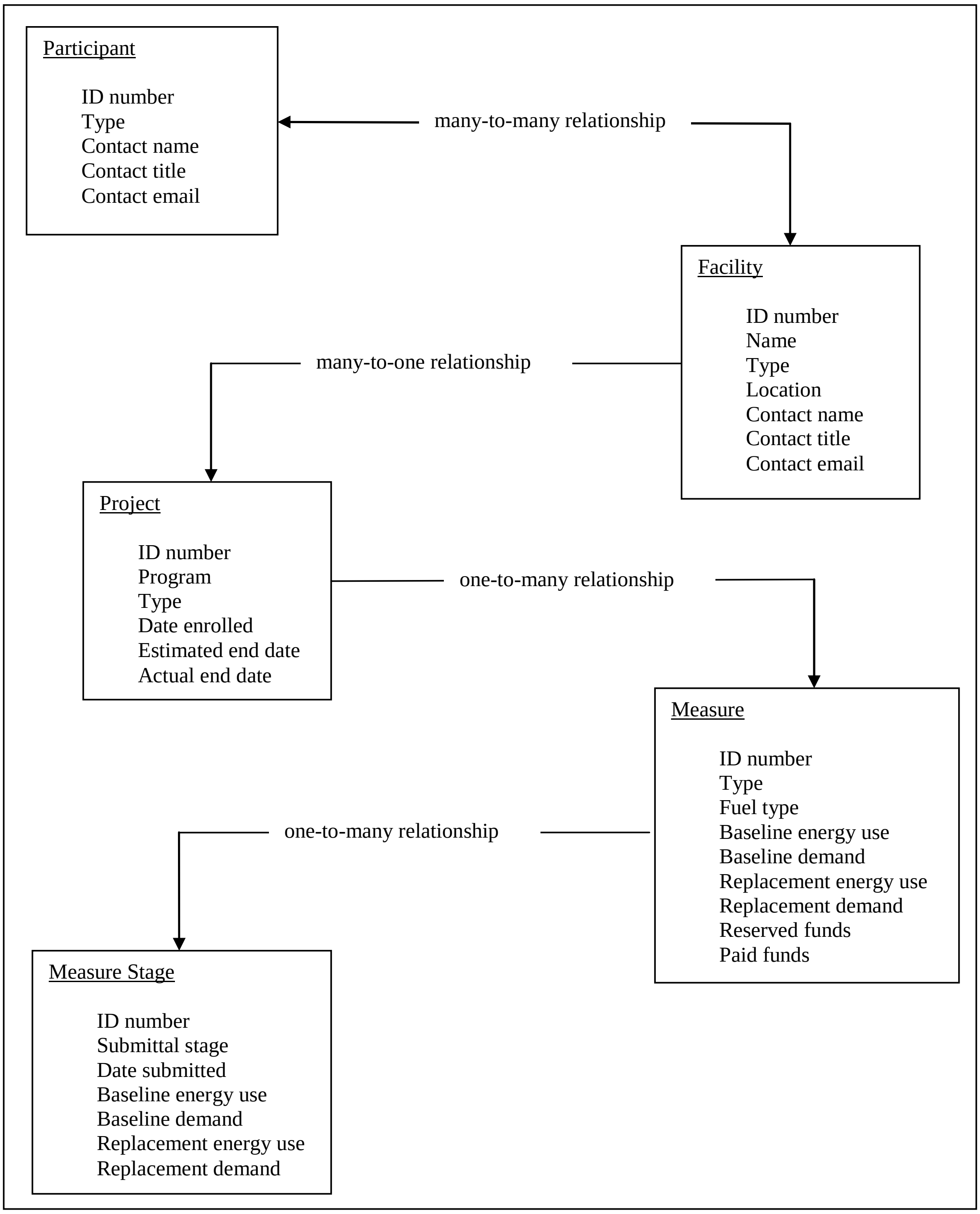


Figure 7-1 Database structure

7.1.2 Document Management

While a relational database will be the foundation of any DSM information tracking system, it is also necessary to plan for an orderly process to receive, store, and retrieve the many paper and electronic documents that support each contract, project, and measure. In the course of negotiating and managing an agreement, and in managing a project, including reviewing submittals and approving savings reports and incentive payments, program managers will accumulate important records that contain details not captured in a tracking database. Particularly noteworthy for impact evaluators are all the correspondence, submittal material, engineering calculations, engineering models, drawings, procedural agreements, M&V plans, equipment inventories, monitored data, hand-written field notes, and other information that together form a complete understanding of a project. Program administrators and planners need to make provision for managing these documents in paper files and on computer systems.

There is a trend in the United States toward appending electronic document management systems to program tracking databases, a feature that adds convenience and reliability to any information system. In some configurations, participants can fill out and upload documents, which program implementers and managers can easily review. However, paper and electronic file storage of documents is the method used for the majority of programs.

7.2 EXPECTED REPORTS

The power of a database is the ability to analyze and combine the information stored in it, and to report the results in ways that serve multiple information needs (e.g., for administrators, reviewers, regulators, evaluators, and financial auditors). Report development tends to be an on-going task, as users of the database discover the need for additional perspectives on program performance. Nevertheless, basic reporting requirements are usually built into any DSM tracking database, and these are the focus of this section.

While there is overlap, it is convenient to think of program management database reports as falling into one of two categories:

- Management reports that provide updates on project status
- Results reports that quantify the outcomes of a program

Management reports are used by a program manager, as well as technical staff, to view the status of projects and the program, and to provide warnings when schedules are slipping or when savings and financial goals are not being achieved. They can also provide estimates of future activity, which can be useful for staffing and financial planning.

