LBNL-1004318

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Guide to Promoting an Energy Efficient Public Sector (PePS)

Philip Coleman

Energy Technologies Area
June, 2015

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Acknowledgements

This document was prepared for the United States Agency for International Development (USAID) by ICF International under Cooperative Agreement No. 00176-LA-11-00003, Leader with Associate Cooperative Agreement AID-OAA-L-11-0000.
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Dedication

To Jeff & Laura, for not giving up on me (or at least not letting on), when they had every reason to.

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INTRODUCTION

The PePS Guide reflects the collaborative work of staff from the Lawrence Berkeley National Laboratory, Alliance to Save Energy, and Comision Nacional para el Ahorro do Energia (CONAE). Begun in 2003 with funding from the United States Agency for International Development (USAID), activity under the PePS initiative compiled an inventory of existing policies, programs, and administrative practices across countries to improve energy efficiency within the government sector. This work was updated in 2014-2015 by LBNL and the guide was finalized with additional support from USAID, under the Energy Efficiency for Clean Development Program (EECDP).

The driving force behind PePS is the opportunity for governments to lead by example. While the degree to which government actions impact their respective energy efficiency markets varies, the opportunity to directly reduce operational budgets through reduced energy bills and decrease greenhouse gas (GHG) emissions is almost universal. In addition, regardless of their stage of development, the majority of countries have the potential to significantly scale up energy efficiency through government projects that create broad public exposure to efficiency technology and benefits. Through project specifications, the construction sector is also provided an opportunity to understand and use new materials and practices. When governments pair direct action on energy efficiency in their own facilities with national policies and regulation on energy efficiency, the market can effectively be opened up to new private sector investment and increased uptake of products and services that decrease energy demand.

This guide provides a detailed look at strategies and success stories for government action on energy efficiency. Existing buildings and new construction, purchasing policies, public infrastructure, and public transportation all provide opportunities for governments to make progress on efficiency. Details and examples of how these programs can be designed and implemented are provided along with guidance on project financing. National and local governments, and those that support them, can use this guide to assess the best opportunities for energy efficiency programs and start small, or big, to begin to shift their markets towards becoming cleaner, more efficient, and sustainable.

Organization of this Guide

This guide is intended as a reference source for public officials, program managers, procurement or other administrative personnel, facility managers, architects and engineers, energy efficiency specialists, and other operating personnel at all levels of government and other public sector entities (such as schools, hospitals, and universities). However, the guide's focus is primarily on programmatic approaches to public sector energy conservation. Consequently, readers will not find technical specifics on energy-efficient building retrofits, new construction techniques, etc. In general, the guide aims to inform programs (e.g., an initiative to promote energy-saving new construction in a national government), not individual projects (e.g., an effort to reduce energy use in one new building).

Many users of the guide may want to focus on specific topics, so the contents of each chapter are summarized below.

Chapters 1 and 2 discuss the rationale and benefits of public sector energy conservation, along with program start-up advice for those considering the creation of a new program or expansion of an existing one. The next six chapters each address a key program area for public sector energy management:

- Chapter 3: Energy management in existing buildings, including performance assessment tools such as benchmarking and energy audits, building operation and maintenance, and occupant behavior.
- Chapter 4: Project financing, ranging from appropriated funds to third-party financing and performance contracting with ESCOs.
- Chapter 5: New construction, including energy-efficient building and the broader area of "green" construction.
- Chapter 6: Energy efficient purchasing policies, a valuable and sometimes overlooked initiative in any public sector program.
- Chapter 7: Public infrastructure systems, namely street lighting, water supply, and district heating.
- Chapter 8: The important topic of public transport, including bus rapid transit, light rail systems, and management of government vehicle fleets.

The final two chapters of the guide examine two activities that cut across all the other program elements. One is the valuable role of outreach, training, and recognition—the "people elements" that are essential to long-term program success (Chapter 9). Chapter 10 addresses the need for careful program evaluation to provide feedback and a basis for continuous improvement.

CHAPTER 1—PUBLIC SECTOR LEADERSHIP

The job of government is leadership. While this truism is apparent in many government activities, public sector facilities do not often present the most shining example of optimum design and operation practices. This guide aims to outline the important role of governments and other public sector entities in the management of their own facilities—from office buildings to schools to public transit systems—to lead their citizenry in the sensible and efficient use of energy. Since energy consumption is at the root of so much of the world's environmental and fiscal troubles, efforts to use it wisely become acts of responsibility in which governments have a special role. When our leaders exercise responsibility, society—private and public alike—is more likely to follow.

1.1. Why the Public Sector?

There are many reasons to promote energy conservation within public sector buildings and operations:

- Energy cost savings allow governments and other public sector entities to devote more of the budget to their primary missions.
- Lower energy demand can ease dependence on imported oil and gas.
- Reduced demand at peak times can improve electricity system reliability and require less capacity and infrastructure, freeing up scarce public and private capital for the many other non-energy infrastructure investments needed for economic growth.
- Saving energy in the public sector helps reduce harmful air and water pollution, and greenhouse gas emissions—generally at a *negative* cost per ton of avoided pollutant or CO_2.[1]

In addition to these direct benefits, public sector actions can lead the rest of the market, both by setting an example for other buyers and by harnessing public sector buying power to create or expand the domestic market for energy-saving products and services. Any one of these benefits by itself could justify a strong program for public sector energy conservation. Taken together, they can appeal to a wide variety of stakeholders under many different circumstances, as we discuss in more detail below.

Good Government

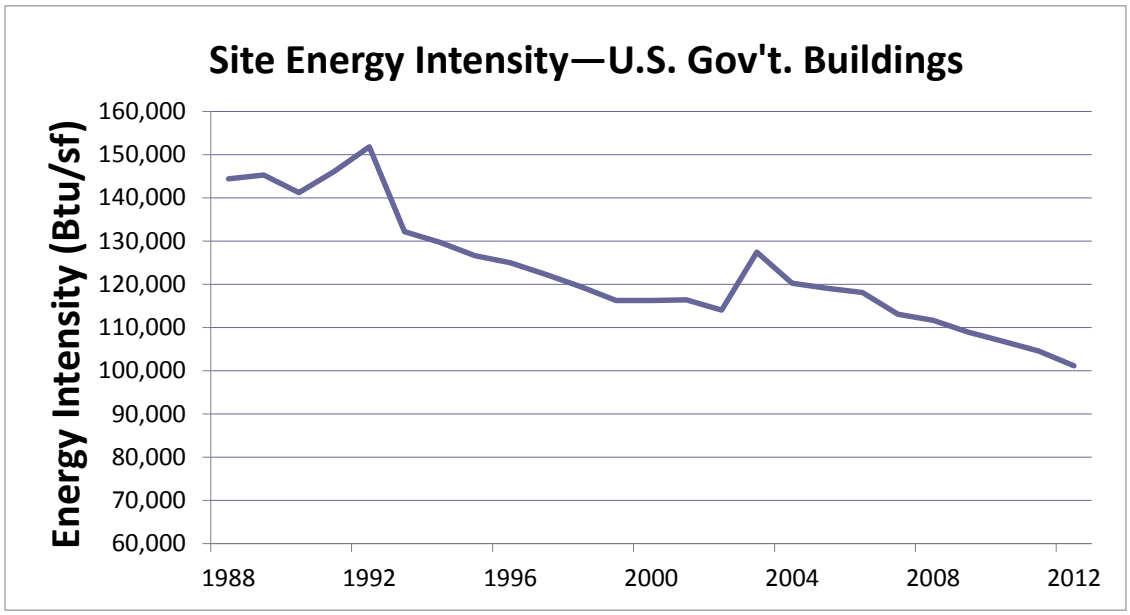
For many policy makers, there is one simple compelling reason to pursue energy conservation: saving energy saves money. Money is often in short supply in the public sector, and savings in energy costs can be used to support mission-critical programs, improve infrastructure, or reduce government debt. Improving energy efficiency offers a good return on investment and makes good business sense. It can be a cornerstone for broader government sector reforms and performance-based management.

One of the oldest and largest national programs for government sector energy management is the Federal Energy Management Program (FEMP), part of the U.S. Department of Energy (DOE). FEMP has helped federal agencies achieve and document impressive reductions in government building energy use for more than two decades. From

[1] By definition, energy-saving measures that are cost-effective will more than pay for themselves through energy cost savings alone, so the added benefit of reduced air pollution or greenhouse gases comes at zero or negative cost.

1988 through 2012, the site energy intensity (consumption divided by floor area) in U.S. federal buildings decreased by 30 percent (see Figure 1.1) (FEMP 2013).[2]

Figure 1.1. Trends in Energy Intensity of U.S. Federal Government Buildings



Mexico's experience has also been encouraging. Its Administración Pública Federal (APF) program, led by the national energy efficiency agency CONUEE (Comision Nacional para el Uso Eficiente de la Energía), was created to focus on energy-saving lighting measures in government facilities. From the start of the program in 1998 through the end of 2005, APF conducted energy audits (many using an online software tool) on more than 2,000 Mexican government buildings with floor space greater than 1,000 square meters. Results from facilities where energy-saving retrofits were performed showed a 30 percent reduction in electricity use (from 115 to 80 kWh/year per square meter, on average). This translates to an estimated electricity savings of roughly 200 GWh/year and annual energy cost savings of over US $30 million (electricity is very expensive for Mexican public sector facilities). CONUEE reports that the average payback time for energy-saving measures in these buildings was less than two years (CONUEE 2006). The initiative has evolved over the years and now includes vehicle fleets and government-owned industrial facilities (CONUEE 2014).

[2] We suggest one note of caution in interpreting these energy savings figures for U.S. federal buildings. A study by the Alliance to Save Energy (ASE 1998) found that substantial reductions in fuel use for space heat and hot water were to some extent offset by increased federal electricity use, especially for air conditioning and "plug loads" such as computers and office equipment. The increasing proportion of electricity use to total energy consumption in federal buildings, combined with a 1991 executive order that required federal energy use to be measured in terms of site (delivered) energy rather than source (primary) energy, has in some eyes distorted the claimed federal savings. Source energy, which accounts for losses in electricity generation and transmission, is often a better indicator of energy cost than site energy. According to FEMP, the source energy intensity of federal buildings declined only 15.3% from 1988 to 2012, versus the 30% for site energy intensity (FEMP 2013). However, this is still a noteworthy result compared to non-federal U.S. commercial buildings, where the average energy intensity was relatively constant during this same period, whether measured in site or source energy.

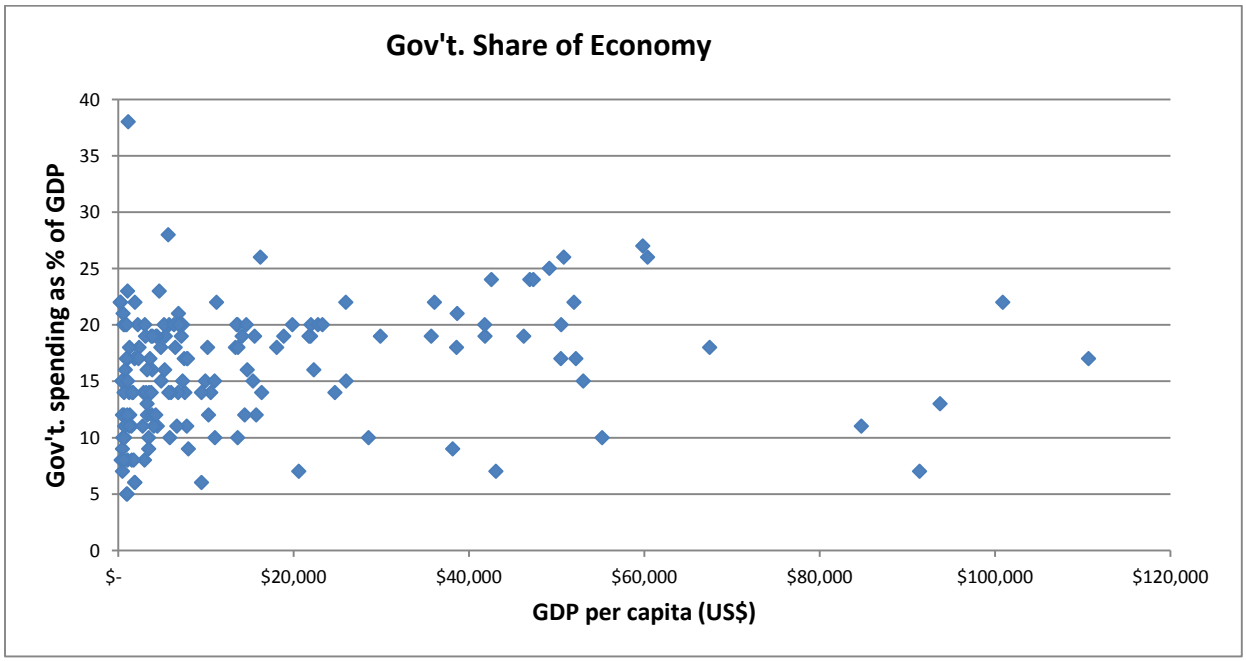
The Canadian government story is also impressive. Since 1991, Canada's Federal Buildings Initiative (FBI) has devoted most of its efforts to energy-saving retrofits of government buildings, implemented and financed through energy service companies (ESCOs). This resulted in over 80 projects (most including numerous buildings) through 2013, with annual energy savings of roughly 15–20% per building and cost savings of roughly US $40 million/year (NRCAN 2014). Since savings must pay for repayments to the ESCOs, all these projects are conducted without up-front costs to the government. They will continue to generate substantial net savings once the ESCO contract term is over and the federal agencies can keep the full benefit of lower energy bills. (ESCOs and other financing strategies are discussed further in Chapter 4.)

The considerable monetary savings in all of these countries—especially in relation to the modest expenditures required—show that public sector energy conservation is a highly profitable investment for governments, even before considering the added value of avoided pollution, reduced greenhouse gas emissions, and other hard-to-quantify benefits. Thus, public sector energy conservation is part of a "no regrets" policy for climate change mitigation, environmental improvement, and economic development.

Economic Significance of the Public Sector

The government sector plays a significant role in the total economy of every country. Over a broad range of per-capita income, from wealthy industrialized countries to emerging economies, the government sector accounts for an average of 18 percent of gross domestic product (GDP), according to data from the World Bank (see Figure 1.2). Other indicators of the relative importance of the government sector include the percentage of total building floor space attributed to public buildings, and the percentage of total employment.

Figure 1.2. Government's Proportion of National Economic Activity



Source: World Bank 2013

Despite the lack of a comparable set of international data on the share of total energy use attributed to the government sector, available data on these indicators tend to track fairly well to the government's share of GDP. One study estimated that government facilities in the European Union account for about 10 percent of total heat and electricity use (on average, excluding vehicle fleets and transit). The public sector share of energy use is as high as 20 percent in Eastern European countries due to their economic structure and the use of district heat, and up to 30 percent in Sweden because of a large public housing stock (Borg et al. 2003).

In the United States, government buildings account for about 21 percent of floor space and 25 percent of energy use. Interestingly, the majority of government spending, floor space, employment, and energy use are at the state and municipal levels—over 75 percent. Still, total government spending (federal, state, and local) accounts for about 16 percent of GDP (World Bank 2013), and the U.S. federal government by itself is estimated to be the world's largest buyer of most energy-related products and services (Harris and Johnson 2000). Clearly, government purchasing policies on energy efficiency are an important force in the market—not only in the United States, but worldwide.

Leadership by Example

While these indicators (share of GDP, employment, or building floor space) show that the government sector is a significant force in the economy, they understate the full potential for the public sector to influence the broader market through its energy efficiency policies and practices. Manufacturers, product suppliers, and energy services providers all pay close attention to government requirements, as public agencies represent 10–20 percent of the total market for energy-related products and services. However, in order to send a clear signal to the market, it is essential that government policies, purchasing and construction specifications, and other contracting requirements use clear, consistent, and widely publicized energy conservation criteria.

By demanding energy-efficient products for their own use, government agencies are most likely to prompt manufacturers and suppliers to respond by offering more efficient products at competitive prices. This occurred in the U.S. in 1993 when President Clinton signed Executive Order 12845, requiring the federal government to purchase exclusively ENERGY STAR® computers and monitors (i.e., ones with the ability to automatically switch into a low-power "sleep" mode after a set time). At the time, this was a new feature and program. Because of the magnitude (and resulting influence) of federal procurement, by 2000 the overall market share of ENERGY STAR computers and monitors was estimated to be 80 percent and 95 percent, respectively (Brown 2000). In addition, government provides powerful motivation for others to follow its lead when it is among the first to take energy-saving actions, and then shares its experience, publicizing its practices, specifications, and results with private enterprises and consumers.

Links with Non-Energy Policy Objectives

Along with the compelling reasons already discussed, improving energy efficiency in government facilities and operations can have positive side benefits that may support additional public policy goals.

Economic Development/Stimulating Domestic Industries

A goal of many government leaders is to encourage economic growth and new enterprises in their country, state, or city, including the promotion of existing businesses and more and better jobs. Energy-saving products and services are especially valuable in this regard because, in general, a larger share of their economic benefits—salaries paid and customer cost savings generated—are re-spent locally to benefit the domestic economy, rather than being

invested in capital-intensive energy supply systems or paid to foreign suppliers of oil and gas. By replacing the cost of supplying and consuming energy, especially imported oil and gas, with cost-effective investments to save energy, these energy efficiency enterprises can strengthen local economies, encourage domestic investment, and help improve the balance of trade.

Government and Market Reform

A trend common to the world's developing and transitional economies is the move toward more competitive, less regulated markets. This is certainly the case in energy markets, where the withdrawal of subsidies for fuels and electricity is often a key policy goal. The difficulty in many countries is that cheap gasoline, electricity, natural gas, and other fuels have been the norm for decades. This can make it difficult for households and small businesses to make the transition to market-based prices, especially when market reforms occur quickly and where many households are already struggling to pay for electricity, fuel, and other necessities.

Increasing the availability and affordability of energy-saving products and services helps reduce the hardship created by energy price increases in the transition to a market economy. For example, a 50 percent increase in the price of fuel or electricity is completely offset by a 33 percent improvement in energy efficiency (e.g., when an input unit price goes from $2 to $3, saving one-third brings the cost for the same degree of output back down to $2). In contrast, subsidizing fuel costs to consumers may ease their immediate burden but it also encourages wasteful consumption and returns nothing to the economy. Redirecting the same government resources to incentives for investing in cost-effective energy conservation measures will produce far more economic benefit in the long run, to individual consumers, enterprises, and the economy as a whole.

Reducing Pollution and Greenhouse Gases

Energy use generates emissions of greenhouse gases and other air pollutants. Efficiency improvements that reduce energy use by government agencies will in turn lower emissions from power generation and direct fuel use, with associated health and climate benefits.

Air Pollution

Energy use in public sector buildings, utilities, and vehicle fleets produces air pollutants that harm human health and the environment. Two major types of air pollution are:

- Particulate matter: Soot, smoke, and other tiny particles released from power plants and motor vehicles (particularly those less than 2.5 microns (10^{-6} meters) in diameter) can cause acute and chronic respiratory diseases, especially among older people and children.
- Ozone and smog: Exhaust gases from internal combustion engines and power plants contain volatile organic compounds, sulfur dioxide, carbon monoxide, nitrogen oxides, and hydrocarbons. These pollutants react chemically in the lower atmosphere to form ozone and then smog, both of which cause respiratory and other health problems, as well as harming animals, crops, and building materials.