Typical management reports include:

- Status reports on projects currently in process, by application stage, showing projected savings and incentive requirements, and counts of expected document submittals by week, month, or other time horizon. Status reports can be prepared for individual projects, which are useful for managing each agreement; or they can be prepared at the summary level with the data rolled up for all projects.
- Anticipated savings and financial obligations, the sum of in-process and completed projects. Using program rules governing submittal schedules and receipt dates in the database, forecasts can be made by month, year, or other interval.
- Overdue alerts, which are lists of projects that have missed a submittal deadline or are missing information. Alerts prompt managers to address problems that might otherwise be overlooked.

Results reports capture the savings achieved by a program and their costs. Results reports can also estimate savings and costs for future dates by factoring in projects currently in process. Typical results reports have at least some of the following formats and content:

- Savings by sector, region, customer type, facility size, fuel type, or other parameter that may be a consideration for program management or design
- Savings by measure or technology, plus cost to the program for each. It can also be useful to report measure savings by sector or other grouping.
- A variance report comparing the achieved savings and costs to those expected.

Pre-defined reports can be run at anytime as required by portfolio administrators and program managers; the only limitation is that the results depend on timely data entry as project submittals are received and processed. Custom reports can be generated by information technology staff as needed. They provide important flexibility to program staff, who will frequently discover the need for yet another way to analyze and present their data.

Preparing meaningful reports requires careful data specification so that the reports contain the intended information. This is a critical issue for portfolios, because individual programs may track different measures of performance due to their differing goals and objectives. In order to prepare summary reports for multiple programs, there needs to be agreement on what common data will be used across the programs so that “like” data can be combined. These common data should be agreed upon during the design of program tracking protocols and the database design period. The specifications are likely to look similar to those depicted in Figure 7-1.

7.3 DATABASE TRACKING SYSTEM BEST PRACTICES

Any business will place a high priority on establishing an efficient financial accounting system that allows its owners to quickly weigh profitability. For a DSM program, the “currency” used to express profits is not measured in RMB but in energy and demand savings. Nevertheless, the need for efficient, comprehensive accounting is as important to a DSM program as it is to a business operation. This section summarizes some of the attributes that characterize best practices in relational databases that are used in information tracking systems.

Best practices for database tracking systems include the following elements:

- Coordination between the designers and the evaluators of programs and databases, so that (1) data needed to track and manage programs are collected as part of the implementation process, and (2) the data are specified in such a way that they can be combined with other programs
- A clear process for receiving applications and for entering and quality- checking data, as well as trained staff who are knowledgeable about the program operation
- Adequate resources to maintain, troubleshoot, and repair the database, including budget and designated information technology staff
- Built-in data quality routines to check for out-of-range errors that alert the user and/or restrict entry
- A quality assurance program that provides for periodic reviews of data by trained and informed staff
- A Web-enabled network platform with access to authorized staff both on and off site

These best practices will be modified and detailed to meet the needs of individual programs, but incorporating these basic elements will provide the foundation for an efficient administrative process and accurate reporting of savings impacts.

Section 8

DSM Financing

8.1 OVERVIEW OF FINANCING MECHANISMS FOR DIFFERENT PROGRAM DESIGNS

8.1.1 The Need for Financing

The DSM program types discussed in this Manual include rebate programs, direct install programs, DSM bidding programs, the standard offer approach, and energy audit programs. The Program Administrators and Program managers design these program types to offer certain incentives and promotional mechanisms to facilitate actions by the Project Implementers related to project planning, equipment procurement, and installation of energy efficient equipment. It is important to note that while almost all the program designs provide certain types of financial incentives to project implementers, rarely do they provide the entire amount of funds required for the procurement and installation. The project implementer therefore needs to have access to financial resources. Experience with such projects worldwide indicates that internal funds have many competing demands and energy efficiency projects rarely get high priority for the allocation of internal funds. Therefore the Project Implementer needs to obtain financing from other funding sources.

8.1.2 Barriers to Financing Energy Efficiency Projects

The following are the typical barriers encountered by Project Implementers in obtaining the financial resources for energy efficiency (EE) project implementation.

- Limited availability of internal funds
- Small project size
- Limited application of “project financing” for EE.
- Lack of knowledge and awareness
- Risk perceptions
- Relatively high transaction costs
- High project development costs
- Requirement for Collateral or Balance Sheet Financing
- Monitoring and measurement of energy savings.

8.1.3 Innovative Financing of Energy Efficiency Projects

To overcome the barriers to energy efficiency project financing, a number of innovative financing mechanisms have been designed and implemented. Examples include:

- Establishment of special purpose energy efficiency funds that may provide grants, loans or other types of financial assistance for project implementation.
- Leveraging financing from commercial financial institutions through mechanisms such as interest subsidies, credit or risk guarantees, etc.
- Encouraging the use of performance contracting for EE project implementation by energy service companies (ESCOs)
- Other financing mechanisms such as carbon financing, lease financing, creation of a "super-ESCO," and financing of EE projects utility bills.

8.1.4 Program Design and Financing

Different financing mechanisms may be appropriate for these different program design types. Table 8.1 below illustrates the needs for financing and the possible financing mechanisms that may be employed for implementation by the Project Implementer (PI).

Table 8.1 – Financing Options for Different Program Design Types

Program Design	Financing Need	Potential Financing Mechanisms
Rebates	PI needs to finance the non-rebate portion of the equipment cost.	EE Fund, Commercial financing ESCOs
Standard Offer	PI needs to finance the installation of the standard measures and demonstrate the savings achieved.	Commercial financing
DSM Bidding	PI needs to finance the design and implementation of the EE project before payment is made.	Commercial financing
Direct Install	PI may have to pay for the contractor (or utility) implementing the measures.	EE Fund Commercial financing
Energy Audits	PI needs to finance the implementation of the audit recommendations.	EE Fund, Commercial financing ESCOs

8.2 DIRECT FINANCING BY GOVERNMENT AGENCIES - CREATION OF ENERGY EFFICIENCY FUNDS

8.2.1 Overview of Energy Efficiency Funds

One approach that has received increasing acceptance throughout both the developed and the developing worlds is the establishment of special purpose funds dedicated to financing EE projects. Such funds are known as energy efficiency funds. A recent assessment of international best practices in energy efficiency funds (see DSM Financing Annex for additional information) indicated that:

- In the United States (U.S.), while the Federal government has implemented a number of energy efficiency initiatives, much of the activity related to energy efficiency funds (EE Funds) has been undertaken at the State level.
- EE funds have been very successfully used in a number of U.S. states.
- The different mechanisms used by states to establish EE Funds include regulations establishing a tariff levy or cess on electricity consumption, special taxes, general state tax revenues, state bonds, petroleum taxes, and certification fees
- The most common, reliable and sustainable source of funding is a tariff levy established by the energy regulator and collected by the utility via the customer's bills.
- The levels of funding vary from state to state. The more progressive states have assessed a levy of 1 to 3% of electricity sales revenue to finance their EE Funds.

Examples of EE Funds in other countries include the following:

- New South Wales, Australia – Sustainable Energy Fund
- New Zealand – Sustainable Management Fund
- Thailand Energy Conservation Fund (ENCON)
- Romania Energy Efficiency Fund (FREE)
- Czech Republic Energy Savings Fund
- IFC – Hungarian EE Co-Financing Program and the Commercializing Energy Efficiency Finance (CEEF) Program
- Brazil – Energy Efficiency Charge
- Sri Lanka – Energy Conservation Fund
- Korea – Korea Energy Management Fund

8.2.2 Characteristics of Energy Efficiency Funds

The responsibilities for the management and operation of the EE Funds may be assigned to the utilities that are collecting the funds through the tariff or in other cases may be assigned to other Fund Managers such as an existing government agency, a specially created statutory agency, a Public-Private Partnership, a municipality, or another type of organization.

The project financing mechanisms utilized by the EE Funds to finance PIs for specific projects include grants, loans, subsidies, equity funds, loan guarantees, credit guarantees, and supplier credits.

The criteria used for selecting the projects for financing generally include technical feasibility, compliance with environmental standards, financial characteristics, acceptability of the level of risk, replicability, contribution to developing sustainable energy efficiency markets, and documentation of project characteristics

8.2.3 Energy Efficiency Funds in China

China's national government and many Provincial governments have established Energy Savings Project Special Funds to provide financial incentives to energy users to implement projects. For the national government, the fund source is the government's budget. In August 2007 the NDRC and the Ministry of Finance created the energy savings projects fiscal incentives. The national program allots an annual amount of RMB 200/ton of coal equivalent (TCE) energy saving for enterprises located in eastern China and RMB 250/ton TCE to those in western China. Sixty percent of this amount is paid up-front once the project's application is officially accepted, with the balance paid at project commissioning. This amount typically corresponds to 10-20% of the capital cost of the energy savings project.

The national government is also establishing a new fund for clean energy projects from the Government's share of revenues earned from CDM projects. The NDRC has formulated the Guidelines for Auditing Energy Savings of Energy Conservation Projects in April 2008 to set up procedures and technical qualifications for energy savings auditors to verify these values for projects. Some Provincial governments have also established special Energy Savings Funds (ESFs); examples include Jiangsu, Hebei and Guangdong. Jiangsu province has an annual budget of approximately 100 million RMB for this purpose. Specified incentive fund amounts are given to approved energy users as a credit on their power bills.

8.3 LEVERAGING COMMERCIAL FINANCING

8.3.1 The Role of Commercial Financial Institutions

Some of the issues in mobilizing financing from banks or commercial financial institutions (FIs) for EE projects are:

- EE project financing is generally viewed by FIs as a small “niche” business.
- Project financing is generally considered for capital projects involving capacity expansion or increased production and not for cost reduction projects such as EE.
- FI staffs do not have sufficient knowledge and experience with EE projects.
- Most EE projects are small relative to other types of projects financed by FIs.
- Financing EE projects may involve changing certain established operational procedures, which FIs are reluctant to do.

In China, there are additional barriers to commercial FI financing of EE projects. The commercial banking system is undergoing a transition from a state-owned to a market-based system, and FIs are still reluctant to make loans that may be perceived as risky or to consider innovative risk mitigation approaches. The interest rates in the Chinese financial markets are controlled, and there appears to be little incentive to take risks. As a result, Chinese FIs have not actively embraced debt financing of EE projects.

In view of China's increasing emphasis on implementing EE projects on a large scale, the government has recognized the need to promote and facilitate increased lending by FIs for EE projects. As China's ESCO industry matures and takes on an increased role in financing and implementation of EE projects (see further discussion below) there is an even greater need for the FIs to step up and participate in collaborating with the ESCOs to provide project financing.