To protect human health and the environment, reducing air pollution (especially in urban areas) is an important policy goal of most countries. Decreasing public sector energy usage can be a significant step toward meeting this goal.

Greenhouse gases

The use of fossil fuels, either in power plants or directly in government buildings and other facilities, generates carbon dioxide (CO_2) and other greenhouse gases that trap heat in the Earth's atmosphere. Increasing atmospheric concentrations of these greenhouse gases are contributing to rising air and ocean temperatures, which in turn are leading to significant impacts on the global environment and ecology. Along with climate warming, increases in sea level (due to ice cap melting and thermal expansion) are threatening coastal ecosystems and human settlements. Changes in rainfall patterns may result in more frequent and severe droughts and floods. Increased frequency of extreme weather and infectious diseases due to climate change also pose threats to human safety and health.

Energy consumption accounts for about 32 percent of all human-related GHG emissions and could grow to 35–42 percent of emissions by 2030, according to the Intergovernmental Panel on Climate Change (IPCC 2007). Increasing the energy efficiency of public sector buildings and equipment, public works activities, and public transportation services can significantly reduce public sector greenhouse gas emissions and contribute to a country's overall goals for emissions reduction.

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CHAPTER 2—PROGRAM PLANNING

Key Considerations in the Development of Public Sector Energy Conservation Programs

Background Research and Assessment of Current Practice

1. Assess the current status in the public sector facilities of such factors as 1) current energy use and activities, 2) utility-generated expenses per type (e.g., electricity, natural gas), and
   3) the knowledge level and motivation of maintenance, purchasing, or other relevant staff at the building and/or agency level.
2. Make a strategic evaluation of other synergistic activities or current concerns in the government. Examples include a strong policy push for energy independence, or a plan to revamp public lighting in order to enhance aesthetics or safety.
3. Determine incentives and disincentives to conserve. Specifically, identify who benefits from any cost savings. Familiarize yourself with the traditional paths of energy budgets, both spent and saved, as well as the potential to modify these paths so that those who invest in conservation see the return on their investment.

Early Steps in Program Development

1. Seek and foster ideas on the initiative across all levels, including high-level officials as well as staff working in and maintaining public sector buildings.
2. Establish benchmarks and goals. These should include savings goals (e.g., reduce usage per square meter of floor space by 10 percent within five years), and should also address more proximate aims, such as installation of meters and performance of building audits.
3. Create the plan. This needs to identify which specific initiative(s) will be pursued, the mechanisms for implementing them (e.g., information dissemination, direct technical assistance, performance contracting, etc.), and the people responsible for execution. In developing the plan, keep in mind that the program will likely attract considerable attention and scrutiny initially, so it may be best to begin with fewer initiatives (possibly even just one, depending on resources) and concentrate more effort on making these successful.
4. "Sell" the program, both to its employees and the prospective "customers" (everyone from agency heads to maintenance personnel).
5. Use private sector participation (PSP) as one way to leverage limited energy management resources, but make sure that contracts are structured to provide incentives for efficiency. PSP includes energy performance contracts, leases, and even large-scale infrastructure operational contracts (e.g., for running a municipal water utility).
6. Leverage investment by one public sector or donor agency—particularly if it leads to early success—to galvanize funding from other public sector entities, leading to buy-in from a broader range of participants and a more robust program.
7. Include program evaluation in your program design. To make the eventual evaluations easier and more fruitful, decide ahead of time how the initiative will be measured.

8. Seek and promote a written policy directing support for a public sector energy conservation program. This kind of support, which includes executive orders, administrative guidance, high-level regulation, or, optimally, law, can provide significant benefits. Key elements in most successful policies are savings goals and clear identification of responsibilities.

This chapter aims to lead policy makers and program managers through the key steps of beginning an energy conservation initiative. While the specifics of a plan are not detailed—these will vary from entity to entity—the program development process described here seeks to take advantage of the successes and avoid the failures of past efforts.

2.1. Identify and Assess Current Practice and Prospects

The first step of a public sector energy conservation program should be to identify specific facilities and operations under the management of the organization or agency initiating the program. A university, for example, may run operations for all buildings within a campus, or alternatively, the control of specific buildings may be the responsibility of respective divisions or schools within the university. City governments may control operations for a wide range of building types, including libraries, kindergartens, and low-income housing, but this will vary across both cities and countries. Identifying the portfolio of relevant facilities and then assessing current energy practices will provide insight on whether energy-saving practices are already occurring at some level—such as shutting off lights and setting back thermostats on nights and weekends, using compact fluorescent lamps (CFLs) or light-emitting diodes (LEDs) instead of incandescent bulbs, and restricting idling time in government vehicles. Find out if there are any directives or precedents for constructing energy-efficient or green new buildings, or any metering practices in place that capture energy use information more frequently than the monthly bill and at a more detailed level than the basic building or building complex (the level at which most utility bills are tallied). Are there energy conservation champions, either at a policy level (such as an environmental affairs office) or at least at some of the facilities?

Profile Energy Use and Identify Best Opportunities

To begin understanding the nature of energy use and where opportunities exist to save it, start by researching the following key questions:

- Where is energy being used?
- Which utilities and fuels are generating the most expense?
- Which end uses (e.g., heating, cooling, lighting, plug load) are generating the most expense?
- Who pays the utility and fuel bills and who benefits when there are energy cost savings?
- Do key management personnel have access to energy cost information that could influence their decisions regarding equipment operations, maintenance, and replacement?
- Is maintenance staff knowledgeable about, and motivated toward, energy conservation?
- Do the serving utilities have conservation incentive programs that can be utilized?
- Are any of the engineering consulting companies that work with the facilities knowledgeable and experienced in energy conservation?

Some of these questions will be difficult to answer fully, especially where the building portfolio is large. The most important thing is to try to develop a broad understanding of energy use and the factors that influence it—even if only informally. Along with understanding the challenges, it is also important to be aware of strengths and assets, such as knowledgeable maintenance staff, government policies that permit savings to be retained within the agency, or generous utility demand-side management incentive programs. These can form the cornerstone of future program initiatives.

Establish Baselines

Once a specific portfolio of buildings has been identified for the program, the first formal pursuit in the background assessment should be to collect energy consumption data for all relevant facilities and major infrastructure systems (e.g., transit or water supply)—at least one year's worth but preferably more (this is covered in more detail in Chapter 3). Collect data for all utilities and fuels; data will generally be available at the level of utility billing meters for each building, complex, or system. By collecting these data, you can establish the baseline consumption for each facility and system.

The second step in the background assessment is to standardize these data for the size or number of users of the facilities; e.g., to divide consumption by floor space area. In the case of industrial facilities, consumption per unit produced (e.g., electricity per volume of mail processed or water delivered) is more meaningful. This will provide a rough ability to compare usage among different facilities, not only individually but also aggregated per agency or department (which may be relevant if savings goals are set at this level of government). There are a number of factors that influence energy consumption such that two buildings of the same size may justifiably use different amounts of energy. These include hours of operation, plug loads, and the presence of data centers. If an energy benchmarking program is available, such as ENERGY STAR in the U.S., this can provide a more comprehensive approach to comparing energy use among buildings and may also factor in energy costs.

Energy cost data are critical because consumption and costs are not always related in a linear fashion. Electricity costs, in particular, often depend on complex rate structures that may make marginal units of consumption more or less expensive than average ones. For purposes of comparison, energy costs should be standardized (by building area, number of patients, passenger-kilometer traveled, etc.). This standardization (of both consumption and costs) will permit benchmarking of facilities, a valuable prioritization tool discussed in further detail in Chapter 3.

There are a few additional reasons to emphasize costs as opposed to just consumption. First, this focus places the incentive for reduction not on energy but on money, which is more likely to generate attention from decision makers. Second, energy costs provide a good proxy for different fuels' inherent quality—since higher quality (lower entropy) energy sources such as electricity generally cost more per unit (e.g., kWh, joule, or Btu) than lower quality ones, like fuel oil (see Box 2-1), assuming that government subsidies have not distorted these relationships. Energy costs also provide a good proxy for scarcity—essentially, the level of difficulty of obtaining various fuels (e.g., if oil needs to be imported to an island nation, its price will reflect this added cost). However, fuel price changes can potentially obscure successful conservation efforts, and in some countries the institution and withdrawal of subsidies may provide a distorted impression. These factors make it worthwhile to track both energy consumption *and* cost.

Pursue Strategic Opportunities

Regardless of the presence or absence of direct financial incentives to conserve, agencies, departments, and even whole governments and other public sector entities may be additionally motivated to take action by "non-energy benefits" of reducing energy use. For instance, an air pollution reduction goal may drive, or at least augment, a conservation initiative, as could a local or national effort to control energy demand in the face of economic development and expected growth (a common motivation for programs in many developing countries). Along with providing motivation, these types of stimuli could represent an important opportunity to ally with other actors in the government.

Government initiatives to upgrade obsolete or failing infrastructure also provide a convenient opening for upgrading efficiency. For example, the consideration of new public lighting for reasons of aesthetics or safety can create a window for promoting energy conservation. Such options could produce savings to use in covering any additional equipment cost, and may be significant enough to additionally reduce the overall original cost of the project over the long term.

Another type of initiative that can benefit from an energy conservation program is one aimed at promoting "energy independence" (i.e., decreased importation of energy). Such initiatives are driven by high costs of imported energy or insecurities regarding future dependability of sources.

These additional "non-energy benefits," even if they do not directly leverage conservation efforts in terms of jointly funded projects or promotional campaigns, may help persuade policy makers and those with budget authority to fund energy programs more fully.

Box 2-1. Site Versus Source Energy

When assessing energy consumption, whether at the level of a single facility or an entire public sector entity such as a university or government, it is often desirable to convert the data for separate utilities into a common unit, such as joules (J), kilowatt-hours (kWh), tons of oil-equivalent (TOE), or British thermal units (Btu). The problem with this method is that it does not account for the different "entropies" (essentially, the degree of inability of a unit of energy to perform useful work) nor the varying rates of loss in conversion, generation, and transmission involved in different energy sources. For instance, electricity is a low-entropy (high quality) form of energy that often requires as much as three or four units of fossil energy (coal, oil, or natural gas) to generate one unit.

Consequently, some policy makers believe it is most accurate to present energy consumption figures in their "source" equivalents—that is, to make conversions, especially for electricity, to truly represent how much energy is consumed in total when one unit is utilized by an end use such as lighting or cooling. This can be done most simply by fixing on a universal multiplier, such as three or four for electricity (to represent the three or four units of fossil energy that, on average, are burned to generate a single unit of electrical energy). Alternatively, one can research—on a facility-by-facility or region-by-region basis—the conversion rates and transmission losses for end-use electricity (as well as other energy sources, though electricity is usually the only end-use energy that commands this attention, since its conversion losses are so high).

Explore Incentives and Disincentives to Conserve

One of the most critical questions to answer in your background research is whether the parties that use energy are also responsible for paying for that consumption. In other words, are energy bills assigned according to use?

The separation of the consumer and bill payer (often referred to as the "principal-agent" or "split incentive" problem) is a classic barrier in end-use energy economics. A common example is tenants who keep their homes cold when they are paying for the heat themselves and much warmer when the utility charges are included in the rent. Split incentives also can create significant barriers to energy conservation in public agencies (see Box 2-2).

Box 2-2. Lack of Incentives in Thailand

In Thailand in the late 1990s and early 2000s, a tax on sales of petroleum provided funding for a government program that offered fully subsidized audits and energy efficiency retrofitting of federal agency buildings. This is a level of support that would make federal energy managers in most other countries envious. However, even after this generous policy had been in effect for several years, very few government facilities were taking advantage of it. Some explained the slow uptake as a result of inadequate promotion; others suggested that it was because agency officials were unclear about how to meet the administrative requirements of the program. One Thai government official, however, identified the heart of the problem: "Most government agencies don't pay attention because they don't have to pay for electricity or gas. Why would they care?" (Sinsukprasert 2003)

One of the most productive energy policies a public sector entity can institute is one that requires a given facility's energy charges to be paid by the entity using that facility—as opposed to the budget of its umbrella division or agency, or even the larger central government. Once such a policy is in place, high energy costs that cut into the capability of an entity to execute its mission are much more likely to draw attention and spur conservation efforts.

However, even when a facility, agency, or department is charged with paying its own energy bills, there can still be principal-agent conflicts. For instance, it is often the case that the person in charge of paying the bills is far removed—both vocationally and spatially (e.g., in a different building or on a different floor)—from the people in charge of energy and facilities for the same division. In such cases, it is necessary to connect the people who have these separate responsibilities. This can be as simple as sending a copy of the monthly utility consumption figures to the people who manage the facilities (and possibly the purchasing)—and then making it clear that energy use is one measure by which their job performance will be evaluated (a perhaps less simple undertaking). A more involved scheme, such as allocating the utility costs (and budgets) to relevant departments might be still more effective, but also administratively difficult and potentially unfair (e.g., does the facilities group get punished for extreme weather or increased staffing that drives up utility bills?).

The key point is that energy use and energy cost will likely only become real concerns for the people responsible for them when those same people reap some of the rewards for reducing them—and perhaps face penalties when they rise.

Assess Political Support

Public sector energy efficiency programs often have a low profile. Perhaps because energy conservation is directed at saving something that is invisible and not central to the mission of most government agencies (except energy and environmental ministries) and other public sector entities, it often tends to garner even less attention than other intra-institutional initiatives. The best way to overcome this lack of visibility and draw people's notice is to have the message come from the highest levels of government—especially in the form of a legislative, regulatory, or executive mandate. Many of the most successful national energy efficiency programs (e.g., FEMP in the United States, see Box 2-3) have benefited from this type of high-level support.

Box 2-3. High-Level Support for FEMP in the United States

In the United States, the mission of the Federal Energy Management Program (FEMP) has been supported by several executive orders, as well as by the Energy Policy Act (EPACT) of 1992, EPACT 2005, and the Energy Independence and Security Act (EISA) of 2007. EPACT 1992, and before it the 1978 National Energy Conservation Policy Act (NECPA), provided the basic authority for U.S. federal energy management activities. Starting with President Carter's 1977 Executive Order (E.O.) 12003, the White House has set progressively more stringent savings goals for federal agencies. The most recent goal-setting, in E.O. 13423 (2007) and EISA, established a target of 30 percent energy use savings (per unit floor area) by 2015 based on each agency's 2003 baseline. The cluster of U.S. laws and executive orders have also instituted a streamlined performance contracting process, an efficient products purchasing program, goals for agency purchase and use of renewable energy, the requirement for an energy "czar" at each agency, water conservation goals, and other conservation programs.

Another indicator of the power of energy management legislation and executive orders in the U.S. is that FEMP regularly gets twenty or more agency attendees at its ad hoc "working groups," which meet two to three times per year to cover topics such as renewable energy, performance contracting, efficient products, and operations and maintenance. Finally, thousands of federal employees participate in FEMP's various on-demand and in-person energy management training classes.

For example, Mexico's Administración Pública Federal (APF) program began as a result of a 1999 decision by the country's energy minister to require all federal buildings of over 5,000 square meters to perform energy audits and implement cost-effective retrofits with the assistance of the national energy conservation agency, CONAE (Comision Nacional para el Ahorro de Energía, the predecessor to the current agency, CONUEE). The mandate was later expanded to include buildings as small as 1,000 square meters. By the end of 2005, nearly 2,300 buildings, or roughly 6.6 million square meters of floor space, had complied.

This high-level support has had an enormous positive impact on Mexican federal agencies' participation in energy management. Before Mexico's APF program became a requirement, CONAE implemented a predecessor program, called "100 Public Buildings." Despite initial difficulty finding even 100 buildings willing to sign up, in the end, the great success of this pilot program was its success in getting the directive for APF from the energy minister.

Because of the importance of high-level political support, it is valuable to formally assess the degree of support for an initiative early on and periodically thereafter. If that support exists, much of the effort to promote the program can be directed laterally (e.g., among other agencies). If support does not exist, a more vertical (upward) effort may be required, to try to increase political support at higher levels.

In addition to political backing, support from other sectors can also be highly beneficial to the success of a program. For example, two of FEMP's initiatives—its performance contracting program and its efficient product purchasing initiative—are greatly enhanced by the support of private sector companies whose products or services promote conservation and have benefited from the programs. These groups can act as advocates for the initiatives (e.g., by lobbying Congress for legislative requirements or program funding) in a way that FEMP cannot (since it is a government entity itself). Most programs will have product and service providers associated with them, and these companies can often help apply pressure for policy changes, funding, and even agency compliance with conservation directives.

2.2. Establish Goals

After assessing the government's current energy use, policies, and practices, setting goals is the next step in the design of a successful savings program. These goals may relate directly to energy consumption (e.g., reduce electricity use by 10 percent per unit area) or they may relate to important savings precursors (e.g., perform audits of all buildings larger than 5,000 square meters) or proxies (e.g., establish turn-off and set-back schedules for all facility heating and cooling systems). The goals should always be specific in both their intended outcome and the timeline for achievement.

There are several compelling examples of the value of goal-setting among successful national government programs. In Mexico, as noted above, CONAE began its APF program in 1999 with a concrete goal of auditing and retrofitting all federal buildings with a floor space greater than 5,000 square meters. Six years later, with the support of an executive mandate, almost all federal buildings of this size had been audited and a majority of the floor space had been retrofitted.

The U.S. experience also provides a testament to the motivational value of establishing goals. Percentage savings goals have been at the heart of U.S. federal energy management, beginning with President Carter's 1977 Executive Order 12003, which set a 20 percent energy intensity reduction target for 1985, and continuing through multiple executive orders and the Energy Independence and Security Act (EISA) of 2007. Though Carter's initial goal was not met, the less ambitious goals of subsequent policy seemed to catch the attention of the agencies. These agencies met both a 10 percent goal by 1995 and the 20 percent mark by 2000 (relative to a 1985 baseline) with at least a year to spare. The 30 percent reduction goal of Executive Orders 12902 and 13123 was almost met, with the estimated reduction coming in at 29.6 percent. Awareness of the missed goal and of the EISA goals (3 percent reduction per year from a 2003 baseline) is high among the energy managers of federal agencies, and all seem to be striving to meet these goals. The general success of the executive orders underscores the value of goals that are simple and clear, and that can be easily measured.

While reasonable goals can provide motivation, overly ambitious goals set at the onset of a new program may be counter-productive. For instance, as mentioned above, the U.S. government energy savings fell far short of early targets set by the Carter Administration. A similar outcome occurred with the 10 percent savings goal (relative to 1993 consumption) established by the Philippines in 1997. However, in both cases, these failures stimulated corrective action. The U.S. began to establish a performance contracting program for federal buildings. The Philippines developed a series of recommended operation and maintenance measures and limited product purchasing guidelines and also started to emphasize the role of energy service companies (ESCOs) to assist its agencies. In the U.S., the early shortfalls and subsequent modification of the effort resulted in a much stronger initiative (including an expansion of FEMP).