8.3.2 Developing EE/DSM Financial Products for Commercial Financial Institutions

Lending for EE projects is likely to be a new line of business for many Chinese FIs. New loan products, including related business plans and marketing campaigns, need to be designed. They may have strong similarities with existing loan products, such as term loans for industrial plant and equipment. The financial product design must define: tenor, pricing, down payment, required security and underwriting guidelines, required documentation and origination procedures. The objective is to design a financial product that is attractive to the target borrowers, easy to use, with reasonable security terms, and where the loan terms, tenors and payments are matched with the target EE project savings benefit streams so that loans can be self-amortizing through savings.

There are several segments to the energy efficiency market to develop customized financial products. A rough breakdown could include the following categories: large state-owned enterprises (SOEs); municipal corporations and infrastructure, and small and medium enterprises (SMEs). The market can be segmented by industry, e.g., steel, cement, petrochemical, pulp & paper, etc. SMEs can be further broken down by size. The market can also be segmented by marketing approach and transaction size.

8.3.3 Structuring Security for EE Loans

EE equipment tends to have low collateral value, so the asset value of the equipment can not be relied upon for financing security. However, EE equipment it is essential to energy user's operations, which improves willingness to pay and saves money, which in turn improves the ability to pay. The main techniques for securing EE equipment and project loans to end-users include (see DSM Financing Annex for additional detail).

- Preferred Drawing Rights and Special Escrow Accounts
- Security Interest in Equipment and Project
- Reserve Funds
- Recourse to Equipment Vendor

- Portfolio Approach to Credit Structure
- Collections via Utility Bills or Property Taxes
- Extra Collateral from the Borrower
- Guarantees and Credit Enhancement Programs

Lending to ESCOs entails additional challenges and puts a greater burden of structuring and due diligence on the financial institution. In addition to the credit of the energy user, the lender must also understand the ESCO credit and capacities, the economics of the project, the terms of the energy services agreement, and other risk actors, making the appraisal process more intensive.

8.3.4 Technical Assistance Programs for Financial Institutions

A typical technical assistance (TA) program for financial institutions may include:

- Market Research & Marketing Support - Market studies can assess demand for various EE equipment, products and financial products, understand equipment and project economics, identify active and qualified EE system vendors and project developers, identify and assess target markets and their credit characteristics, and assess perspectives and programs of other key government, NGO, donor and policy actors which affect the market environment.
- Transaction Support & Development of New Financial Products - EE finance may be new to FIs and TA will be highly valuable to structure initial transactions.
- Training & Business Planning - EE finance training for lenders can cover EE technologies and applications, EE project economics, structuring EE equipment and project loans, lending to ESCOs, special risk and credit features, case studies, marketing FI financial services, and other topics.
- Engineering Due Diligence - A TA program can provide engineering due diligence on equipment and systems, and independent engineering reviews to confirm technical viability and economics of given projects.

8.3.5 Recruiting and Engaging Commercial Financial Institutions to Participate

The vast majority of EE project finance must come from private sector commercial financial institutions. The need exists to mobilize commercial financial institutions to offer properly structured, adapted EE financial products. In China, ample liquidity and financial resources exist in the commercial banking systems, but need to be mobilized for EE/DSM lending. Attracting commercial lenders to EE finance requires a substantial, steady, and creditworthy flow of demand for their financial products that can be originated profitably, with manageable transactions costs.

Development finance institutions, like World Bank, Asian Development Bank, China Development Bank, other

Government agencies and Program Sponsors can play instrumental roles to mobilize resources and capacities of commercial lenders for EE financing. Where sufficient liquidity exists, credit enhancement and risk sharing products can be instrumental to mobilize funding from commercial lenders; where it does not, DFIs can provide credit facilities; in some cases, both may be needed.

Lenders also need to be understood as large corporate organizations, acting in a policy and regulatory environment. Getting lenders to truly adopt and promote EE financial products involves an organizational process of introducing innovation. This requires leadership at the Board level, plus active understanding and advocacy of senior management. Further, to get middle management to implement the program, senior management must provide a clear mandate, especially when the innovation involves introduction of new credit risk management practices.

8.4 FINANCING MECHANISMS WITH ESCO IMPLEMENTATION

8.4.1 Overview of ESCOs and Performance Contracting

An approach for financing and implementation of energy efficiency projects that is becoming increasingly popular in many countries is the use of performance contracting. This approach addresses some of the major barriers to the implementation of EE projects such as the lack of awareness and knowledge of EE opportunities, lack of technical expertise and capacity for implementation, limited internal capital and inability to access external capital for implementation. Performance contracting refers to energy efficiency implementation services offered by private sector organizations known as energy service companies or ESCOs that are characterized by the following key attributes:

- ESCOs offer a complete range of implementation services, including design, engineering, construction, commissioning, and maintenance of the energy efficiency measures, and monitoring and verification.
- ESCOs also provide or arrange financing (often 100%) and undertake “shared savings” or “guaranteed savings” contracts, such that the payments to the ESCO are less than the cost savings resulting from the project.
- Under the performance contract, ESCOs offer specific performance guarantees for the entire project (as opposed to individual equipment guarantees offered by equipment manufacturers or suppliers) and generally guarantee a level of energy and/or cost savings.
- Payments to the ESCO are contingent upon demonstrated satisfaction of the performance guarantees.
- Most of the technical, financial, and maintenance risk is assumed by the ESCO thereby substantially reducing the risks to the energy user.

The potential benefits of the performance contracting approach offered to energy users (customers) by ESCOs include:

- Performance contracts will provide performance guarantees to assure the successful implementation of the energy efficiency measures.
- ESCOs will generally provide operation and maintenance services to assure that the installed equipment continues to perform at a high level of efficiency.
- A mutually agreed upon monitoring and verification scheme is established to allow for actual measurement, verification and demonstration of savings.
- The ESCO provides breadth and depth of capabilities as well as training to staff of the energy user..
- The ESCO facilitates access to external capital for project implementation.

8.4.2 Alternative Models of Performance Contracting

While there are many different variations in the specific approaches to performance contracting, these can generally be characterized into two basic models - “Shared Savings” and “Guaranteed Savings.” In both models, the ESCO provides the complete range of implementation services and generates energy and cost savings. The differences are in the manner in which the customer makes payments to the ESCO and the way the benefits of the savings are allocated between the ESCO and the customer.

In the Shared Savings model, the ESCO generally provides or arranges for most or all of the financing needed for the implementation of the project. The performance contract then specifies the sharing of the cost savings between the ESCO and the customer over a period of time. The performance contracts may typically be 3 to 7 years in duration and the sharing of the payments is structured such that the ESCO will recover its implementation costs and obtain the desired return on its investment within that period. The customer generally makes no investment in the project and gets a share of the savings during the contract period and 100% of the savings after the contract period. A Shared savings contract requires as part of the performance contract a pre-specified protocol for measurement and verification of the actual savings achieved.

In a Guaranteed Savings performance contract the ESCO guarantees certain performance parameters (such as efficiency, energy savings, cost savings and/or other performance parameters) in the performance contract, which specifies the methods to be used to measure the performance and verify that the guarantees have been met, and the payments to be made to the ESCO once the performance guarantees are satisfied. The Guaranteed Savings contract generally provides the ESCO a fixed payment or payment stream upon the satisfaction of the performance guarantee, but may also provide the ESCO an incentive payment if the actual performance exceeds the guaranteed level.

In China, The World Bank, the International Finance Corporation (IFC), and the Asian Development Bank (ADB) have devoted considerable efforts and funding to establishing and growing ESCOs (see DSM Financing Annex for case studies of these programs). In China, ESCOs are also known as Energy Management

Companies or EMCs.

8.4.3 Financing Models for ESCO Implementation

Four distinct models of ESCO financing and implementation are discussed below:

- Financing with ESCO as Borrower - In this model (see Figure 8.1) the end-user enters into an Energy Services Agreement (ESA) with the ESCO for the project financing and implementation. The performance contract will specify the energy user payment obligation based on project performance, savings, delivered energy or the value of capital and services provided. The loan is typically on the ESCO's balance sheet. The ESCO assumes the energy user credit risk and may need lender assistance to assess this.
- Financing with Energy User as Borrower - In this model (see Figure 8.2) of ESCO financing and implementation, the energy user borrows the funds from the financial institution (sometimes with the assistance of the ESCO).

  The project is implemented with two separate agreements, one for turnkey project implementation services between the energy user and the ESCO (Energy Services Agreement), and the other for project financing (Financing Agreement) between energy user and the financial institution (FI).

Figure 8.1 - Financing with ESCO as Borrower

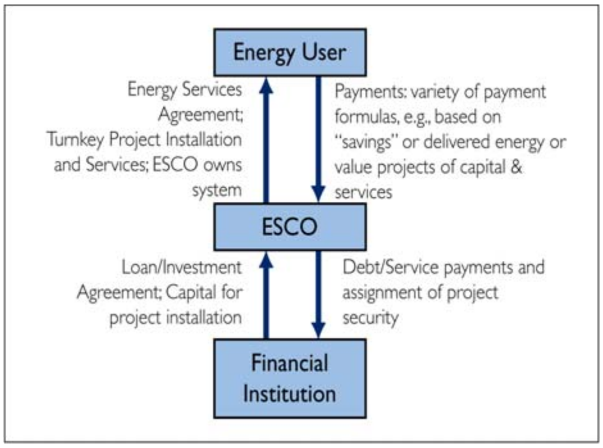
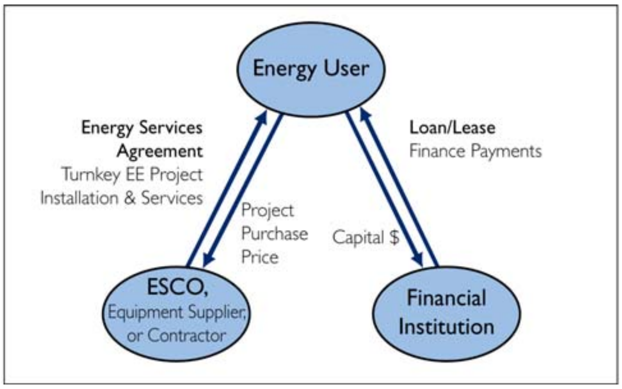
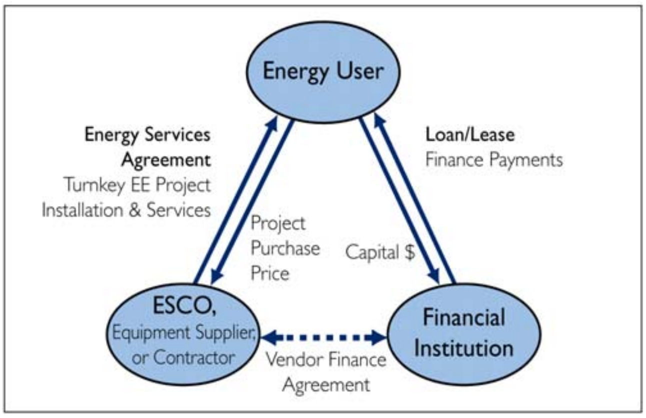