Overall, experience with national energy-saving programs demonstrates clearly that setting goals has value. The goals seem most effective when they use specific baselines (e.g., those of 1985 and 2003 in the U.S. initiatives), set timelines for achieving the targeted savings, and provide specific qualifications (e.g., Mexico's initial inclusion of all buildings of 5,000 square meters and higher in its APF initiative). Percentage reduction goals appear to be valuable, but may be more successful when complemented with other goals that address the means for achieving these reductions—such as building audit and retrofit targets. In EPACT 1992, for example, the U.S. specified that its agencies should audit 10 percent of their buildings each year and implement all measures identified with a payback of 10 years or less. The substantial reduction goals (in this case, 20 percent energy savings by 2000 compared to 1985) were set through legislation that also provided energy managers with guidance on *how* to reach the milestones.

2.3. Create the Plan

The next step is to establish a broad initiative-level plan. Given sufficient background research (see Section 2.1, "Identify and Assess Current Practice and Prospects"), this step should be surprisingly easy. The key considerations are 1) the savings prospects identified (i.e., where are the greatest opportunities), 2) the goals set (sometimes this is done in conjunction with the development of the plan), and 3) the resources available. The plan should address:

- Which types of programs will be pursued (the main candidates, ranging from building retrofits to vehicle fleets, are considered in the next six chapters).
- What specific mechanisms will be used to implement each program (e.g., performance contracting for building retrofits or information development and technical assistance for new construction).
- Who the key actors will be, ranging from dedicated staff to in-house facility managers to private sector partners.

When creating the plan, keep in mind that the greatest scrutiny of the program will likely occur in its earliest years. Consequently, rather than spreading staff and money over numerous efforts, it may be better to concentrate them in just one or two initiatives at first. The success of these early initiatives can then pave the way for greater receptiveness from the program's target audience, along with increased budgets from funders. CONAE, for example, focused virtually all its early federal efforts on its voluntary "100 Public Buildings" program. Due to the successes and lessons learned from this inaugural effort, "100 Public Buildings" evolved into the mandatory, and much more comprehensive, APF program, which is still active almost two decades later.

There is no specific blueprint for creating the plan. The important things to keep in mind are that both a vision and an implementation path need to be mapped out, at least broadly, and preferably with enough detail to allow others to understand and help execute them.

2.4. Allocate Resources and Assign Responsibilities

The next step in designing an energy saving program is to designate people for various duties and to allocate the funding. The optimal strategy for such resource allocation will vary considerably among different governments and circumstances. This section suggests some guidelines, all of which should be considered in light of the types of programs being implemented (discussed in Chapters 3 through 9).

While energy management is an engineering discipline, it is also fundamentally about people: not only keeping them healthy, comfortable, and productive, but also involving them in successfully implementing any proposed changes.

Most energy conservation initiatives achieve their best success when occupants are aware of, and to some extent participate in, their planning and execution. Consequently, staff involved in the design and implementation of any program should include both those with engineering knowledge and those with marketing and promotional skills. For example, most FEMP employees—including almost all of the leadership—have traditionally not had technical backgrounds. FEMP maintains a staff of program managers who know how to plan and present their initiatives and who rely on the technical expertise of consultants and the Department of Energy national laboratories. In a similarly successful approach in Mexico, CONUEE has relied over the years on as many non-energy experts as technical personnel to run its successful federal programs.

In summary, in addition to developing a strong technical rationale, the marketing and promotion of a program—during its design and planning stages, through implementation and follow-up—is also critical to its success. This must be considered in determining roles and responsibilities. In some cases, the technical and promotional skills may reside in the same individual; in others, it will be necessary to assign different people with different skill sets to various jobs within the program.

2.5. Explore Leveraging Opportunities

In most countries, public sector energy management is chronically underfunded. There are almost always more desirable projects and program initiatives than money to fund them. A lack of training and easy access to information and tools, along with split incentives (e.g., where one department is responsible for purchasing energy-using equipment but another pays the energy bills), exacerbates the problem. Additionally, energy-savings projects are often difficult to "sell" compared with more visible initiatives like road construction or the development of public parks. Given competition for funding, energy conservation often loses.

In the almost inevitable circumstance where goals and ambitions for a program are not feasible within the funding allotted, it is often possible to leverage those limited funds. Success can be achieved in many different and creative ways. For instance, to help broaden the reach of its programs in the late 1990s and early 2000s, CONAE employed Internet/phone centers throughout Mexico, staffed by engineering students who were sufficiently versed in the agency's offerings and could answer callers' questions (or direct them to someone who could). In the U.S., many state governments (including New York, California, and Arizona) have capitalized on the efforts of the federal government's energy efficiency purchasing initiatives—most notably, the ENERGY STAR® endorsement labeling program and FEMP's energy efficiency purchasing specifications—by incorporating these tools into their own purchasing recommendations or mandates.

An even more dramatic example is the successful leveraging effort by FEMP. With a typical annual budget in the US $20–25 million range, FEMP is probably the largest public sector energy management agency in the world. FEMP's analysts estimated in the early 1990s that four dollars of energy savings were resulting from every dollar invested in the program. Despite this impressive return on investment, FEMP's management realized that the combined impact of its information, awareness, and technical assistance programs was still far too little to reach the ambitious savings goals set for the U.S. government in EPACT 1992 and other legislation and executive orders—even when augmented by the energy funding appropriated directly to the government agencies themselves. This was the impetus for FEMP's strong push for U.S. federal facilities to use energy service companies (ESCOs)—private firms that would provide turnkey energy management services, from project identification through financing. Two decades later, these companies are furnishing on the order of US $600 million annually in energy-savings projects to the government.

Private Sector Participation

One of the most common means of extending public sector energy management initiatives is through the use of private sector resources. Public-private partnerships (PPPs) have been adopted by many governments, in both developed and developing countries.

There are two basic approaches to PPPs in energy and water management (since water supply and treatment are energy-intensive processes for governments, they are included here). The first, and most common, is where the public sector entity simply pays a private sector firm to run a system, such as the district heating for a municipality. In this model, contracts can be structured to provide incentives for efficiency—for instance, by basing the payment to the private sector firm on thorough service provision (i.e., on performance) rather than on simply completing agreed tasks. The second approach is the energy savings performance contract (ESPC) or equipment lease, where a project is installed on the assumption that it will provide operational cost savings for a period into the future. These projected savings, which are often guaranteed by the leasing company or ESCO, can represent the cash flow upon which the project is financed over a number of years. Both of these models are discussed further below.

A decision to involve the private sector in the management of a public sector entity's basic services is usually based on the assumption that a private company has more expertise or can do a given job more cheaply than the government (or school, hospital, etc.). Another rationale is that the public sector entity may not be able to attract the money to do the project, whereas the PPP option offers project financing from an anticipated future stream of savings or revenues. Determining the level of private sector involvement is often the decision of the officials who oversee these services, but PPPs may be supported or prevented by law or regulation. For example, the national government and most state and municipal governments in Mexico forbid contracts from extending into future years (Singh 2010). This restriction, which is common in other countries as well, precludes the long-term financing typical of ESPCs.

Given a legal and regulatory environment that is amenable to private sector involvement, several other factors must be considered before deciding whether, and to what degree, PPPs should be used in energy management. These include the current level of in-house expertise, the degree to which systems need to be improved, and the amount of investment required to make the changes. The availability of financing for these investments will also help determine the extent to which a public entity can work with the private sector.

Since the early- to mid-1990s, multilateral development banks and a range of donor organizations have increasingly sponsored public service improvements via PPPs. The results of these projects have been mixed. In some cases, such projects have brought about tangible achievements, like improved access to electrification in previously underserved neighborhoods. In other cases, these partnerships never achieved traction—for reasons ranging from outcomes of the project that work against its own success (e.g., tariff increases) to disagreements between the affected parties (i.e., the general public; the municipal, state, or national authority; and the private sector partners). Some projects were cancelled as political pressures became too great, leaving service improvements unrealized.

Another phenomenon worth noting regarding PPPs (and conservation projects, in general) is that heavy energy price subsidies, where they exist, may need to be removed, or at least decreased, in advance of the initiative in order for it to work. If customers are paying only a small portion of the true cost of their utility service, a program to motivate changing to LED lighting or conserving water usage will likely not generate nearly as much interest as when the full cost is being shouldered by these customers.

Governments may find that large, multinational partners seem more interested in the substantial investment opportunities presented by some projects than in others (e.g., potable water provisions in large metropolitan areas versus less lucrative street lighting or public building retrofits). Furthermore, local companies often have the expertise, local presence, and indigenous perspective that make them ideally suited to the management of these types of smaller systems. In order to design a successful PPP initiative, policy makers need to match each type of project with the appropriate implementer.

Governments around the world are incorporating PPPs in different ways. While some models do not explicitly address energy use, an energy component can be incorporated based on the nature of the service being provided. The three most common models for energy projects are explained below and described in detail in Chapter 4.

Energy Savings Performance Contracts (ESPCs)

According to the classic ESPC model, an ESCO develops and implements energy conservation measures (ECMs), including obtaining financing and guaranteeing or sharing the verified savings from the ECMs. One or (more commonly) many measures can be included in a project. The installed equipment is transferred to the clients when construction or installation is complete. This transfer of capital equipment allows the client to have use of the new equipment long before they otherwise would have been able to fund replacement of the old equipment themselves.

The cost savings (from energy, but also sometimes water or related O&M savings) are used by the customer to pay off the cost of the project on an agreed basis for a predetermined amount of time. The ESCO offers a "turnkey" project (all components are within the ESCO's responsibility; it simply hands over the "key" when the project is fully operational). The components include project development, engineering, installation, and certain other services (such as measurement and verification of savings, training, and sometimes on-site operation of the equipment). The benefit of ESPCs is that they do not hamper cash flow for the client, which can implement the project with little or no up-front capital cost (sometimes the client may choose to pay off some of the project at its inception, reducing the term of the project as well as the necessary financing). Furthermore, auditing, modeling, implementation, and financing are often either directly handled or arranged by the ESCO, which is a very attractive feature for many public clients. ESPCs are discussed extensively in Chapter 4.

Equipment Leasing

Equipment leasing came into the spotlight as a useful PPP tactic in the 1980s and 1990s. Through leasing, governments could obtain better, more efficient equipment without incurring the up-front capital costs. Since the lease is paid out of operating funds—in most cases, the same pool that is used to pay for energy costs—there is a strong incentive to select energy-efficient equipment. This strategy has served the needs of the Czech Republic while supporting an entirely new industry in the country (see Box 2-4).

Box 2-4. Equipment Leasing in the Czech Republic

Municipal leasing accounts for roughly 40 percent of all municipal investments in the Czech Republic. The Czech company UniLeasing worked in more than 60 municipalities from the mid-1990s to the mid-2000s, and, as a result, municipal leasing accounts for about 20 percent of its total revenues. Before entering into a contract with a municipality, UniLeasing conducted a financial analysis to evaluate the municipality's level of debt and credit history. Perhaps partly because of this screening, the leasing company found that municipalities nearly always upheld their end of the payment contract.

Although tax and insurance laws remain barriers to expansion outside the country, Czech law provided UniLeasing a strong market in the Czech Republic, allowing an increased rate of depreciation for leased (relative to owned) equipment. These laws also provide a reduced (or delayed) tax burden for lessees. Financial leasing is divided into five categories of depreciation, as follows: 1) standard passenger cars and office equipment; 2) municipal buses and taxis; 3) construction machinery; 4) heating equipment; and 5) buildings. Income tax law favors leasing in categories 1 through 4. Consequently, municipalities often lease equipment in these categories.

Leasing equipment in buildings (Category 5) is not attractive to leasing companies such as UniLeasing since the tax laws complicate the transfer of ownership in a number of ways. For example, the leasing company must buy the building and then, at the end of the contract, transfer ownership to the lessee. In both transactions, the leasing company must pay a tax of 5 percent of the building value.

Lessons learned from the Czech experience include the following:

- Tax laws can provide incentives for governments to lease, rather than purchase, costly equipment.
- Local leasing companies can compete well with foreign companies, due to the fact that they are well-versed in the local situation.
- Prior to undertaking contractual commitments with a municipality, the leasing company should review the municipality's financial background to ensure that payment commitments are upheld.

Most vendors of energy-efficient equipment can engage in equipment leasing. Since it has the advantage of being conceptually similar but significantly simpler, it can represent a good stepping stone to ESPC. Equipment leasing is discussed further in Chapter 4.

Operational Contracts

Only a little over 60 percent of people living in sub-Saharan cities had access to safe drinking water as recently as 2010 (Pullan 2014). Operational contracts through PPPs—such as those outsourcing the management of municipal water treatment and distribution—can help provide basic services such as these to underserved communities. If the contracts are structured properly, they can be effective tools for promoting energy and water efficiency. However, services such as water provision can be extremely sensitive and can lead to political backlash if the community is not allowed significant input in decision making. In Cochabamba, Bolivia, the 1999 sale to Bechtel of the municipal water utility became a source of such contention—the Water Revolt—that the company was forced to pull out, abandoning large capital investments and a long-term contract.

Operational contracts can range in scope from operation of specific services (like meter reading, billing, or collection) to full concessions (system privatization) involving the handover of utility operations to private companies. In the latter case, there are greater opportunities for efficiency gains, especially when the contract is structured so that the operating entity earns a profit when resources are saved. This motivator is jeopardized when the operator has limited control over strategic system decisions. Box 2-5 demonstrates a successful operating contract in Albania that avoided this pitfall.

Non-PPP Leveraging Opportunities

Leveraging can take many forms and need not involve private sector firms. As discussed above, political support for public sector energy conservation initiatives are often strengthened by showing connections between energy-saving efforts and other government policies such as greenhouse gas reduction, air and water quality improvement, "good government" administrative reforms, and improved workplace health and safety. Energy efficiency public procurement policies can often build on "green" purchasing initiatives for recycled and environmentally preferable products. Similarly, energy conservation in public buildings can (and should) be an important component of a broader "green buildings" policy.

As an example of this ability to capitalize on other governmental activities, the FEMP program gained prominence (and arguably additional funding, though cause-and-effect is not certain) from its U.S. Department of Energy (DOE) management in the mid-2000s with an initiative to promote to FEMP's federal facilities audience the use of technologies developed by other DOE research and development programs. FEMP essentially committed to showcasing and promoting technologies such as LED (light-emitting diode) and spectrally enhanced (also called scotopic) lighting that had been developed with assistance from DOE's Office of Energy Efficiency and Renewable Energy (EERE), of which FEMP is a part.

Interagency and Intergovernmental Collaboration

Information sharing, on an interagency or intergovernmental basis, is one way to leverage limited resources and take advantage of lessons others have learned. Many public agencies have a long tradition of observing and adapting best practices from other agencies, including the use of model language for contracts and policies. Information sharing can be a first step toward more specific collaborations. For example, in the area of public procurement policy favoring energy-efficient products (see Chapter 6 for more detail), collaborating across governments to harmonize energy efficiency specifications creates a much larger "virtual buyer" with more influence on suppliers to provide efficient products and services.

Utility-sponsored Programs

Where electric and gas utilities offer demand-side management programs to their customers, such as energy efficiency rebates and technical assistance, public agencies may also be eligible for these programs. In the U.S., state and local agencies in some regions have benefited from tens of millions of dollars of utility-sponsored energy conservation programs (primarily rebates for high-efficiency equipment), while federal agencies have been able to finance energy conservation projects (on average, more than $100 million per year) using utility-sponsored paid-from-savings contracts (usually, like ESPCs, the financing is provided by a third party).

Private Enterprise Contributions to Outreach and Marketing

Finally, there are some circumstances in which private firms may provide services—in their own business interests—that support government energy conservation programs. For example, where governments base their energy efficiency purchasing actions on a voluntary labeling program like ENERGY STAR in the U.S., or the Sello FIDE label in Mexico, firms with qualifying products may be more than happy to actively market these efficient products to government customers, thus helping to spread the word more effectively than government policy guidance might by itself. Similarly, as architects and design engineers become more familiar with sustainable and energy-saving "green" design principles, they may actively promote these ideas when bidding on government contracts as a way of distinguishing themselves from their competitors.

2.6. Design with Evaluation in Mind

Regardless of the merits of a program, it is unlikely to receive sustained funding, especially in the face of constrained government budgets, unless the program's successes are well-documented. Although focusing on the documentation aspect of a project may require a tradeoff with other program elements, the ability to generate savings figures must be a high priority in any program design, whether on a micro- (project or building) or macro- (whole campus or government) scale. Since demonstrating savings is so critical to sustaining and growing programs, evaluation should be an integral part of program design. Steps for designing projects with evaluation in mind are outlined in this section; actual program evaluation is discussed extensively in Chapter 10.

Project- and Program-Level Baselines

In order to be able to evaluate success, it is important to establish a baseline of consumption for any given energy project, whether the project is as simple as implementing a schedule for lighting use or as complex as a comprehensive multi-system retrofit project. Without a baseline, assessing the success of the project will be impossible. Sometimes a facility-level baseline will suffice, but unless an energy-saving intervention affects a large proportion of that facility's energy use, such as the retrofit project with multiple measures mentioned just above, the change in such a broad baseline may be almost imperceptible even when the intervention is successful.

To illustrate the need for a project-specific baseline, imagine a building lighting project where standard incandescent "A" type lamps are replaced with CFLs or LEDs. If lighting accounts for one-third of the building's electric consumption, and the incandescents represent one-fifth of that, even a 60 percent reduction in those fixtures' consumption (which would easily be achieved from the CFLs or LEDs) would still only constitute 4 percent of the building's electricity use. Thus, the energy savings would seem minor when comparing electricity consumption from the same period during the previous year—even if everything else in the building (e.g., weather, hours of use, types and quantities of equipment) stayed the same. If any of these other variables did in fact change, the reduction would be virtually impossible to recognize. Consequently, to be able to document energy savings, it is

usually critical to develop a project-specific baseline, either through direct measurement or engineering estimates (which may be good enough for simple projects such as lighting retrofits), before implementing energy conservation measures.

Box 2-5. Albanian Water Utility Privatization

The Elbasan Water Company was the first public entity privatized in Albania. Elber Sh.p.k., a private entity formed by Berlin Wasser International (BWI) and Rodeco, a small German consulting company, signed a concessions agreement with the Albanian government to operate the municipal water network of Elbasan, a city of about 150,000. A German development bank (KfW) loaned funds at a favored rate to help close the deal.

A key element in the partnership is that Elber Sh.p.k. agreed to make investments in the network. The rationale for this approach came from the previous experience of other Albanian water enterprises in which donor funds were used to purchase and install new equipment but were *not* used for augmenting management. In the absence of changes in management, the performance of those water enterprises did not improve.

The concessions agreement placed full management control in the hands of Elber Sh.p.k., which had the distinct advantage of enabling it to make management and investment decisions without having to gain consent from external authorities, such as the Albanian government or Elbasan. Elber's goal was to improve efficiency in both energy use and water provision in order to provide a reliable service in a manner that was also profitable. According to its general manager, "Whether you are talking about resource savings, cost savings, or energy, it is all about efficiency."