Figure 8.2 - Financing with Energy User as Borrower



- Vendor Financing with ESCO implementation - A vendor finance program is a programmatic relationship between a company (vendor) selling EE equipment and a financial institution, under which the FI will provide financing to the energy user for the energy user to purchase the vendor's equipment (see Figure 8.3)

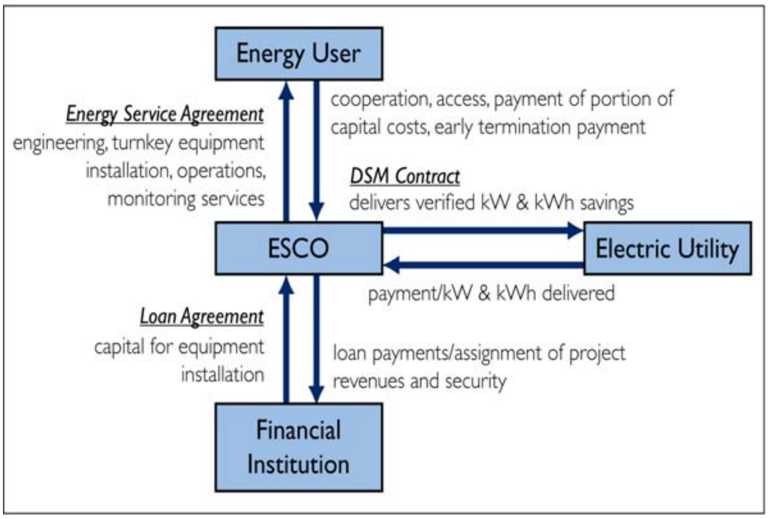
Figure 8.3 - Vendor Finance Program



Alternative vendor financing structures may also be possible and are further discussed in the DSM Financing Annex.

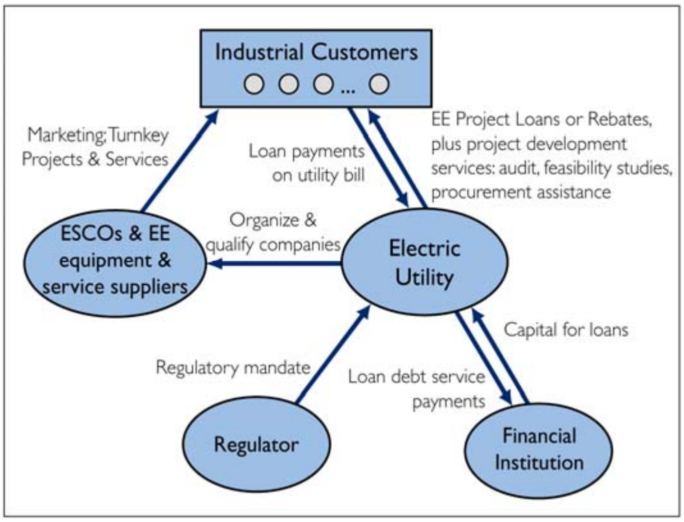
- Utility Financing of ESCOs - ESCOs have been frequently used as delivery mechanism in utility DSM programs. Utilities can contract with ESCOs to deliver energy savings as shown below. Utilities can also qualify ESCOs and EE companies and then provide financing to customers, in the form of loans or rebates that pay a portion of the cost of the project. Under one form of utility program, the utility purchases energy savings (see Figure 8.4):

Figure 8.4 - Utility Purchase of Energy Savings



The second type of utility program is a Direct Install program in which utility provides project development services to target industrial customers, and organizes and qualifies the delivery of equipment and services. The utility provides financing to the customer for the project and collects loan repayments through the utility bills (see Figure 1.5).

Figure 8.5 - Utility Financing Program



8.4.4 Mechanisms for Facilitating ESCOs as Project Implementers

ESCOs were introduced to China in the late 1990's by the World Bank Energy Conservation Phase I Program. ESCOs face several barriers to their business development. The two most important ones are (i) high costs and risks for selling and developing projects; and (ii) difficulties arranging project financing. To address this first issue, Program Administrators can provide marketing, customer education, engineering and project development services to get energy users “decision ready” to make EE investments. This directly creates opportunities for EE equipment and service sales, and significantly lowers the ESCOs’ project development sales costs and risks. Second, Program Administrators can organize financing for EE projects and equipment. Program Administrators Sponsors can also provide finance-related business development services such as building capacity for financing and contracting skills in existing ESCOs, providing financial advisory services, develop multi-project financing facilities, developing standard contract provisions that support financing, assisting ESCOs in business planning and raising equity capital, and conducting ESCO procurements.

8.5 OTHER FINANCING MECHANISMS

8.5.1 Carbon Finance

One of the benefits of improved energy efficiency and reduced energy consumption is the reduction in greenhouse gas (GHG) emissions. Organizations that contribute to reduction of GHG emissions can receive carbon credits that can be translated into funding using carbon financing through the Clean Development Mechanism (CDM) Established under the Kyoto Protocol.

Using CDM, developed countries can invest in low-cost abatement opportunities in developing countries and receive credit for the resulting emissions reductions. Developing countries benefit from the increased investment flows and also from the requirement that these investments advance sustainable development goals. From China’s perspective, CDM can:

- Attract capital for projects that assist in the shift to a more prosperous but less carbon-intensive economy.
- Encourage and permit the active participation of both private and public sectors.
- Provide a tool for technology transfer, if investment is channeled into projects that replace old and inefficient fossil fuel technology, or create new industries in environmentally sustainable technologies.
- Help define investment priorities in projects that meet sustainable development goals.

While the funding available from a CDM project may not provide 100% of the needed financing to a Project Implementer, it can be a valuable source of supplemental financing. CDM projects must qualify through a rigorous and public registration and issuance process designed to ensure real, measurable and verifiable emission reductions that are additional to what would have occurred without the project. The mechanism is overseen by the CDM Executive Board, answerable ultimately to the countries that have ratified the Kyoto Protocol. In order to be considered for registration, a project must first be approved by the Designated National Authorities (DNA), which in China is the NDRC which has designated energy efficiency as one of the priority areas for CDM projects. NDRC has prescribed a project development process which is described in the DSM Financing Annex.

8.5.2 Equipment Leasing

A lease is a contractual arrangement in which a leasing company (lessor) gives a customer (lessee) the right to use its equipment for a specified length of time (lease term) and specified payment (usually monthly). Depending on the lease structure, at the end of the lease term the customer can purchase, return, or continue to lease the equipment. Depending on local tax and leasing laws, leasing companies can provide an important vehicle for commercial financing for energy efficiency projects.

Equipment leases are broadly classified into two types: operating lease and finance or capital lease. In an operating lease, the lessor (or owner) transfers only the right to use the property to the lessee. At the end of the lease period, the lessee returns the property to the lessor. Since the lessee does not assume the risk of ownership, the lease expense is treated as an operating expense in the income statement and the lease does not affect the balance sheet.

In a capital lease, the lessee assumes some of the risks of ownership and enjoys some of the benefits. Consequently, the lease, when signed, is recognized both as an asset and as a liability (for the lease payments) on the balance sheet. The firm gets to claim depreciation each year on the asset and also deducts the interest expense component of the lease payment each year.

China's rapid economic growth story in recent years has provided an opportunity for the development of the equipment leasing industry. The growth of the leasing market has been enabled by the overall growth of the economy together with rapid growth of the underlying equipment market combined with the low existing leasing penetration rates. Additionally equipment manufacturers and vendors are increasingly recognizing the need to provide an equipment finance solution to complete their offering to their customers. Therefore, leasing is likely to be a potential financing source for EE projects in China.

8.5.3 Establishment of a Super ESCO

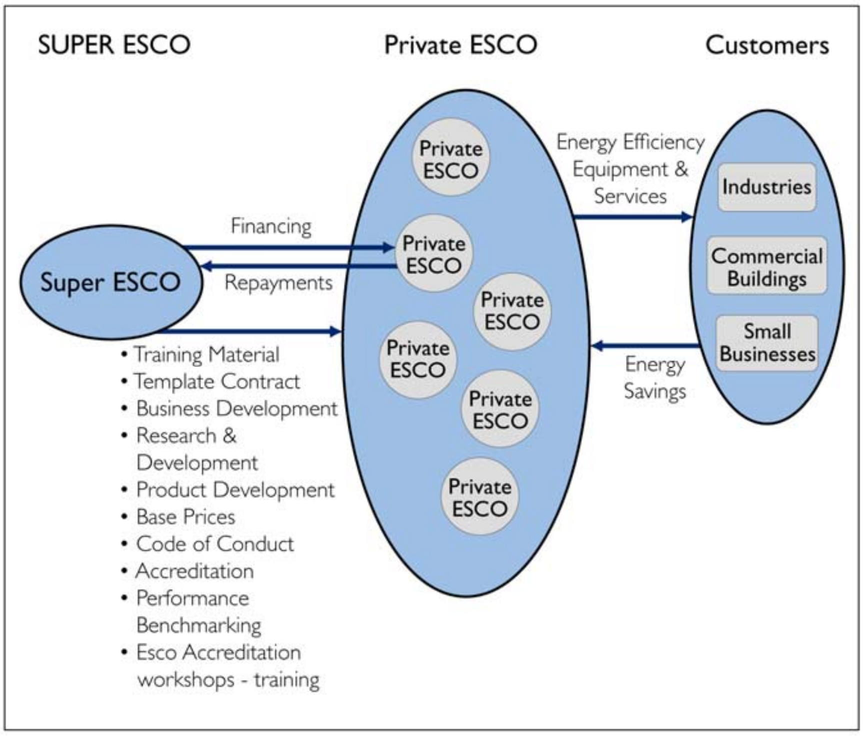
Energy Service Companies (ESCOs) can be an important institutional mechanism for the delivery of energy-efficient investments. Many ESCOs have been established around the world to implement energy efficiency projects for energy users. However, the growth and development of the ESCO industry has been constrained in many countries by their access to financing. While in many cases ESCOs have successfully negotiated financing arrangements with commercial financial institutions, interest and willingness of commercial FIs to provide financing for EE projects has been limited due to a number of barriers, as discussed above.

A super ESCO supports capacity development and activities of other ESCOs, and provides financing for projects. It can also take the form of a leasing or financing company to provide ESCOs and/or customers with energy-efficiency equipment on lease or on benefit-sharing terms. A Government may promote the ESCO industry by setting up a super ESCO, which may act as an ESCO for the public sector (hospitals, schools, and other public facilities) and as an organization providing financing for smaller ESCOs operating in the private sector (industrial and commercial customers).

In China, as a result of efforts initiated by the World Bank (see case study in the DSM Financing Annex), a number of ESCOs have been established, and many more are being created. However, these are concentrated in certain Provinces, while in other Provinces few ESCOs are operating in the market. Also the growth of the ESCO industry has depended on the financing provided by the World Bank.