Pumps are generally the major electricity consumer in waterworks, and the standard pumps in the Albanian waterworks were only 30–40 percent efficient. Elber initially spent 40 percent of its operating costs on electricity. To improve cost efficiency, the company tendered an open bid for a supplier of new pumps expected to cut the electricity bill by up to 60 percent. The second major opportunity was in leak detection and repair in both distribution pipes and consumer piping in buildings. Elber detected and repaired many leaks in the supply system, but the process was slower than anticipated, due in part to the lack of information about the existing infrastructure (much of which was unmapped or understood only by veteran system engineers based on their experience with the system).

PPPs (in the form of concessions) have resulted in numerous positive outcomes in Albania. However, these relationships have also been problematic for a country that has little experience with privatization. Investors foresee long-term profits (the partnership was signed for 30 years) but have found the venture initially costly. In addition, negotiations are ongoing between the shareholders and the Albanian government about several legal (and tax) issues unforeseen in the concessions agreement. Albania's tax code prevents private companies from writing off debts. In an environment where it may take years before people are able (and willing) to fully pay for services, this may not be sustainable.

Despite these and other obstacles, the Elbasan Water Company provides an excellent example of the potential to improve management of community services through partnership with the private sector. These are the key lessons learned from Elber's Albanian experience:

- Restructuring the water company by simultaneously investing in the physical network (infrastructure) and the management (capacity-building) was critical to success.
- A concessions agreement that put management control in the hands of the investors provided the investors with the incentive to save water and energy.
- Energy management was a crucial strategy for managing costs.
- Transparent, open, public bidding processes led to increased interest and reduced costs.
- Having a measurable target for reducing losses ("unaccounted" water) provided a motivating goal.

Box 2-5. Albanian Water Utility Privatization, continued

Establishing baselines for educational and awareness programs, and even for some technical assistance programs, can present more complex challenges. In some cases, it will be necessary to survey the target population. This could involve, for example, determining what proportion of people shut off their office equipment during nights and weekends, the degree to which people can distinguish efficient from standard equipment, or how comfortable they are in their workspaces. In other cases, like a new construction technical assistance program, establishing a building performance benchmark score and then comparing it to other, non-participating, facilities can provide a means by which to measure success.

Measuring Change

Establishing a baseline for an agency, a building, or even a particular system on which retrofit measures will be performed is the most critical step toward ultimately assessing what an energy-saving initiative achieves. Nonetheless, baseline development must be followed up with a number of other measures to truly assess change.

For project-oriented programs where interventions are focused on direct energy savings, determine ahead of time how these savings will be measured. There are a number of issues to consider in making this determination:

- Can the measurement process simply repeat the method used to develop the baseline? (e.g., using the same data loggers on the same sample of fixtures to determine the number of hours the fixtures are turned on after, for instance, occupancy sensors have been installed)
- Can engineering estimates (e.g., coefficients of performance (COPs), motor efficiencies, or lighting watts) be used instead of direct measurement?
- Will building or facility-level meters be sufficient to measure the changes attributable to the intervention, or does a piece of equipment or a system need to be assessed in isolation?
- Should ancillary effects (e.g., the reduction in cooling or increase in heating requirements from improved lighting efficacy) be measured along with direct savings?

For initiatives in which savings are inherently less direct, such as education and awareness programs aimed at changing purchasing habits or behavior, evaluation is generally more difficult and often requires the use of proxy measures. For instance, for an energy efficiency purchasing initiative, it will generally be very difficult to track all purchases. However, contacting procurement officials ahead of time to assess possible procurement tracking methods may lead to a feasible evaluation strategy for a minimal amount of up-front effort.

Indirect measurements, such as the number of visitors to a website where product efficiency specifications are posted, can be highly indicative of how well a program is doing. Moreover, these may be the only realistic ways of assessing such a program given the excessive costs of data collection needed to assess some broad-reaching initiatives.

Surveys can also be helpful in assessing the impact from programs that are seeking to educate, train, or otherwise transform the market for energy-conserving products or practices. The key is to design a survey that will reveal what impact the program had in changing behavior, since other factors may have been involved as well. These and other nuances of evaluation are discussed further in Chapter 10.

Irrespective of the specific means for measuring program and project success, it will always be easier to conduct these measurements if the program makes provisions for them in terms of both program design and budget. If evaluation is considered only after the program design is complete, it is likely that some of the desired data will be inaccessible and that collecting any desired data will be more difficult and expensive.

2.7. Pursue Policy Adoption

While a public sector energy conservation program can be launched regardless of supporting policy, most programs that have remained active and successful over many years do have a firm basis in written policy. The government policy document may be a national law or local ordinance; an executive order issued by the mayor, governor, minister, or president; or a policy directive or regulation established by a senior government official or central administrative agency. The initial policy push for government-sector energy conservation may come from top elected officials, from middle management, or from grass-roots initiatives by working-level staff. Regardless of its origin, it is important for legitimacy and continuity that, at some stage, the policy be endorsed by government leaders at the highest levels.

While there are rare cases of successful programs that were not authorized by explicit, written policy, looking more closely at these cases often reveals an unspoken consensus among government officials and senior managers that efficient operation of public facilities, and use of public funds, are assumed to be part of "good governance."

With few exceptions, then, it is essential to have a clear and specific written policy promoting energy conservation in government operations. The policy statement should:

- Establish agreed-on expectations and quantitative targets.
- Outline the types of programs to be pursued, whether broad-based or narrow; e.g., audits, retrofits, new construction, or education.
- Assign responsibilities and resources.
- Provide continuity in the face of likely turnover in both elected officials and government staff and managers.

There are almost limitless variations in the format, wording, and scope of energy conservation policy documents. The scope can be narrow (limited to a specific agency or to a single area of activity such as energy savings in existing public buildings) or it may be government-wide (or university-wide, etc.), calling for improved energy conservation in many functions through multiple points of intervention.[3] Whether narrow or broad, there are some core elements that add both focus and legitimacy to any statement of public sector energy efficiency policy:

- Rationale—This justifies why government action is needed, and what problems or opportunities are being addressed.
- Statement of purpose—This states, in broad terms, what the government hopes to achieve. (This should be linked to the rationale.)
- Specific goals, objectives, and performance targets—Examples of goals may include:
  - Quantitative energy savings targets (with specified dates).
  - Objectives for specific actions to be undertaken and completed (e.g., percent of buildings to receive energy audits, or number of new alternative-fuel vehicles to purchase per year).
  - Criteria for investing public funds (e.g., "Design new public buildings to be 30 percent more efficient than the existing stock;"; "Use life-cycle cost criteria when comparing energy cost savings and first-cost of new equipment"; or "Implement all energy-saving retrofit measures with simple payback periods up to 5 years").
- Program strategy—In this section, the policy document should broadly outline the main program elements and how they should relate to one another. In some cases, the policy document itself may include very specific actions. More commonly, the policy will set overall strategy and then direct one agency to coordinate drafting of an action plan with specific measures, practices, resources, and responsibilities. Where possible, the action plan should be linked to existing procedures (e.g., the budgeting cycle and reporting requirements) to make compliance as simple as possible.

[3] An example of a relatively comprehensive policy is the Energy Policy Act of 2005 (Title I, Subtitle A) in the United States, endorsing several existing administrative provisions for federal energy management and making them mandatory by law.

- Responsibility—This important section defines who will be responsible for each set of actions envisioned. It is especially important to define the role of a lead agency (or an office within an agency) to be responsible for coordinating the activities of other agencies, provide detailed guidance and technical assistance, collect and report information, and perhaps allocate government-wide funding.
- Resources—While it is generally not practical for a policy document to make specific budget allocations (especially for future years), the document will ideally indicate what scale of effort and investment is envisioned, and what sources of funding are anticipated: for example, which activities will be paid for by annual government revenues, which will be financed through government borrowing, and the expected role of third-party (e.g., ESCO) funding—see Chapter 4.
- Reporting and feedback—This section of the policy document provides for agencies to report back to senior officials or the legislative body on actions taken and results achieved (also see the evaluation discussion in Chapter 10). The specifics about the means of measuring and reporting these achievements may also be addressed.

Turning Policy into Practice

Once a clear statement of policy and specific goals have been articulated, additional steps are needed to put this policy into effective practice. These include the drafting and implementing of the following:

- Administrative regulations, as needed to implement the general policy.
- Guidance documents and decision tools to clarify actions and results expected from each agency.
- Information dissemination and training mechanisms to get the word to employees and then to repeat and reinforce the message at regular intervals.
- Documents detailing organization, the assignment of responsibilities, the allocation of resources, and the methods of reporting at a more fine-grained level than provided in the policy document itself.

Pitfalls to Avoid

While the main focus of this guide is on how to design public sector energy policies and programs for success, it is also worth noting some of the ways in which even a well-intentioned policy can fail as it moves from intent to implementation. There are two major sources of difficulty: a) the policy itself can be poorly conceived, incomplete, or lacking sufficient support from key decision makers, or b) the policy may be sound but, for any number of reasons, there may be insufficient effort, resources, or commitment to follow through for a sustained period.

To avoid the first type of difficulty, the policy needs to be clear, achievable, and specific about what actions are to be taken, who is responsible, and what results are to be achieved by when. A policy statement is unlikely to be taken seriously if it consists only of broad goals, without a clear strategy and actions to achieve these goals, or without the delegation of authority (e.g., to a specific agency or department) to develop a concrete plan of action. Similarly, both the time frame and available resources (staff and money) must be realistic in light of the program's goals. In some cases, there may be inadequate information, training, or other infrastructure in place to allow agencies and government employees to respond effectively.

An unrealistic time frame and inadequate advance preparations were a source of difficulty for early efforts by the U.S. federal government to adopt energy efficient purchasing policies (described in more detail in Chapter 6). In

1995, the country's vice president convened a number of agency heads to commit to a document called the "Energy Efficiency and Resource Conservation Challenge." Despite the important signatures on that document, actual implementation was delayed significantly because the infrastructure was simply not in place to tell federal buyers which products met the criteria for "energy-efficient," or where to find them. It took another year and a half before the first set of purchasing criteria was issued by the Department of Energy, and then another year before the general policy had been translated into regulatory language and added to the government's "Federal Acquisition Regulations."

Another potential source of weakness is the lack of provision of both incentives and penalties for both agencies and individuals to perform at their best. Incentives can be as varied as awards and recognition, provisions allowing agencies to retain all or part of their energy cost savings to spend on their own priorities, or actual salary or bonuses paid to employees for exceptional energy-saving ideas or results. Penalties could include poor performance ratings for a manager or an agency. One simple strategy that is sometimes effective as both an incentive and penalty is simply publicly listing the relative energy performance of agencies, departments, or individual facilities. The European Union, for example, requires that all public buildings post their relative energy ratings on the Internet; similarly, in the U.S., the federal Office of Management and Budget issues an annual energy report card making public each agency's energy-saving activity results for the past year.

A final pitfall to avoid is the adoption of a policy and implementation process which is too rigid and fails to provide for periodic review and revision based on achieved success, unexpected barriers, and new ideas that arise during implementation. Over the long term, the most effective policies are those that combine ambitious, long-term goals with concrete, achievable near-term steps and have good provisions for regular feedback and accountability. A flexible process provides the means whereby all parties involved—from individual facility managers to top policy makers—can learn from experience and continually refine objectives and improve day-to-day practices.

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CHAPTER 3—EXISTING BUILDINGS

Key Considerations in Developing an Energy-Efficient Existing Buildings Program

1. Existing buildings present the greatest opportunity for energy savings for most public sector entities. While their construction features may constrain what can be done, they can also offer relatively easy cost-effective opportunities.
2. The first step in addressing a portfolio of buildings should be to determine their baseline energy consumption and gather at least a couple of years of historical data, if available. During this step, a method for systematically tracking future usage, which will allow the identification of consumption trends, should be created.
3. Benchmarking energy consumption by comparing usage among similar buildings can identify potential opportunities to improve efficiency. Benchmarking over time can be done for a single building against itself as well as for a portfolio of buildings to show the impact of past retrofit projects and prioritize future ones.
4. In the process of tracking and benchmarking, it is important to become familiar with the unit costs of energy that facilities are using. Developing an understanding of any time-of-use, demand, firm versus interruptible, and other charges affecting utility costs will help determine what kinds of measures will be most cost-effective.
5. Sub-metering, especially in conjunction with an energy information system that permits effective data visualization, can provide the kind of specific equipment- or system-level performance data that reveal operating problems. It also allows users to optimize the components for the most effective combination of service provision and energy conservation.
6. Energy audits are critical to any building retrofit program. Whether conducted internally or by outside firms, a protocol should be developed to prescribe the desired elements of the audits and the format and content of the reporting.
7. Audits do not guarantee that a project will be implemented; in fact, most audits do not lead to any retrofit work at all. Steps to initiate an audit should pay close attention to addressing financing, administration, clearances, etc., so that the results can be more easily acted upon.
8. Improvements to energy-related operations and maintenance (O&M) generally provide long-term energy savings and lengthen equipment lifetimes. Since public sector facilities tend to remain in place and continue the same function longer than private sector ones, the opportunity for strong O&M becomes even more compelling.
9. Waiting to replace equipment only once it fails often appears to save money initially. However, the facility is ultimately exposed to a much greater risk of equipment breakdowns, diminished equipment efficiency, and decreased occupant comfort and productivity.
10. "Preventive" maintenance prescribes intervention at fixed points in time; "predictive" maintenance uses diagnostics to continually assess actual needs. This second approach helps eliminate unexpected equipment failures and increases energy savings, while also decreasing costs for parts and labor that may be unnecessary under a scheduled preventive maintenance program.

11. The key elements for implementing an effective O&M program can be grouped under the following three headings: management resources (such as training and administration), material resources (such as diagnostic equipment and spare parts inventories), and appropriate metrics for evaluation (which can range from equipment-related metrics like capacity factor to staffing metrics such as absentee rate).
12. Commissioning of existing buildings (i.e., bringing them back into alignment with their designer's intent) generally provides impressive paybacks from energy savings, especially in facilities that were not commissioned upon construction. Commissioning also serves to increase comfort and productivity, reduce O&M costs, and improve control of building energy systems, especially HVAC.
13. Building occupants have a significant impact on building energy consumption. Initiatives directed at occupant behavior can range from instituting office equipment shut-off policies to rewarding employees for identifying problems. Communicating these programs effectively is critical to their success.

Existing buildings impose a multitude of obstacles to improved energy efficiency, since many features such as orientation, thermal mass, glazing types (and ratios), insulation, and HVAC system types are set during construction. However, they also offer a multitude of opportunities, sometimes even *because* of these same features. Features like constant volume air delivery, for example, can be cost-effective retrofit targets. In addition, technology advances often offer energy managers a few easy fixes for existing buildings, such as replacing T-12 fluorescent lamps and magnetic ballasts.

This chapter introduces a conceptual framework and sequence of operations for increasing the energy efficiency of a portfolio of existing public sector buildings—from tracking consumption to implementing retrofits to influencing occupants' behavior. While succeeding chapters will deal with complementary issues, such as project financing and purchasing energy-efficient equipment, this chapter provides the starting point for initiating a program to address existing buildings.

3.1. Tracking and Benchmarking Building Consumption

Assessing and tracking trends in energy consumption—both in the future and, if possible, the recent past—is essential to managing energy effectively in existing buildings. The time-honored energy managers' mantra—"if you can't measure it, you can't manage it"—is as relevant at the building (and system) level as it is at the program level.

Establishing a Baseline

The first step in establishing a baseline is to collect historical usage data from utility bills or existing records (e.g., from energy management control system or energy information system data). If this information is not available internally, it can sometimes be provided by utility companies. If possible, gather the data going back at least two to three years. This will provide a good picture of recent consumption trends and a gauge of what is normal versus use that may be due to abnormal circumstances (e.g., an unusually mild or severe heating or cooling season). If parts of a building are sub-metered or have an extra connection, and thus an extra meter, collect output from these meters too, if available. Try to gather not only consumption information, but also electricity demand data and any other figures that are relevant to the computation of energy charges (e.g., peak vs. off-peak electric usage and firm vs. interruptible gas consumption).

Tracking Trends

Energy data can be collected and then recorded in a simple, basic spreadsheet or in a proprietary or publicly-available energy tracking software program. A popular U.S. tool is the U.S. Environmental Protection Agency's web-based ENERGY STAR® Portfolio Manager program (available through www.energystar.gov). Portfolio Manager permits any number of buildings to be entered and tracked, and provides a useful graphing capability that allows the user to view building consumption over time.

Tracking building consumption data reveals trends that can let the energy manager know where usage is most concentrated—for example, in summer air conditioning. Trends, or deviations from them, might also reveal equipment malfunction. For example, a sudden spike in monthly gas use during a period of constant weather might indicate equipment failure.

Tracking can also demonstrate savings achieved through conservation initiatives. For example, instituting a night and weekend temperature set-back or lights-off strategy in a facility where none existed before will most likely yield a decrease in year-to-year (same month) energy use. Tracking usage will document that trend and can be used to either modify a program or promote it. However, energy program interventions are often not the only energy-related changes occurring in public sector buildings. Changes in weather, building occupancy patterns, and usage (e.g., the conversion of office space to food service use) will affect consumption also, and potentially create difficulty in demonstrating the results of newly instituted energy conservation measures (with either increases or decreases in consumption).

The last and crucial step in tracking monthly energy data is to establish a system whereby the data will continue to be recorded at regular intervals (preferably monthly, but at least quarterly). This responsibility needs to be assigned to an individual; experience shows that it will not happen otherwise.

Benchmarking

Once tracking systems are in place, the next step is to make some relative measure of how your target group, or "portfolio," of buildings is performing. Benchmarking compares buildings' energy performance to others like them (as well as to their own historical performance). Benchmarking programs, such as the one offered through the web-based ENERGY STAR Portfolio Manager, require the user to enter a building's descriptive information, including energy consumption. The characteristics generally include (but are not limited to):

- The general type of facility, such as office building, hospital, or laboratory.
- The location of the building (to indicate the climate).
- Size, usually in terms of floor space (e.g., square meters).
- Number of occupants.
- Regular hours of operation.
- A characterization of the various space uses within a building—such as offices, computer centers, and day-care facilities.
- For each space type, the density of occupants and office equipment.

The programs' algorithms then "normalize" (i.e., adjust) the energy use given these factors and the weather data for the building's location. This leads to a score for the building that permits its comparison with other buildings of the

same type, all normalized for the same factors (weather, occupants, etc.). For Portfolio Manager, the score is a 1–100 percentile rank relative to other U.S. buildings of the same type (as indicated by DOE's Commercial Building Energy Consumption Survey, or CBECS, a periodic survey of U.S. buildings by the Energy Information Administration of DOE).

While tools that utilize large databases of buildings are valuable, simple benchmarking can be done within a government's or school district's portfolio of buildings by simply tracking consumption of the various facilities, expressing the usage per floor space, and comparing similar buildings with one another. This comparison will not only allow a rough identification of the "problem" facilities, but also permit comparisons within a building over time. Sudbury, Canada took this more simple approach and combined it with a comprehensive auditing program that yielded very impressive savings (see Box 3-1).