The commercial banking industry is undergoing a transition in China. While the government and multilateral donors such as the World Bank, IFC and ADB have provided technical assistance and financial resources to commercial financial institutions, much more needs to be done to fully engage commercial FIs in EE project financing. Therefore it may be appropriate to consider a government sponsored super ESCO at a Provincial level to work with the existing and newly-formed ESCOs in EE project financing and implementation.
An illustrative example of a super ESCO is the model proposed by the Asian Development Bank for the Philippines (see Figure 8.6).

Figure 8.6 - Illustration of a Super ESCO



In this model, the super ESCO will be established by the Program Administrator to provide technical and financial support to private sector ESCOs. The super ESCO will be funded by the Program Administrator by establishing a revolving fund using government or other funds. The financial support provided by the supoer ESCO may include loans for project development and project financing for energy efficiency performance contracting projects undertaken by the ESCOs. The availability of financing from the super ESCO will allow the individual ESCOs to finance and implement a large number of EE projects, and the payments received by the ESCOs from these projects will lead to repayments of the loans from the super ESCO.

8.5.4 Utility Financing

Utility financing is a mechanism under which the electric utility provides the funds for the implementation of the EE projects. These funds may come from the utility's own resources or from other sources such as special funds established by the government or levies established by the regulator. In some cases the funds may come from a commercial financial institution. The funds are provided as a loan to the customer for equipment purchase, and loan repayments are recovered by the utility through the customer's electric bill.

In most cases, the loan repayments are arranged such that the amount of the repayment is smaller than the customer's cost reduction from the energy savings created by the energy-efficient equipment. This allows the customer to be "cash flow positive" throughout the life of the EE project. Recent examples of utility financing of EE projects through the billing mechanism include the Bangalore Efficient Lighting Program (BELP) launched by the Bangalore Electricity Supply Company (BESCOM) in India, and the PROSOL program in Tunisia for financing and installation of solar water heaters (see DSM Financing Annex for additional information).

8.6 CASE STUDIES OF DSM/EE FINANCING

The DSM Financing Annex provides a number of case studies of financing programs in China and other Asian countries. The following case studies are included:

- The World Bank Energy Conservation Financing Programs in China
- International Finance Corporation (IFC) China Energy Efficiency Financing Program
- Asian Development Bank (ADB) China Energy Efficiency Multi-Project Financing Program
- ADB Guangdong Energy Efficiency Power Plant Project
- Thailand Energy Efficiency Revolving Fund
- Korea Energy Management Fund
- India - State Energy Conservation Fund in Kerala.

8.7 A “ROAD MAP” FOR DESIGNING DSM FINANCING MECHANISMS

8.7.1 Major Factors and Characteristics

This section has highlighted the fact that there are many different options and mechanisms for financing EE projects. *The key lesson learned from international experience is that the selection of the optimum financing approach and mechanism(s) will vary across different countries and also within a country from region to region.*

The applicability and benefits of financing mechanisms for a particular province in China will depend on a number of local factors and characteristics including:

- Characteristics of the energy users
- Portfolio of DSM programs and related implementation approaches and financial incentives
- Goals and objectives for energy savings
- Existing financing activity in the market by energy users, financial institutions and ESCOs
- Barriers to increased financing of EE projects
- Technical capacity within FIs and ESCOs for implementing innovative financing mechanisms

The following discussion identifies the key steps in the selection and implementation of financing mechanisms to promote and facilitate increased implementation of EE projects.

8.7.2 Key Steps

The following are the key steps:

1. ***Define DSM Portfolio*** - The Program Administrator develops the portfolio of DSM programs that may include a mix of audits, rebates, direct install, standard offer and DSM bidding approaches, along with the definition of the implementation strategies and financial incentives for each type of program.
2. ***Identify Targets by Market Sector/Segment*** - The Program Administrator also identifies the target market sector(s) and segments (for example, specific industrial sectors/segments such as steel, chemicals, paper, etc.). For each sector the Program Administrator also identifies the targets for the DSM program results including energy savings and other performance parameters.
3. ***Assess Current Financing Activities (Customers, ESCOs, FIs)*** - The next step is to identify the current status of financing activities supporting the implementation of the EE projects intended to meet the specified targets. This will include an assessment of the maturity of the market in terms of the roles of ESCOs and commercial financial institutions.
4. ***Identify Barriers*** - The results of Step 3 are used to identify the existing barriers to large scale financing of EE project implementation.
5. ***Assess Existing Mechanisms to Address Barriers*** - In this step an assessment is carried out to determine to what extent the program designs (from Step 1) will address some of the existing barriers and to what extent additional financing mechanisms may be needed.

6. ***Identify New Financing Mechanisms -*** The results of Step 5 lead to the identification of potential new financing mechanisms to promote and stimulate increased EE project implementation.
7. ***Assess how these will address the Barriers -*** Once the potential new mechanisms have been identified, this step involves an assessment of how these will address the barriers identified in Step 4.
8. ***Select New Mechanisms -*** Based on the results of the assessment in step 7, the best new financing mechanisms are selected for implementation.
9. ***Implement Financing Mechanisms -*** The selected mechanisms are then implemented in cooperation with the stakeholders (who may include government agencies, ESCOs, FIs and donor agencies).
10. ***Provide Information and Technical Assistance as Needed -*** The final step is to develop and implement an information and communication program combined with appropriate technical assistance to facilitate the stakeholders to effectively and efficiently implement the new mechanisms.