Box 3-1. Comprehensive Auditing and Benchmarking of Public Facilities in Canada

In response to its Strategic Energy Plan developed in 1995, the region of Sudbury, Canada (now the City of Greater Sudbury) conducted an initial study to benchmark current energy use and assess potential savings in its public buildings. Energy consumption and corresponding CO_2 emissions were documented for each facility. This benchmarking exercise was an essential element in gaining support for the overall plan and for identifying viable financing options.

Building on the benchmarking exercise, the project team performed detailed audits of 30 regional facilities, representing nearly 90 percent of the region's electrical and gas use. The team identified 86 different potential energy-saving measures and projected the cost savings and reduced emissions from each proposed measure. The bulk of the projected cost savings arose from proposed measures at the region's water supply and wastewater treatment plants. However, by completing audits and savings projections for all 30 facilities under the umbrella of the strategic plan, Sudbury was able to demonstrate that retrofits at the other facilities could also be cost-effective, and that some other desirable measures could be partly cross-subsidized by the biggest savers.

The Strategic Energy Plan was finalized in 1997. The implemented retrofits totaled nearly US $63 million and, while saving less than expected (simple payback had been expected at closer to seven years), an audit in 2005 estimated a simple payback from energy savings (excluding benefits from longer equipment life and lower O&M expenditures) of roughly 10 years. In addition, the initiative reduced the city's CO_2 by approximately a quarter and left the municipality with a set of clear lessons for implementing future projects, such as the value of monitoring and verification of results and the importance of staff training on new equipment (in order to optimize savings).

Sources: Greater Sudbury 2005; www.greatersudbury.ca

One rather confusing element of benchmarking is the choice of whether, and how, to combine different energy sources, such as electricity, natural gas, and centrally supplied steam. The simplest means for handling this is to aggregate the site's consumption of all different energy sources, providing an overall kWh per square meter or Btu per square foot (U.S.) rating. However, these metrics do not account for the difference in energy used at the source (e.g., at an electric generating or central steam plant), nor for the transmission losses to deliver them to the site. Since on-site use is the most pertinent number when analyzing for efficiency, some benchmarking measures keep the separate inputs disaggregated (e.g., kWh for electricity and kJ or MMBtu for natural gas).

Another option is to express the aggregate consumption in terms of the source energy used (or carbon produced) in order to furnish the site-consumed quantity (this is how ENERGY STAR Portfolio Manager computes and benchmarks utility information provided to it). In this case, the site uses have to be corrected by conversion factors that account for generation and transmission losses (Portfolio Manager uses U.S. national averages).

In general, if a building has a mix of different energy sources that is typical for its location and type, the aggregated site figure will not be a deceptive one. Only if a building is unusual in this regard (for example, if it is an all-electric building in a climate that requires significant heating of the facility) is it crucial to investigate a source energy benchmark. An exception to this general rule might be in a case where the contribution of greenhouse gases is a primary driver of the energy initiative—as is increasingly common.

Cost can be an effective proxy for source energy consumption, even to non-energy professionals. Expressing the energy consumption of a building in terms of cost per square meter will not only make the information highly accessible to people, but will also help direct building operators towards reducing costs instead of just commodities. This strategy may help promote the energy-saving campaign with senior managers and government officials.

Utilizing the Results

Collecting data on the various utilities (electricity, natural gas, steam, etc.), entering them into a tracking system, and doing some preliminary benchmarking will provide a good picture of the energy performance of a portfolio of buildings over time. It can also provide a sense of an individual facility's energy performance compared to others like it.

In addition to understanding the charges and rate structure for each utility (e.g., what are the per-unit electric demand and consumption charges), this information will help to identify where the greatest potential for savings is. For instance, if electric demand (kW) charges are low and overall electric usage charges are high, a program to reduce electric usage, irrespective of time of day (e.g., installation of occupancy sensors to shut off lights in unused spaces or variable frequency drives on HVAC equipment), might produce impressive financial savings. If electric demand charges are high, a simple lighting retrofit involving the replacement of incandescent lamps that are consistently on during the day with CFLs or LEDs would be a worthwhile measure. If gas or steam heat charges are predominant in the facility, a simple night and weekend temperature setback initiative might be warranted.

Metering and Energy Accounting

The measures suggested above are low- or no-cost opportunities that can be implemented fairly simply. A host of other measures that are more complex, or which might require investment, may not be as obvious but are very likely to yield cost-effective savings, particularly for those facilities whose benchmarked usage is high or whose increasing consumption cannot be explained. At this stage, there are two paths—either or both of which can be undertaken—to take advantage of the savings potential in your buildings:

- Explore individual energy systems through increased tracking of data from existing meters (ideally with the help of an energy information system) and/or the installation of additional metering.
- Pursue a building energy audit.

The United States' Energy Policy Act of 2005 states that "By October 1, 2012 … all Federal [sic] buildings shall, for the purposes of efficient use of energy and reduction in the cost of electricity used in such buildings, be metered." The reason for this directive in the law is that U.S. federal buildings, like the overwhelming majority of government buildings worldwide, were "under-metered." It is very common that large public sector buildings have only one meter, or sometimes even only one meter for an entire campus, such as a military base.

What is wrong with this metering status quo? The answer hearkens back to the energy manager's maxim: "If you can't measure it, you can't manage it." Tracking whole-building consumption and benchmarking that usage against similar buildings is very valuable, but once this broader information is understood and the prospect for substantial savings seems likely, more detailed information is necessary to move beyond the most basic and evident conservation measures (such as a fluorescent lighting retrofit). Sub-metering provides these detailed data—for example, of the consumption rates of individual energy-using products or systems.

Meters can also permit users to perform tests of individual pieces of equipment and discrete systems. For example, operators can learn how to optimize the energy performance of their facility's systems by monitoring energy consumption of equipment, such as chillers, under different conditions (e.g., when set to deliver 9°C chilled water rather than 6° C).

Additional metering should be implemented on a "decreasing marginal utility" basis—that is, placing the meters at the points of greatest consumption, and suspected waste, of energy. Good targets are major heating and cooling system components, such as chillers or steam lines. However, this is highly dependent on the building and is probably best determined by the building manager in consultation with his/her staff.

Making Sense of the Data

Energy managers can use logs to monitor metered data in order to observe trends and recognize malfunctions. Most digital meters have some memory function to support logging, and some modern energy management control systems save and graphically visualize metered data as part of an integrated energy information system (EIS). Many North American utilities offer EIS programs, which allow utility-metered data from facilities to be viewed over the Internet in any number of user-defined ways. Some standalone proprietary EIS tools offer an excellent way to look at fine-grained (including building sub-metered) data. In general, EISs permit the assimilation and centralization of energy data from any number of meters and present the data in understandable, graphical formats that can be viewed from an individual office computer, a network, or online. Some packages also offer diagnostic capabilities to assist in identifying the source of energy waste.

3.2. Building Audits

At the heart of existing building retrofit initiatives is the energy audit. Audits recognize the problems and opportunities—in performance, comfort, and energy consumption—and then propose actions. Audits are key catalysts to achieving large-scale energy savings in buildings. This is especially true in the public sector, where a lack of sub-metering and staff attention will limit awareness of, and response to, energy-savings opportunities.

The first consideration in establishing an energy audit program is the level of resources. Will audits be paid for by a dedicated energy management program, as they once were in Thailand (Wangskarn 1997), funded from the central government, courtesy of a national tax on petroleum? If so, how much money does the government's energy office have to devote? Alternatively, will the government facilities need to fund audits themselves, or is funding available from a mix of sources (e.g., including a serving utility or state program)? Who is responsible for the training of facility managers, or technical support, such as the software to generate the audit report? If the audits are provided for free, how will they be rationed among requesting facilities if demand outstrips supply?

Answering these questions will help managers decide on the scope of audits that will be affordable and worthwhile. For instance, is it better to provide cursory (e.g., "walk-through") audits to a large number of facilities or more in-depth ones to a smaller subset? Perhaps a majority of large buildings can receive walk-throughs that identify a small percent that warrant a more thorough audit to identify investment costs and payback periods. This has proven to be a popular technique in several countries and is especially valuable if consumption benchmarking (see Section 3.1) has not been conducted to gauge the relative energy use of facilities.

Canada's Federal Buildings Initiative favored the approach of sponsoring a private sector program where energy service companies (ESCOs) provide the audits (and are ultimately compensated for them through financed payment of the measures the ESCOs identify and implement). The U.S. Federal Energy Management Program (FEMP) for many years used a split approach. It promoted the use of ESCOs by government agency facilities, but supplemented this program with a partially subsidized program of cursory audits to assist facilities that were less convinced of the savings opportunities in their buildings, or that wanted to use means other than performance contracting to address them.

Prescribing the Audit Protocol

Standardization

When designing an audit program, it is beneficial to standardize as many elements of the audit's implementation and reporting as possible in order to provide consistency in evaluation. For instance:

- The audit protocol could direct that at least two years' worth of utility bill data be collected and that the information be recorded in a particular, consistent format that facilitates a common understanding and comparison among different facilities' reports.
- A clear graphical presentation of annual utilities' consumption and cost data should be included in the introduction of all audit reports.
- An inventory of all energy-using equipment, including the capacity and rated efficiency for each, should be developed.
- An identification scheme for different lamp, ballast, and fixture types should be prescribed for the lighting inventory.
- Illumination levels should be measured in a consistent manner (e.g., at the middle and corners of hallway floors; at the center of desks).
- Air flows and temperature measurements should be taken at specific locations (e.g., at the face of registers or indoor air conditioning units for air flows or at specified distances from exterior walls for temperature).

Targets

It is critical for auditors to consult with building operators to target the facility's areas of greatest savings potential. Some obvious areas that need attention in almost any building energy audit, and which should likely be included in your audit requirements, are:

- Lighting: Lighting retrofits usually provide good savings at moderate cost, since many facilities are over-illuminated and employ lamps, ballasts, and fixtures that are considerably less efficient than cost-effective alternatives in the local marketplace. All energy audits should consider illumination levels, lighting quality (such as color rendition, "correlated color temperature," and glare), lighting equipment, and on-off control schedules.
- Motor-driven systems: Pumps and fans in HVAC systems can often benefit from retrofitting with properly sized premium efficiency motors and variable frequency drives. If buildings contain central heating and/or cooling, these motor-driven systems should be investigated in the audits.
- "Dead zone": One of the easiest savings opportunities in commercial buildings is the setting and maintenance of a reasonable "dead zone" or "dead band," where neither heating nor cooling is (actively) taking place. In North American buildings, a typical dead zone might be 20°C (68°F) to 24°C (75°F). Building audits should investigate temperature control during occupied hours.
- Off-hours set-back: If the building is unoccupied during any prolonged periods (such as nights or weekends), a temperature set-back (and sometimes even air system turn-off) strategy will usually provide substantial savings. Audits should consider hours of use along with pull-up and pull-down times (i.e., the time it will take to bring the building back to working temperatures after a set-back period) to determine what set-back strategies would work.
- Water: Water conservation opportunities, from sources as varied as toilets to cooling towers, are frequently overlooked but generally offer impressive savings, especially where water and sewer rates are high, or where saved water is being heated. Audits should include an assessment of water-savings measures.
- Utility rates: Facility audits should always investigate utility bills, breaking them down into fixed and variable components (including both energy and demand charges). As well as pointing to areas of greatest and least expense (both by utility type and season), these investigations often reveal surprising, and sometimes even improper, charges (e.g., facilities that are being billed on incorrect rate schedules). Auditors should ensure (sometimes with the help of the supplying utility itself) that the facility is not being overcharged for any of its utilities.
- Cooling and heating plant equipment and system efficiency: Where these space conditioning functions are being served centrally, there are often cost-effective savings opportunities (because even minimally wasteful practices and equipment can generate substantial expense at such a large scale).

These are some areas that are worth considering in almost any building, but there are no doubt others that make sense for any set of public sector facilities and can be incorporated into the audit program. Moreover, each audit will vary in its emphases: If a university's facilities are primarily heating or cooling-dominated, the audits should be focused disproportionately on those systems.

Procuring Audits

Prices for building audits range enormously—in the U.S., from as little as $0.25 per square meter ($0.025 per square foot) for the most cursory survey of a very large facility to as much as $10.00 per square meter ($1.00 per square foot) for an in-depth audit of a small building. One lesson learned from experience on procuring auditing services is simple: Don't shop on price alone.

The approach to the procurement should focus on two areas: a) establishing clear and detailed guidance on areas for the audit(s) to cover and the way the results will be reported, and b) scrutinizing the background and past record of prospective auditors to establish that they have the knowledge and experience to conduct thorough surveys and communicate the results in a cogent, accessible report. Requests for proposals should emphasize past experience and insist on demonstration of prior audit reports, along with customer references. Ideally, a national energy services provider accreditation could be established based on demonstrated aptitude and experience. This exists in some countries and is being pursued in others, such as Jordan (USAID 2015).

Another possible selection method could involve the auditing by prospective firms of a small but representative space. Though price is a factor in any purchase, building audits are not commodities, and the selection needs to focus as much on what the product will be as on what it will cost. The weighting of various selection criteria should be established ahead of the request for proposal (RFP) issuance and made explicit to prospective proposers in the associated documents.

Moving From Audit to Project

One additional important step in designing an audit program is to plan for how the audits will be turned into actual projects. Too often, building audits that reveal good savings opportunities are never translated into retrofit work. In Australia, audits of federal buildings are required within one year of occupancy, even in leased space, and once every five years following that. However, despite high compliance with this directive, there is still a clear under-investment in cost-effective retrofit opportunities.

FEMP's experience with this phenomenon of limited numbers of projects relative to audits is instructive. Its SAVEnergy program, begun in 1995, selected up to two dozen federal sites among a pool of applicants each year to receive partially or wholly subsidized facility audits. In SAVEnergy's initial years, only about a quarter of the audits led to retrofit projects. Subsequently, the program managers instituted a dual approach of both screening the applicants in advance of subsidizing the audit, and then following up with the site energy contact(s) after the audit to encourage and assist in project development. The initial screening assessed:

- The agency's willingness to share in the cost of the audit.
- The site's utilities prices and consumption levels.
- The desire, and plan, to move forward after the audit.
- The presence of a "champion" who was likely to shepherd a retrofit project forward.
- The availability of appropriated funds to conduct the project, or a willingness to use alternative financing (through a local utility or an ESCO).

Six months to a year following the audit, if FEMP had not been apprised of movement towards a project, a FEMP representative called the facility contact to assess progress, suggest paths to move forward, and offer assistance.

After FEMP incorporated the screening and follow-up procedures into the SAVEnergy program, the rate of project execution following the audits doubled, to over 50 percent. The lesson from the early years of the SAVEnergy program is that it is unreasonable to assume that audits will routinely lead to executed projects. Furthermore, investing program resources into determining which facilities should receive audits is eminently worthwhile, as is continuing involvement after the audit to see that feasible prospective projects actually come to fruition.

Naturally, one of the biggest obstacles to turning promising audits into executed projects is the difficulty of finding the money to do so. Chapter 4 is devoted exclusively to this critical topic.

3.3. Operations and Maintenance (O&M)

Effective operations and maintenance (O&M) is one of the most cost-effective and swift methods for achieving energy conservation and waste reduction. Good O&M also saves other resources (such as water and labor) and helps to ensure reliability and safety. Inadequate maintenance of resource-using systems is a major cause of waste and pollution, including enormous losses from steam, water, and air leaks.

In public sector facilities, the O&M imperative is even more compelling because government facilities, relative to private enterprises, are much less likely to change hands—or even their function—over the years. This situation should, but often does not, inspire a long-range perspective to facility management, one that heavily favors a strong O&M program. Since public sector facilities are "here to stay," it is incumbent on policy makers and managers to make sure they endure.

Motivation

A 2012 New Buildings Institute study with a modeled office building prototype showed estimated energy savings from best practice operations to range from 10 to 20 percent (across 16 different U.S. climate zones), while poor practices led to as much as 30 to 60 percent *higher* energy use (Frankel 2012). From small to large sites, these savings can represent thousands to hundreds of thousands of dollars each year, and most improvements can be made at minimal cost.

Another study of more than 500 maintenance audits in 40 developing countries (UNIDO 1994) found that the "technical availability" of industrial production-type equipment averaged less than 30 to 40 percent; in other words, this equipment was not operating at all (or was functioning in an unintended condition) roughly two-thirds of the time. No estimate was provided for the loss of productivity that accompanied this poor performance, though it was no doubt substantial. The study went on to report that an estimated 80 percent of the unavailability was related to maintenance issues.

Beyond the potential for significant productivity improvement and resource savings, an O&M program performing at high "operational efficiency" has other important effects:

- A well-functioning O&M program is a safety program. Equipment is maintained properly, mitigating any potential hazard arising from deferred maintenance.
- Proper O&M reduces the risks associated with the development of costly indoor environmental quality (IEQ) problems in buildings. This is of increasing concern from a productivity standpoint, as well as a legal one.

- Properly performed O&M ensures that the designed life expectancy of equipment will likely be achieved, and in some cases exceeded. Conversely, the costs associated with early equipment failure are usually not budgeted for and often come at the expense of other planned O&M activities, creating a "vicious cycle" where O&M becomes an increasingly reactive, and expensive, activity.
- An effective O&M program increases the likelihood of compliance with local and national regulations for air and water pollution, where they exist.
- The staff of a well-functioning O&M program corrects situations before they become problems. Along with minimizing callbacks and keeping occupants satisfied, it also allows more time for scheduled maintenance. This is the opposite of the aforementioned "vicious cycle."
- A well-run public sector O&M program not only instills pride in building operators but also inspires confidence in the citizens that interact with the facility, setting an example for other facilities in the region.

Box 3-2. Tracking Steam Use at the U.S. Department of Energy

A demonstration focused on O&M-based energy efficiency was conducted at the U.S. Department of Energy's Forrestal Building in Washington, D.C. in 1994 (Claridge and Haberl 1994). A significant component of this demonstration was metering and tracking of steam use in the building. Within several months, US $250,000 per year in steam leaks were found and corrected. These included leaks in a steam converter and steam traps. Because the building steam meter was not actively read (the lease agreement set fixed utility expenses) and there was no proactive O&M program, these leaks were not detected earlier, nor would they have been detected without the demonstration. Some key lessons were learned from this case study:

- O&M opportunities in large buildings do not have to involve complex engineering analysis.
- Many O&M opportunities exist because building operators may not have proper information (in this case, steam-use profiles) to assess day-to-day actions.
- Involvement and commitment by building administrators to develop and sustain a proactive O&M program is a key ingredient for a successful O&M program.

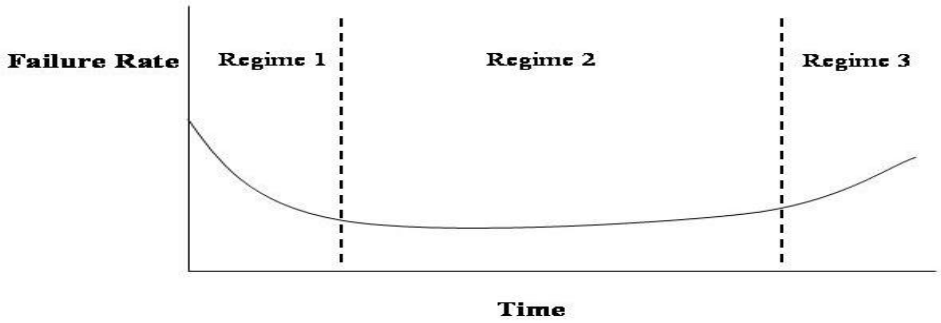
Maintenance Defined

Maintenance should focus on preventing a device or component from failing; a further goal is to optimize its performance. Unfortunately, data obtained in many studies indicate that most facilities, including public sector ones, do not expend the necessary resources to maintain equipment in proper working order, much less optimize its use. Rather, building operators tend to wait for equipment failure and then take whatever actions are necessary to repair or replace that equipment. This practice is often referred to as "reactive maintenance."

Characterizing Equipment Life Cycles

The typical profile of equipment failure is well represented by the "bathtub curve." The curve, shown in Figure 3-1, reports frequency of failure (Y-axis) as a function of time in service (X-axis) and is distinguished by three distinct regimes. Regime 1 is defined as the start-up or "burn-in" period and is characterized by a high but decreasing number of failures over time, mostly related to errors in construction, assembly, or start-up. Regime 2 is defined as the period of "normal operation." This is characterized by a relatively flat failure rate with upward slopes on either end. The goal of effective O&M is to maximize this regime with proper procedures for start-up, burn-in, and ongoing maintenance. Regime 3 is the end-of-life period, and is distinguished by age-based failures. It is desirable to have this regime coincide with cost-effective replacement before actual failure.

Figure 3-1. Equipment Failure Frequency—The "Bathtub Curve"



O&M Definitions

Two formal definitions, one for O&M and one for "operational efficiency," follow. These definitions have been used to develop programmatic mission statements—an exercise strongly encouraged for any organization embarking on a new O&M program.

Operations and maintenance consists of the decisions and actions related to the upkeep and control of property and equipment. These include, but are not limited to:

- Actions focused on the control and optimization of scheduling, procedures, and systems (this is primarily an operations emphasis).
- Performance of routine preventive and predictive actions (scheduled and unscheduled) aimed at preventing equipment failure or decline, with the ultimate goal of increasing efficiency, reliability, and safety (this portion focuses more on maintenance).

Operational efficiency represents the life-cycle cost-effective mix of preventive and predictive maintenance that, together with equipment calibration and tracking, converge to target reliability, safety, occupant comfort, and system efficiency (USDOE 2002).

Types of Maintenance Programs

All equipment and infrastructure have an operational life expectancy. For example, a road or a water distribution system may be designed to operate for 50 years. However, implicit in this expectation are regular maintenance

activities. While it is possible that with proper maintenance, the system may outlive its expected life, the reality is that without this level of upkeep, the system *will not* reach its life expectancy.

Most equipment requires periodic maintenance. Belts need adjustment, rotating equipment requires lubrication, alignments need to be maintained, and so on. In some cases, certain components (e.g., wheel bearings on a motor vehicle) need replacement to ensure the main piece of equipment lasts for its designed life. Anytime there is a failure to perform maintenance activities intended for the equipment, the operating life of that equipment is shortened.

But what options are there? Approaches to maintenance that ensure that equipment reaches or exceeds its design life are possible. Although some of these approaches have no doubt been in practice for centuries, there has been an increasing attempt to formalize and document them more recently. In addition to waiting for a piece of equipment to fail ("run-to-failure" or reactive maintenance), operators can utilize preventive maintenance, or a more recent concept, predictive maintenance.

Reactive Maintenance

Reactive maintenance is when a piece of equipment is run until it breaks. Little or no effort is taken to maintain equipment as the designer originally intended to ensure its expected lifetime.

Advantages to reactive maintenance are short-term (see Box 3-3). If equipment is relatively new or has been maintained very well historically, one can expect minimal incidents of failure at first. If a maintenance program is purely reactive, there is little to no associated maintenance cost for a short period (the length of which will depend on the age of the equipment and the level of maintenance that was being practiced before), and money will likely be saved. The downside is that during this short window of ostensible savings, hidden liabilities accumulate, and at a much quicker rate than would have been the case under a more ambitious maintenance regimen. This approach, in effect, adds capital cost because the life of the equipment is decreased, resulting in more frequent replacement. The facility may also be incurring future costs because one device's failure leads to the premature breakdown of a secondary device.

Over time, not only do capital expenditures begin to rise, but also labor costs associated with repair, since failures will require more frequent and extensive repairs. If a breakdown occurs with a critical piece of equipment, the facility may face additional costs: overtime pay to expedite the repair quickly and loss of productivity due to the outage.

Box 3-3. Pros and Cons of Reactive Maintenance

Advantages

- Initial low cost
- Smaller regular staff (temporarily)
-

Disadvantages

- Increased long-run cost due to unplanned downtime and reduced life of equipment
- Increased labor cost, especially added overtime to address "unexpected" failures
- Increased damage from cascading breakdown effect
- Decreased equipment efficiency and reliability
- Decreased work force productivity and inefficient use of staff resources
- Reduced occupant comfort and indoor environmental quality

Preventive Maintenance

Preventive maintenance is performed on a schedule (based either on absolute time or equipment run-time) that mitigates degradation of a component or system with the aim of extending its useful life and maintaining its efficiency.

Preventive maintenance has several advantages over that of a purely reactive approach (see Box 3-4). By performing maintenance as the equipment designer envisioned, the equipment is run more efficiently and its life is extended. While this does not altogether prevent catastrophic equipment failures, their frequency is decreased. Reduced failures translate into maintenance and capital cost savings.

Box 3-4. Pros and Cons of Preventive Maintenance

Advantages

- Cost-effective in most capital-intensive processes
- Increased component life
- Energy savings
- Reduced equipment failure
- Improved quality of service (e.g., air quality)

Disadvantages

- Unexpected failures still occur
- Labor and parts expenditures for performance of some maintenance tasks that are superfluous
- Potential for incidental damage to components in conducting unneeded maintenance

Predictive Maintenance

Predictive maintenance involves the anticipation of degradation through investigation of a device's or system's mechanisms. This approach allows causal stressors to be eliminated or controlled prior to any significant deterioration in the equipment's physical state (and its accompanying efficiency loss).

Predictive maintenance differs from the preventive approach by basing maintenance activities on the actual condition of the equipment, rather than on a pre-set schedule. While preventive maintenance is time-based (activities such as changing lubricants are based on either elapsed time or equipment run time), predictive maintenance aims for greater insight into the causes of degradation and failure. For example, most people in the U.S. change the oil in their vehicles every 3,000 to 5,000 miles traveled. This approach is effectively basing the oil change needs on equipment run time. No concern is given to the actual condition and performance capability of the oil—it is changed because the distance milestone has been reached. This method is analogous to a preventive maintenance task. If, on the other hand, the operator of the automobile discounted the vehicle run time and had the oil analyzed periodically to determine its actual condition and lubrication properties, she might be able to extend the oil change until the vehicle had traveled 10,000 miles. This example demonstrates the fundamental difference between predictive maintenance and preventive maintenance. Predictive maintenance defines needed maintenance tasks based on measured equipment condition.

Table 3-1. Common Predictive Monitoring Techniques

Predictive Monitoring Technique	Equipment Monitored
Vibration Analysis	Rotating machinery: pumps, compressors, turbines, gearboxes, diesel/gasoline engines.
Oil Analysis	Lubrication/hydraulic systems: compressors, turbines, large pumps, diesel/gasoline engines.
Ultrasonic Analysis	Steam systems, plant air or pneumatic systems, hydraulic and vacuum systems.
Thermographic Analysis	Boilers, roofs, furnaces, steam systems, electrical switching, motor control centers, high voltage lines.
Performance Trending	Heat exchangers, pumps, motors, compressors, refrigeration equipment, diesel/gasoline engines.

A well-orchestrated predictive maintenance program that includes a range of monitoring techniques (see Table 3-1, above) will all but eliminate unexpected equipment failures. Maintenance staff is able to schedule maintenance activities to minimize or eliminate overtime cost. Staff can reduce inventory while also procuring parts well ahead of time to support anticipated maintenance needs. This will, in most cases, optimize the operation of the equipment, saving energy costs and increasing plant reliability (see Box 3-5, below).

Its advantages for efficiency and smooth operation notwithstanding, a predictive maintenance program is not inexpensive to initiate. The equipment itself and training of personnel to effectively utilize predictive maintenance technologies can require considerable outlays. Program development requires an understanding of predictive maintenance and a firm commitment to making the program work by all facility organizations and management.

Box 3-5. Pros and Cons of Predictive Maintenance

Advantages

- Increased component reliability and operational life
- Decreased equipment or process downtime
- Decreased costs for parts and labor
- Improved worker and environmental safety
- Energy savings

Disadvantages

- Increased investment in diagnostic equipment
- Increased investment in staff training
- Savings potential not obvious to management in short term

Comparison Study of Maintenance Programs

A study compiling pump/motor data (Piotrowski 2001) reveals some intriguing maintenance cost findings. These data, presented as cost in dollars per horsepower per year ($/hp/yr), reflect the annual maintenance costs of operating pump/motor equipment in the three major maintenance modes (see Table 3-2). The study reports a 50 percent decrease in maintenance cost when moving from a purely reactive program to a predictive program.

Table 3-2. Pump/Motor Maintenance Cost as a Function of Maintenance Mode

Maintenance Mode	Maintenance Cost (US $/horsepower/year)
Reactive	$18/hp/yr
Preventive	$13/hp/yr
Predictive	$9/hp/yr

While these figures may be intuitive to some, the challenge to implementing a more rigorous O&M program is that it will likely entail more spending for training and diagnostic equipment initially, and will in most cases only show its full benefits in the longer term. These benefits should be explained to decision makers at the start to help assure their support during the institution of a high-quality O&M program.

Critical Operations and Maintenance Resources

The necessary resources for a fully functional O&M program are rarely given attention at upper management levels, both within and outside of the public sector. In most cases, operations and maintenance functions are viewed as subordinate, and not critical to the mission. Consequently, they are rarely pursued proactively. Following is a description of some of the key resources necessary for a successful and cost-effective O&M program.

Management Resources

O&M management is a critical component of an overall program. Good management should bind the distinct functions of the program into a cohesive entity. Public sector O&M managers can establish five initiatives (and links between them) based on a common breakdown of O&M functions: operations, maintenance, engineering, training, and administration. O&M managers also are responsible for interfacing with other department managers and making the case for often vulnerable budgets. This five-part structure will likely be helpful in substantiating these budget requests.

Material Resources

A well-functioning O&M program requires a host of tools and equipment to be effective and sustainable. Material resources can be broken down into the following categories:

- *Tools and equipment*—A functioning program will have ready access to standard tools necessary for equipment diagnostics and service. Equipment manufacturers typically provide lists of necessary service tools.
- *Technologies*—Modern predictive maintenance technologies continue to become less expensive, more diagnostic, and easier to use. Table 3-1 lists common predictive maintenance technologies relevant to energy performance and some of their applications.
- *Technical documentation*—Obtaining appropriate documentation must take a high priority in a developing program. Without appropriate technical documentation, the proper operation, maintenance, efficiency, training, and safety of an O&M program are potentially compromised.
- *Spare parts inventory*—The logistical challenges of maintaining the recommended complement of parts can be significant. In addition to standard inventory-organizing challenges, public sector institutions in some countries face language, currency, and import issues. These considerations need to be addressed as a program is developed.

Metrics for Evaluation

Traditionally, program evaluation for O&M initiatives focused only on reliability. Though every O&M manager of course wants a reliable facility, this metric alone is not enough to evaluate an O&M program. O&M managers need to be responsible for controlling energy and other resource costs, evaluating and implementing new technologies, and tracking and reporting on health and safety issues. The metrics used to support these activities both assess program effectiveness and assist in justifying the cost of equipment purchases, program modifications, and staff hiring.

Below are a number of these metrics. Not all of them relate directly to energy use, though there is often an indirect link. Some are not relevant in all situations. However, a program should use as many metrics as possible to better define deficiencies and, equally important, to publicize successes.

- *Capacity factor*—This is the average operating level as a percentage of full operation. It relates actual plant or equipment operation to the full capacity of the plant or equipment. It is a measure of availability, but may also sometimes indicate that equipment (e.g., an air conditioning unit) is oversized.
- *Work orders generated/completed*—Tracking of work orders generated and completed (closed out) over time allows the manager to better understand workloads and better schedule staff.
- *Backlog of corrective maintenance*—This is an indicator of workload issues and the effectiveness of preventive/predictive maintenance programs.
- *Safety record*—This is commonly tracked either by number of loss-of-time incidents or total number of reportable incidents. This record is useful in getting an overall safety picture.
- *Energy use*—This is a key indicator of equipment performance, level of efficiency achieved, and possible degradation.
- *Inventory control*—An accurate accounting of spare parts can be an important element in controlling costs. A monthly reconciliation of inventory that records what is installed and operating can provide a good measure of cost control practices.
- *Overtime worked*—Weekly or monthly hours of overtime worked has workload, scheduling, and economic implications.
- *Environmental record*—Tracking of discharge levels (air and water) and non-compliance situations permits better planning for minimizing them.
- *Absentee rate*—A high or varying absentee rate can be a signal of low worker morale and should be tracked. In addition, a high absentee rate can have a significant economic impact.
- *Staff turnover*—High turnover rates are also a sign of low worker morale. Significant costs are incurred in the hiring and training of new staff. Other costs include those associated with errors made by newly hired personnel that normally would not have been made by experienced staff.

Commissioning

Existing public buildings represent a treasure trove of opportunity for increased efficiency through operations and maintenance. The discipline of building commissioning has led the way toward better operation and performance of buildings. Building commissioning is the process of ensuring systems are installed, functionally tested, and capable of being operated and maintained according to the owner's needs and original design intent. Although this definition of commissioning does not explicitly address energy conservation, field studies have consistently indicated that substantial energy savings are almost always available from commissioning because un-commissioned energy-using systems rarely function according to their design intent. A large meta-study by Mills (2011) found that savings from commissioning of existing buildings resulted in a median energy savings of 16 percent, with a simple payback of just over one year.

Building re-commissioning relates to commissioning actions in existing buildings that underwent original commissioning upon construction (another term, retro-commissioning, applies to existing facilities where significant commissioning has never occurred). Re-commissioning is usually a very cost-effective efficiency measure and generally provides valuable non-energy benefits, such as increased comfort and air quality.

Costs for commissioning of existing buildings vary with building size and complexity, but generally range between US $1.50 and US $7.50 per square meter (roughly $0.15 to $0.75 per square foot) in the U.S. Mills' meta-study found a median cost of 2009 US $0.30/sf. The benefits of building commissioning include:

- Increased energy efficiency
- Improved building control
- Reduced operations and maintenance costs
- Heightened occupant comfort, indoor air quality, and productivity
- Improved building equipment performance
- Decreased potential for owner liability

While it is beyond the scope of this book to provide a detailed guide to commissioning, we have reviewed a number of successful commissioning projects to produce the following compilation of top commissioning measures for commercial buildings. The measures are those that were found frequently in re-commissioning projects and generated consistently impressive savings (see Table 3-3).

Table 3-3. Common Cost-effective Commissioning Measures in the United States.

Commissioning Measure	Description/Action
Adjust temperature settings and schedules	Temperature settings should be adjusted to accommodate balance between energy efficiency and comfort, and to track occupancy.
Stage/sequence boilers and chillers	Boilers and chillers should be sequenced to provide optimal energy use and minimize cycling losses.
Adjust and repair dampers/economizers	Proper operation of dampers/economizers represents one of the most significant efficiency opportunities because substantial shortages and/or excesses of design air flow can be avoided.
Eliminate simultaneous heating and cooling	This common wasteful practice should be identified and eliminated.
Verify controls operation, calibration, set-points, and scheduling	Control systems often drift and require recalibration and resetting. This should be a regular job task.

The best practice for existing building commissioning used to be seen as primarily a one-time, or periodic but infrequent, intervention strategy. However, the concept of ongoing commissioning, with particular emphasis on the use of energy information system software—leading to the term "monitoring-based commissioning"—has gained favor as an approach that generates deeper savings and is still cost-effective (see, for instance, Mills and Mathew 2009). (N.B. It is for this reason that we place this chapter's commissioning section within the O&M section.)

Developing O&M Programs and Strategies

Operations and maintenance programs and strategies should exist at many levels, including at the component, equipment, system, and whole-facility level. The steps below outline good ways to improve existing O&M programs, from evaluation of current practices to implementing new ones.

- Conduct study of current practices and needs: A system-wide assessment of O&M programs and procedures, as well as opportunities, should be completed. It should include a quantification of expected monetary costs and benefits for proposed changes, and translation of these into conventional financial evaluation metrics (e.g., internal rate of return, net present value/life-cycle cost, or simple payback period). These can then be used to justify proposed activities.
- Identify funding source(s): Due to the low visibility of O&M and the perception that it offers poor returns on investment, alternative avenues for funding program development are often needed. Potential opportunities lie in cost-recovery through service charges (to recipient departments), establishment of O&M endowment funds, or even potentially raising the awareness at the national/international level where grants and aid organizations (e.g., World Bank, Global Environmental Facility) have funding available.
- Train staff: For an O&M program to be sustainable, existing and new personnel require regular training on the facility's key systems. Training needs should be included in budgetary planning.
- Initiate program: Start with a manageable sector or system with a high probability of success and visibility. From the beginning, the program should use metrics (see "Metrics for Evaluation" in this chapter) for tracking and determining economic and performance impact.
- Communicate: All planning and implementation of proposed program components should be well documented and communicated to appropriate parties, including not only internal management but also sometimes outside parties such as vendors, neighboring communities/governments, and prospective funders/donors.

3.4. Behavior

Occupant behavior is frequently identified as an important (usually negative) aspect of building energy consumption, and is often overlooked when energy-savings programs are being considered in public buildings. It pays to initiate an energy conservation ethos and to educate building occupants about some of the key aspects of their behavior that affect energy consumption. Numerous accounts have identified savings impacts in the range of 10 percent.

There are two main elements to consider in designing an energy-savings program geared toward occupant behavior. First, which behaviors are most worthwhile to address in terms of energy-saving potential and likelihood of success, and second, how should the program be communicated? The two are closely linked since any measure needs to be communicated clearly and convincingly to succeed, and also carries a downside risk of generating confusion and, often relatedly, apathy among occupants.

Candidate Initiatives

There are a multitude of opportunities for saving energy through modifying behavior. Although not all are relevant for all buildings, depending on the way the energy-consuming infrastructure is configured and controlled, the list below provides some good potential candidates:

- *Office equipment shutoff*—Turning off computers and (especially) monitors is a good prospect for behavioral campaigns, as is the end-of-day shutdown of printers, copiers, and assorted other office equipment. Although in some cases turning off computers can jeopardize important network functions like backups, remote access, and file sharing, monitors can be turned off without risk in virtually all circumstances.
- *Lighting shutoff*—This is a common initiative but must be defined well so that emergency and critical access lighting is not included and employees are not left in the dark.
- *Minimizing plug load*—Miscellaneous electric devices of all sorts are found in employee workspaces, some left on continually. Even those that are turned off are often drawing "stand-by" power. If employees are attuned to the effort to save energy, they are more likely to be attentive to reducing unnecessary power draws.
- *Thermostat adjustments (where employees control these)*—Occupant education on how heating and cooling control works can change behaviors. It is useful to explain that adjusting the thermostat drastically will not make the space heat up or cool down any faster with most systems and that night/weekend set-backs provide substantial savings.
- *Closing doors and windows*—This is an important initiative when active heating and cooling is operating (though natural ventilation and cooling via windows can also be a big energy saver in some instances).
- *Alerting maintenance staff to problems*—Encourage open lines of communication to address malfunctioning systems, such as continually running toilets and urinals, or inordinately overheated or -cooled spaces.
- *Use of revolving doors*—These limit air exchange relative to conventional swinging doors, so their use should be promoted, especially in extreme weather.
- *Avoiding unnecessary lighting*—Encourage the use of natural daylighting and/or task lighting instead of overhead lights.
- *Closing of blinds and other window treatments*—Education of building occupants about efficient window management is important to prevent unwanted heat gain or loss.

Communication

Communicating energy-saving messages to broad audiences is more art than science, but there are a few lessons learned from experience. When considering an occupant behavior initiative, a critical thing to remember is to first, do no harm. A well-intentioned initiative may be completely misguided, such as when directing employees to shut down their computers at night and on weekends results in their missing important network backups and software upgrades. Not only will these kinds of failures result in operational disturbances but, more damagingly, they will generate cynicism toward the program.

Another risk in communicating energy-saving information to building occupants is that the message may be misinterpreted. For instance, a request to shut off lights or office equipment at the end of the day may be interpreted overzealously by some employees, such that others still at work are left grappling with pitch-dark halls or unprinted documents. This can cause a rapid backlash against the initiative.

Here are a few key tips to keep in mind in communicating the program effectively:

- *Obtain management approval*—Make sure to consult with any building managers and maintenance staff before announcing a new program to employees. This will avoid operational disturbances and safety breaches. It will also insure against awkward retractions that can jeopardize the whole effort.
- *Keep it short*—Long-winded and frequent messages are much more likely to be ignored. Consider a monthly or quarterly correspondence that can be read quickly.
- *Keep it simple*—Non-energy professionals will likely not have the background (or interest) to digest complex explanations. Provide the key message (e.g., "Please remember to turn off your work area lights and printers/copiers if you are the last to leave at night.") early in the communication, with more detailed explanation, if necessary, given later.
- *Be specific*—If, for example, you are requesting occupants to notify maintenance staff of obvious building system problems, state clearly whether you are encouraging all employees to make calls to maintenance or asking that one person per floor or department (e.g., an office manager) makes such calls.
- *Be practical*—Any request that significantly inconveniences employees or jeopardizes more than a minute or two of their time will be resented and ignored in most cases. For instance, it is reasonable to ask employees in exterior offices to close their blinds or shut off lights before they leave, but it may be asking too much to request that the last person to depart close all the blinds on her floor or shut down a number of remote lights.
- *Be open*—Encourage employees to seek clarification or explanation of the communications. This will not only insure that the message gets across properly, but will also convey the information in a friendlier way that is more likely to be heeded. In a similar spirit, consider asking employees to identify energy-saving actions.
- *Be appreciative*—If a message is acted on in a noticeable and effective way, be sure to recognize and reward this, if only through mention in future correspondences. Consider a reward system for employee suggestions that are adopted and then generate savings.

Chapter 9 will address employee outreach efforts further, with special attention to their appropriate media.

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CHAPTER 4—FINANCING

Key Considerations in Financing of Public Sector Energy Conservation Projects

1. There are three broad categories of funding sources for public sector projects: internal appropriations, debt, and third-party financing.
2. A rule-of-thumb of energy efficiency finance is that as risk is shifted away from the project owner—that is, as the financing source moves from internal to external—project price escalates.
3. Internal financing through budgeted funds is generally the most cost-effective means for funding energy projects, since interest is not owed, there are fewer administration requirements, and all project savings accrue to the host.
4. Despite the obvious advantages of internal financing with capital and operating budgets, these funds—especially the former—are usually difficult to obtain for energy projects due to competition with other government priorities.
5. Revolving loan funds, despite some administrative complexities, are an excellent project finance source. While establishing an initial pot of money for these funds is often a formidable obstacle, there are numerous potential sources and creative solutions to this problem.
6. Many public sector entities are restricted from borrowing money. But in those cases where borrowing is possible, loans—particularly those subsidized or guaranteed by international financial institutions—can be a relatively simple and cost-effective source of funds for implementing conservation projects.
7. Bonds, particularly tax-exempt bonds, offer a low-cost way to finance energy projects when the government has legal authority to issue them and there is a secondary market in which to sell them. As with loans, investors will likely focus on tax revenues (rather than energy savings) as an assurance of repayment capability.
8. Leasing of energy-efficient equipment is a potentially attractive financing option because payments can come from operating (not capital) budgets and be made to approximate the estimated savings stream, creating a "net zero" cash flow.
9. Energy savings performance contracts (ESPCs) permit large energy-saving projects to be implemented with no up-front costs. Unlike lease payments, ESPC payments can be structured to depend on actual savings, which transfers the project risk away from the host facility. The downside of this risk removal for the host is that ESPCs are generally the most expensive way to implement an energy conservation project.

Throughout this guide, the value of energy conservation is well demonstrated. However, it is often the critical element of funding that determines whether an energy-saving project will actually be implemented and thus will generate savings for a public facility. The key to success for most energy projects is the ability to overcome the barrier of high initial capital costs.

4.1. Basics of Energy Conservation Project Financing

While direct internal funding of projects has great appeal due to its simplicity and relatively low cost, budgets for public sector energy conservation projects generally fall far short of the level needed to implement all economically attractive opportunities. This situation leads many facilities to look outside for project financing. This is logical in

that energy conservation projects provide a stream of savings (revenue) over time that can be used to pay down the financial obligation.

Especially for such externally funded projects, financing is intimately tied to the issue of risk. Energy conservation projects inevitably are priced according to investors' and financiers' risk perception—whether or not the risks are real. The key to energy conservation finance is to assign these perceived risks as closely as possible to those most capable and willing to assume them.

Energy conservation finance is made up of various costs that vary with each financing option and with the parties involved. In addition to the transaction costs that are part of administering any financed project, there are three general areas of risk that affect project costs:

- *Cost of capital risk*—When borrowing money is anticipated for the project (whether within or outside of the government), this is the "market" risk on interest rates that affect any loan.
- *Credit risk*—This is the perceived risk that, if money is loaned for the project, the borrower (whether a public sector entity or an energy service company [ESCO]) will not survive or have sufficient funds (or willingness) to pay back the money. This is affected by the legal environment because it dictates the degree of enforceability of contracts.
- *Project performance risk*—This is the risk that the project, once installed, will not provide the energy-related services, or the savings, expected. This can be due to poor design, lower than expected use, failed equipment (that lacks a warranty or guarantee), or faulty installation or service.

These types of risk vary in the burden they place on the public host facility—some risks may be tolerable for the facility while others pose legal, budgetary, public-perception, or other types of problems. Because of these varied sources of risk, the optimal project financing path for a public entity may not be obvious. For instance, an ESCO-installed retrofit project may be funded with the most "expensive" money, and yet may be the most desirable solution for the public host, since all risks are transferred to other parties and the project hosts have assurance that the equipment will be installed promptly and without any up-front capital cost.

Appropriate energy efficiency financing instruments can be an effective way to match the cost of a project with its expected benefits. Since the costs can be substantial and are immediate, while the benefits accrue over many years, it is often difficult to convince public sector entities (or any other prospective project host) to engage in efficiency investment. With strategic financial engineering, the financial returns from the energy savings can be matched to the costs of the project's funding, creating the "win-win" scenario that makes energy efficiency so compelling.

In considering the various financing options, it is beneficial to keep in mind the basic features of the anticipated project. Most efficiency retrofit projects go through the same development cycle, regardless of funding:

- *Conduct an energy audit*—An audit is required to define the general needs of the system or facility and the opportunities for efficiency. The audit is usually conducted by either internal or external engineering experts. It is important that this audit be detailed enough to allow for follow-up engineering and equipment specification.
- *Complete a feasibility study*—A study is required to evaluate the financial implications of the efficiency project. Financial institutions will require a rigorous "bankable" study that provides their preferred investment decision criteria.

- *Formulate an investment plan*—A decision is then made to evaluate the retrofit options against an investment criterion, such as a simple payback period or an internal discount rate (usually using a net present value or internal rate of return analysis). These financial analysis methods are discussed in detail later in this chapter. The investment decision also must include an assessment of the sources of financing available and include those costs and benefits.
- *Identify and secure a source of funding*—If the project can be funded internally, then this step entails managing the bureaucratic procedures to secure funding. If outside sources of funding are desired, then a financing plan must be put in place to meet the needs of outside financiers.
- *Proceed with engineering, procurement, and construction*—This process may require detailed engineering and equipment specification. This can be handled internally or through an engineering firm, or contracted out to a firm that provides both design and construction services.
- *Measure and verify energy savings*—If financing is sourced internally or is part of a larger borrowing (e.g., a bond), the requirement to measure and verify energy savings may be minimal, except as an internal auditing function. However, in cases where payments to outside financial entities are tied to energy savings—such as any of the shared or guaranteed savings plans promoted by ESCOs—this process becomes very important.

4.2. Types of Financing Commonly Available to Public Entities

Generally speaking, there are three different types of financing available to public sector efficiency projects and programs: internal (through standard budgeting), debt, and third-party finance. Third-party finance combined with energy savings performance contracting is an attractive and increasingly common form of financing projects, so this will be addressed as an additional topic.

Each one of these financing options has various advantages and disadvantages, but one general statement can be made: the more complex the financing structure, the less risk there is to the public facility—but the greater the cost of the project is. As risk is shifted to outside parties, the project's price to the host escalates. Therefore, the threshold rate of return on the efficiency measures must also go up.

Internal Financing

There are several mechanisms for internal funding of conservation projects, but the most common are direct budget allocation and revolving funds (which can also be seen as a form of debt financing, but will be covered in this section). The first is most appropriate for one-time projects, while the second (also usually involving an initial budget allocation) is better suited to ongoing, self-sustaining conservation programs with multiple projects.

Direct Budget Allocation

The most time- and cost-effective way to finance conservation retrofits is to allocate funds directly from capital or operating budgets. This can be done through internal budgets or through sub-national or national program funds, if these are available. The budgeting process is generally clearer (although often quite political) and is therefore easier to administer than debt or third-party financing.

While this book does not provide a detailed discussion of the mechanics of public budgeting processes, it is important to note that a proposed conservation project must be well documented and presented in order to

compete with other programs or projects. There are two basic budget types that can be accessed for efficiency upgrades:

- *Operating budgets*—These are most commonly used for smaller projects that can be implemented within a public entity's annual budget. This kind of funding is most often handled through budget allocations within the agency or department and requires little interaction with the larger public sector entity for approval. Smaller projects do not often justify the extensive development and transaction costs typical of outside financing.
- *Capital budgets*—Capital budgets are most commonly used for larger projects. These funds may come from a budgetary authority outside the specific entity managing the facility, and are often received as part of a larger capital expenditure or efficiency program.

In either case, the process for generating approvals usually is straightforward and common to all budgetary requests. The key to success is to "sell" the retrofit as a cost-saving (or revenue-generating) opportunity. Similarly, it can be pitched as an effort to maximize public funds and assets—that is, as a prudent investment.

- *Advantages*—Administratively, direct budget allocation is the simplest option for a public sector manager. It requires little extraneous expense in order to implement a project (no detailed financial plans or contractual structures), and has a lower (or nonexistent) measurement and verification threshold than third-party or even debt finance. These features make it less expensive and also shorten approval time. Additionally, all of the savings generated by the efficiency improvements are retained by the public entity. There are no interest payments or ESCO fees reducing the net benefit to the host entity.
- *Disadvantages*—The disadvantage to this process is that there is often competition from other departments and projects for limited budget money, so the number and scope of energy projects is often limited to only those with the highest returns. Meanwhile, attractive projects that might ultimately be funded directly sometimes wait in line for years. This underscores an opportunity cost that is often overlooked: While projects conducted with appropriated funds may have the cheapest price tag, the months and years of savings lost while waiting for appropriations to materialize can eliminate that advantage.

  The public entity also must pay the entire cost of the efficiency retrofit up front, with the expectation that future returns will justify it. Additionally, the entity itself assumes the full responsibility and risk for the performance of the efficiency measures (except to the extent that equipment and installation warranties exist).

Revolving Loan Funds

Revolving funds are an effective device for internally financing multiple conservation projects on a self-sustaining basis over time. Usually begun as a lump sum, start-up monies can come from internal resources, general government funds, legal settlements, grants, specified sales (such as the sale or privatization of a power plant), or from unique revenue-generating schemes, such as a fuel surcharge. They can also be funded through a bond offering (bonds are discussed further under the "Debt Finance" section presented later in this chapter). In general, however, these funds can be initiated at a modest level and then, if properly managed, grow through reinvestment from the savings stream. For example, a one-time allocation of $1 million, if properly managed, can grow into a multi-million, self-sustaining fund over time. There is even the potential for the original funding to be repaid to its source.

Revolving funds can be set up within a discrete government entity (e.g., a school system or the ministry of power) or can be managed for a government within a financial institution, such as a bank or even a utility company. Whether the managing entity is within or outside of the government, these funds may begin to act more like external sources of debt for a public facility manager and the mechanics can be treated as a loan (though usually with lower interest rates).

Internal revolving funds probably are the easiest, most sustainable method of financing a stream of small projects over time, since the funding source is dedicated to energy projects (i.e., conservation projects are not competing with non-energy priorities) and also lies within the public sector entity itself. As savings accrue from early, high-return investments, some of those savings are repaid to the revolving fund, which then makes them available to successive projects. As the number of projects grows, so do the returns to the fund and the amount available for reinvestment into projects with longer payback periods. Even with modest early budget allocations, a revolving fund can grow over time through reinvestment (see Box 4-1).

Box 4-1. Revolving Loan Fund in Phoenix (U.S.)

The City of Phoenix, Arizona established a revolving fund in 1984 with seed capital from an oil surcharge program. The revolving fund finances Phoenix's Energy Conservation Savings Reinvestment Plan, which is managed by the city for the purpose of investing in municipal facility retrofits. Projects range from mundane lighting change-outs to installation of thermal storage, district cooling, and cogeneration systems. Phoenix gained the support of department managers early on by augmenting their budgets with program funds.

Each year, the city planned to reinvest half of the documented energy savings derived from retrofits back into the plan and use the remainder to augment its general operating budget. Within two years, however, investments by the plan were generating nearly US $1 million per year in documented savings. At this point, the city capped reinvestment at US $500,000 annually. While this figure has moved some over the years, it is currently (in 2014) over $1 million (including portions from, and for, water and solid waste projects). The cumulative savings estimate since the plan's inception is pegged at roughly US $120 million. The fund is now used for projects ranging from upgrading HVAC systems and controls to installing solar panels and green building measures.

Sources: www.iclei.org; Laloudakis 2014.

- *Advantages*—The main advantages of internal revolving funds are the low or nonexistent interest rates, and the full retention of savings within the public entity. While there are some transaction and administrative costs with this system, including measuring and verifying the savings and determining the amounts to be repaid, they are modest compared with the effort involved in obtaining funding from outside sources. Most important, the rate of repayment can be determined by the flow of savings, a

hallmark of good energy efficiency finance. Another theoretical advantage of revolving loan funds is that, with correct incentives, they can be started without dedicated seed funding (see Box 4-2); however, instances of this do not seem widespread.

Box 4-2. Revolving Loan Fund in Philadelphia (U.S.) Schools

In 1983, the City of Philadelphia School District had the desire to start a revolving fund—but had no funds with which to do so. To overcome this barrier, the district initiated an incentive-based program of energy conservation targeted at school administrators, maintenance staff, and teachers. The Save Energy Campaign rewarded schools that could show energy savings on their annual energy bills. Documented energy cost savings were distributed among the school (with a portion of savings going to maintenance staff to reward their support for the program), the school district, and an incipient revolving fund. Schools initially looked at low-cost/no-cost solutions and, in the first year, generated US $3 million in savings—10 percent of the total district energy bill. Funds from the revolving fund were subsequently used to develop energy conservation programs in approximately three-quarters of the district's roughly 260 schools, generating more than US $150 million in total savings through 2001. At that point, unfortunately, the program was suspended for three years over fiscal and leadership turmoil in the district and was never successfully revived. The district is now (in 2014) implementing some very successful energy management initiatives—such as block-and-swing electricity procurement, oil-to-gas conversions of boilers, and substantial demand response participation—that have cut more than 30 percent from its total energy bill over the past five years. But funding for capital projects is very limited, and borrowing ability is limited amidst an unprecedented fiscal crisis. This further underscores the value of a dedicated funding source like the district's revolving loan fund once was.

Sources: www.iclei.org; Lee 2014.

- *Disadvantages*—Initial establishment of a revolving fund is the most difficult element in managing such a fund. Requests for a substantial one-time allocation usually compete within a larger capital budgeting process. If the fund is to be generated through a fuel surcharge, one-time sales revenue, or even a grant, the process of realizing the fund is generally a long and cumbersome one, potentially requiring legislative or regulatory action. Fair, open, and consistent governance is another challenge. Lending criteria need to be clearly stated and adhered to, and political influences—both in lending and debt forgiveness—need to be avoided. Determining the minimum rates of return, savings validation method, and savings repayment process can also be complicated. Additionally, once the fund is in place, it requires competent energy auditing, project design, and measurement and verification of savings. All of these activities need to be understood and integrated by the fund management.

Public Internal Performance Contracting

One hybrid approach to internal financing that has been experimented with in Europe is called public internal performance contracting, or PICO. In the PICO model, an energy service unit is established *within* the government, but behaves like a conventional turnkey ESCO (i.e., one able to provide all the necessary services, either directly or by contracting for them), implementing and financing projects in different government agencies and getting remunerated based on a contractual (or quasi-contractual) basis out of the savings from the installed measures. This permits the PICO unit to finance future projects in a scheme that is similar to a revolving fund.

While the PICO model has not been used widely yet (2014), its successful implementation in several European municipalities (most prominently the German city of Stuttgart) and its structure—reinvesting cities' own (presumably low-cost) financing and recycling savings into future projects—are intriguing.[4]

Debt Finance

Debt finance can be as simple as an intergovernmental loan from a central banking authority or as complex as a specialized bond issued to the international investment community. The type and scope of borrowing mechanisms available to a public entity will vary. In developing countries the options are generally more limited; borrowing from commercial financial institutions is often prohibited by law, and even where not, this money is expensive. Loans from governmental financial institutions, either directly or with the support of international financial institutions (such as multilateral development banks), can be an appealing alternative. Bonds are a very efficient mechanism for securing capital, but require a secondary market (where they can be traded). Few of these are in place in developing countries, although they are spreading with the support of international donors.

A major obstacle to borrowing in many places is the requirement for loan security, or collateral. Since most government agencies do not "own" their assets, there is nothing they can pledge (and where they can, few banks in developing countries are able to accept these assets as collateral). Most banks are not familiar, and will not be comfortable, with the prospect that repayment of their loan is contingent on a stream of (invisible) energy savings. However, this situation is changing gradually. As banks become more educated about this type of financing, increasing numbers of pledges for future revenue streams (e.g., from energy savings) are being secured.[5]

Beyond the obvious influence of prevailing economic conditions, interest rates charged by lenders, whether for loans or bonds, depend on the credit capacity and tax status of the borrower, the collateral pledged to the loan, the risk associated with the financed project, and the amount borrowed (interest rates are generally lower for larger amounts). Interest can also vary with the type of guarantee that is offered. The stronger and more credible the guarantee, the better the rate will be.

Debt financing is generally only well suited for larger conservation projects, or multiple smaller projects under a single program, or efficiency upgrades that are part of larger facility upgrades. The exception to this is when an existing line of credit can be accessed and normal loan generation procedures can be waived. The two primary

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[4] See, for instance, the discussion of Austrian, French, and especially German cities' use of PICO described in the PROST report (Borg 2003).

[5] As an example, banks in Mexico and Chile have recently shown a willingness to lend to energy conservation projects. An NGO, the Efficiency Valuation Organization (EVO), maintains an "International Energy Efficiency Financing Protocol" (EVO 2009).

types of direct borrowing—loans and bonds—are addressed below, as are the related instruments of leasing and lease-purchasing.

Direct Loans

Loans can come from governmental banks or commercial sources, although the latter is less common in developing countries. Repayment terms may be negotiated to best match the projected savings of the efficiency upgrades in order to neutralize the impact on the borrower's cash flow. However, the biggest burden is often the limitation on borrowing (i.e., taking on obligations for future administrations) that is placed on public institutions by government authorities. As a result of this limitation, few public entities use direct loans.

Becoming increasingly available, however, are *efficiency loans*—from both commercial and government banks—that are backed by international financial institutions or donor funds (see Box 4-3). These funds, like the Hungary Energy Efficiency Co-Finance Program (HEECP), which is backed by the International Finance Corporation (IFC) of the World Bank, have been very successful at helping to create a market for efficiency debt. Through HEECP, the Global Environment Facility (GEF) and the IFC established a loan guarantee program for local financial institutions whereby a portion of the loan (50 percent) could be guaranteed by the IFC. This lowers the risk to the financial institution, which in turn lowers its rate of interest to the borrower.

These loans often carry better terms (longer terms, lower interest rates, and reduced collateral requirements) than those available from conventional banks. Some governments also borrow directly from multilateral development banks, such as the European Bank for Reconstruction and Development (EBRD). All of these international sources can provide superior terms and better understanding of efficiency, but these loans can also carry increased administrative costs and often some foreign exchange risk.

Box 4-3. Bulgarian Municipal Energy Efficiency Program (MEEP)

In 1999, U.S.-based company, Electrotek Concepts began implementation of the U.S. Agency for International Development (USAID)-supported Municipal Energy Efficiency Program (MEEP) in Bulgaria, following an agreement between USAID and the United Bulgarian Bank (UBB). Under the program, local municipalities and industries were able to get loans for implementing energy efficiency projects using a "Development Credit Authority (DCA)" mechanism—a guarantee line established by USAID that offered up to 50 percent coverage of losses for loans taken from UBB for energy efficiency projects. By mid-2003, more than 30 projects had been initiated under MEEP. The total cost of these projects amounted to roughly US $11 million, 40 percent of which was devoted to municipal initiatives. Projects were conducted on central heating systems in schools and other public buildings, in addition to municipal street lighting. These municipal projects demonstrated an impressive return, with an average payback period of three and a half years.

Source: www.electrotek.com

The mechanics of direct borrowing vary by financial institution but, in general, the process involves identifying the amount of funding required and demonstrating the availability of cash flows to pay off the loan. In the case of an energy efficiency upgrade, a demonstration of net savings (after loan service) makes the most compelling argument to a prospective lender.

- *Advantages*—A major advantage to direct borrowing over other types of borrowing is the simplicity of using one source of capital. This will almost invariably shorten the time needed to obtain funds and embark on the project. Once a relationship is established between a lender and a borrower, direct borrowing is a mechanism that can be used many times with little additional effort. Another positive feature is that, through negotiation of loan terms, the net cash flows from the efficiency project to the public entity can be positive; alternatively, if there is a desire to pay the loan off sooner, permitting 100 percent savings retention by the public sector borrower, a more aggressive pay-off schedule can be arranged.
- *Disadvantages*—Direct loans depend on the existence of a financial institution that understands energy efficiency projects and is willing to structure financing accordingly. Borrowing limits, incompatibility with conventional lending terms (including collateral requirements), and administrative costs frequently make direct borrowing impossible, or at least difficult. These barriers can be overcome through use of a government lender or by taking advantage of a lending program supported by an international financial institution such as the USAID (see MEEP example above, for instance).

Bonds

Bonds represent another form of direct borrowing. The major difference between these and standard loans is that, instead of a single lender, debt capital is divided up and sold in pieces to investors. Bonds can be structured in many ways to accommodate both the interests of investors and the needs of the borrower. Bonds can be paid off over time so that there is no remaining principal at the end, or they can require only interest payments over their life, with the principal amount then paid at the maturity date. Another option is zero-coupon bonds, which require no payments, but instead are sold at a discount to their stated value. For example, a five-year bond with a face (maturity) value of US $100,000 and a 10 percent (annually compounded) interest rate would sell for US $62,092.

Bonds are usually developed and marketed by private, or at least quasi-public, financial service companies (e.g., an investment bank). They package the bond, determine the interest rate and the "tenor" (payback period), handle all of the other legal conditions attached to the issue, and finally market the bonds to the "public" (primary buyers are usually institutional investors such as insurance companies). These banks often also manage the repayment process and assume some responsibility if there is any default problem. Another benefit they offer is their ready access to the international bond markets, which have trillions of dollars available for investment. The institutional investors that buy bonds usually maintain a very broad portfolio of bond assets, with different risks, returns, tenors, and geographic origin.

In many countries, the ability to utilize bonds for energy conservation financing may be limited. Bonds generally require a secondary market—either within the country itself or in the international capital markets—in order to instill investor confidence. Bonds from Asia and Latin America, for example, are often traded on the markets in New York and London, as well as Buenos Aires and Kuala Lumpur. However, bonds from smaller markets, such as

Uganda or Bangladesh, may have more difficulty finding a receptive secondary market. The role of bonds will depend, among other things, on the quality of this secondary market.

There are many types of bond structures, but a few are most common to public entities. The authority to issue bonds usually derives from an entity having its own source of funding or taxing authority. The "coupon" (interest rate) for the bond will depend not only on the typical factors (such as prevailing rates and perceived host/institutional risk) affecting debt finance, but also on investors' confidence regarding the stream of funds from taxes or other revenue sources that will serve to pay them off. For instance, a bond issued by a sports stadium authority is likely to be well subscribed if the arena it is upgrading is well used and ticket sales are brisk, whereas a bond issued by a library would likely have to be directly supported by its municipal government (i.e., taxes) since libraries generally have little or no direct revenue. Since the revenue from energy savings is not likely to ensure investor confidence in most cases, other sources of funds for repayment will likely need to be demonstrated in order to attain low-interest bond financing for energy efficiency projects.

General obligation bonds (GOBs) are a common type of bond issued by public entities and are backed by the "full faith and credit" of the issuing agency or its parent. GOBs are not self-supporting, which means that, regardless of the application of the funds and any savings or revenues that are generated, these bonds must be paid off by the government; consequently, they are generally an inexpensive source of debt. GOBs are generally used for large-scale government programs or construction and are not common for stand-alone energy efficiency projects, although GOB issues dedicated to efficiency improvements do exist (see Box 4-4). Many GOBs, though, include some funds for energy conservation projects, among other initiatives.

Revenue obligation bonds, also sometimes called limited obligation bonds, legally secure the revenue from a particular source that is dedicated to repaying the bond obligations. These are common for projects where a predictable amount of revenue can be established (e.g., from municipal water authorities or electric utilities). If, for some reason, revenue is interrupted, there is no obligation on the part of the government to cover those losses. Because they shift some of the risk of repayment from the government to the lender, these bonds generally carry a higher interest rate.

Box 4-4. Bond Finance in a Transitional Economy

Municipal bonds, usually general obligation bonds (GOBs), are commonly used in many developed countries for energy conservation financing, but have only recently been attempted in transitional economies. The Bulgarian city of Varna, a Black Sea resort of 250,000, sold US $3 million in Euro-denominated bonds to fund efficiency improvements in 2002, largely targeting the replacement of outdated street lighting. The GOBs were paid out of the savings generated by the energy efficiency improvements and carried a 9 percent annual interest rate and a relatively short term of three years. The first payment was due after the first year. Since the energy efficiency investments have a projected payback of less than three years, the energy savings was more than sufficient to cover the bond obligations.

The projected energy savings of the conservation investment underpin the payments on the bonds; therefore, these bonds act much like revenue obligation bonds. However, Bulgaria's National Law of Municipal Budgets (1998) and the Law of Public Offering of Securities (2000) grant municipal governments the right to sell GOBs only. The security for the bondholders is that they are first in line for municipal revenues. However, because municipal governments in Bulgaria have little local taxing authority, the success of the bond issues was predicated on the support and explicit agreement of the national government to provide Varna with the necessary funding. According to the newsletter Clean Energy Finance: "One of the keys to the success of the bond sale was ensuring that the national government would not reduce its revenue payments to Varna in response to the municipality's lowered energy bills."

Source: Rezessy 2010.

One of the potential advantages to public-sector issued bonds is that they can be made tax-exempt by law in many countries. Consequently, they can offer a much lower interest rate than loans or taxable bonds. To a lender (bond purchaser) paying a 35 percent marginal tax rate, a 6.5 percent tax-exempt bond is as good as a 10 percent taxable one. This 3.5 percent savings in interest payments by the public entity can be enormous over the life of the bond.

- *Advantages*—While bonds can be more expensive to establish initially, they are generally the cheapest source of (unsubsidized) debt financing due to the competition inherent in their markets. Additionally, except for the cost of servicing the debt (interest), all of the energy savings are retained by the host entity. Since they can be structured in a variety of ways, bonds are also very flexible debt instruments. For instance, payments can be matched with savings (revenues), leaving the organization's cash flows intact or even improved over both the short- and long-term.
  Bonds are better suited than loans to accommodate the complexity of larger projects or a multi-project program. Where this level of funding is desired and tax exemption is available, there is a clear incentive for the public entity to utilize bonds, since the cost of funds will be cheaper than through direct loans.

- *Disadvantages*—The primary disadvantage to financing with bonds is the higher cost of obtaining and administering the funds from debt, relative to direct internal resources. Other disadvantages include:

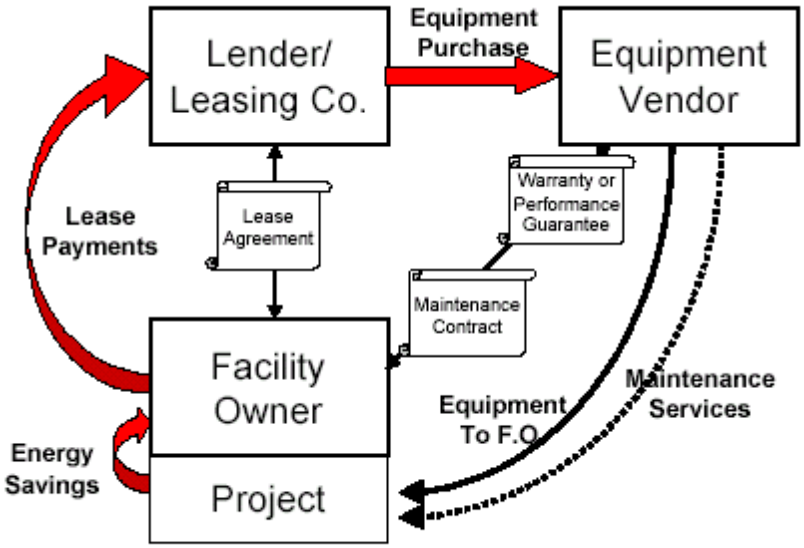
    - Debt costs can vary tremendously, exposing the borrower to the risk of interest rate fluctuations as well as other administrative costs that may be uncertain when the debt financing is first sought.
    - Institutions can run into debt ceilings or other limitations on borrowing. Public or legislative approval may be required, considerably lengthening the process of obtaining funds.
    - Debt borrowing of any kind limits an institution's ability to borrow for other projects.
    - Bond funding is more complex than direct loans. This complexity carries fixed costs, making bonds a poor choice for smaller projects unless they are aggregated by one institution (e.g., one government agency).

Lease or Lease-Purchase

Lease or lease-purchase schemes allow a customer to have the use of energy-efficient equipment and to pay for it with fixed payments over a defined period (see Figure 4-1). The only difference between lease and lease-purchase schemes is that the lessee (in this case, the public sector entity) can opt to acquire the asset at the end of the lease in a lease-purchase arrangement. This is commonly done for equipment that has useful life beyond the lease term, such as heating, ventilating, and air conditioning (HVAC) systems. For technologies that are quickly and constantly improving (e.g., computers or telecommunications equipment), the lessee generally will opt to renew the lease with newer equipment.

Leases are financed either by the equipment company (manufacturer or vendor) itself or by a third-party leasing firm. The credit capacity of the leasing company determines the availability of financing. Lease payments are usually considered to be an operating expense and thus avoid much of the scrutiny of a capital budgeting or loan process. This liberates the government from borrowing limitations or from the necessity of making difficult budget decisions. Lease payments can be structured to best match the expected savings and thus approximate a "net-zero" budgeting opportunity for the government—meaning that the actual out-of-pocket costs to the government at any time are zero.

Figure 4-1. Typical Lease or Lease-purchase Arrangement



Source: Nexant 2001.

A significant benefit to using a lease arrangement is that the payments for the leased system do not begin until the equipment has been installed and is accepted by the lessee. Thus, the public sector entity does not pay until the energy savings are actually produced, whereas under a loan or equity investment scheme, payments must sometimes be made before savings can be generated. This arrangement also transfers the construction and installation risk to the leasing company. Of course, any shift of risks and costs to the lessor will be reflected in the lease package's price; nevertheless, this arrangement does reduce cash flow problems for the government.

One potential problem in leases is the assignment of payments or security interests (collateral) in case of default. Often leases are collateralized by the equipment itself, particularly where it is seen as "critical" (for the lessee) by the lessor. In this case, the leasing company's threat to remove the equipment is often sufficient to ensure prompt payments. In other cases, there may need to be some assurance of payments from general funds or other sources.

A key cautionary note is that lease payments are normally fixed and regular, and not tied contractually to the performance of the equipment. In other words, the risks associated with energy savings not matching lease payments is carried by the lessee (in this case, the public sector entity). This risk can be mitigated by ensuring that a separate energy-savings warranty is created by the leasing company or the equipment manufacturer. Such warranties indemnify any loss to the lessee due to underperformance. However, these legal agreements can become onerous, driving up the costs of a lease arrangement. There is also the possibility of tying energy savings to lease payments. This arrangement is a type of performance contract and is discussed below under *Guaranteed savings leases* and in the "Energy Savings Performance Contracting (ESPC)" section.

Leases are attractive since they can be used for both large and small projects. While individual leases can be negotiated on any size project, for smaller projects or for institutions with multiple leasing needs, a leasing company may create a "master" lease arrangement that can then be amended to include new projects as they emerge. This master lease arrangement can reduce negotiation and administrative effort, and can enable the lessee

to spread the leasing costs over a portfolio of projects. In some cases, a master lease allows a large municipality or other public sector entity (e.g., a large university or hospital) to make efficient equipment available to numerous agencies or departments that would otherwise have to negotiate individually. This can create a great savings of time, effort, and management oversight.

There are several ways that public sector entities can utilize the lease structure to finance energy efficiency. For smaller projects, either the vendor or a leasing company can provide the capital. Lease revenue bonds are employed when a public institution wants to make available efficiency leasing to subsidiary institutions. For example, a city government can issue a municipally backed bond, the proceeds of which will be used to set up a lease arrangement with a hospital. The lease payments from the lessee (hospital) to the lessor (city) cover the payments to the bond holders.

There are two generic types of leases: capital and operating. A *capital lease* is simply a loan that is equal to the value of the equipment. At the end of the lease term, the lessee usually pays for the remaining worth of the equipment for some nominal value. Under an *operating lease*, the leasing company retains ownership of the equipment and any of the tax benefits that accrue. The lessee can renegotiate the lease for newer equipment (often done for computer or telecommunications equipment), or can purchase the equipment for the residual value.

The legal difference between these two lease types is usually a matter of tax regulation and their handling on the balance sheet. Since most public entities are tax-exempt (exceptions might be some parastatals, such as a state-run utility), the tax issue is generally not relevant. While private sector capital leases are usually considered as debt, both capital and operating leases within the public sector are generally handled as "off balance sheet" financing, which avoids the common governmental prohibition against assuming future obligations in the form of asset liens or unfunded payment obligations from general funds.

Beyond the more common standard lease and lease-purchase agreements, there are several alternative types of leases. *Guaranteed savings leases* may be either operating or capital leases. They are distinguished by the addition of clauses in the lease agreement that tie lease payments to a guaranteed level of energy performance. These are basically energy-savings performance contracts (described in the next section) using a lease structure. The advantage is that performance and financial risk are transferred from the public sector entity to the leasing company. However, with this shift in risk comes increased cost (i.e., higher lease payments).

Municipal (tax-exempt) leases are attractive options for municipalities in countries that offer tax-exempt status for municipal governments. These can be used with both operating and capital leasing options. The key provisions of most municipal lease arrangements are that the repayments must be appropriated annually in the operating budget, that they apply to essential equipment (this ensures an incentive to maintain lease payments), and that there is no commitment to the leasing company if the payments are not appropriated (though in these instances the leasing company can reclaim the equipment).

- *Advantages*—There are several key advantages to pursuing leasing to raise funds for energy conservation initiatives:
    - Leases are flexible instruments, capable of accommodating small to large initiatives, or even portfolios of projects.
    - Leases are not considered debt for most governments, so they do not limit (and are not limited by) a public entity's ability to borrow, nor do they require difficult internal budgeting decisions.

- Lease payments begin only once the project is installed, creating better matching of payments to savings for the end-user. Risks of installation and financing during start-up are borne by the lessor.
- Leases for municipalities may enjoy tax-exempt status, thus lowering the cost of capital.
- Most leases offer very competitive interest rates.

- *Disadvantages*—Most disadvantages are linked to the inherent complexity surrounding ownership of leases.
  - Leases can require competent financial and legal advice, and are therefore sometimes expensive to set up.
  - Costs of capital are still linked to borrower risks, as well as project risks.
  - Lease agreements usually include capitalized interest, reserve fund provisions, and other expenses that can drive up transaction costs and make leases more expensive.

Third-Party Finance and Energy Savings Performance Contracting

Third-party financing of energy conservation assets and services is a viable alternative to equity (internal budget) and debt financing. Third-party financing implies that an entity other than the equipment vendor will assume the responsibility for paying the capital costs of a project, with an ESCO (energy service company) installing the equipment and providing energy savings over a specified period. The financing entity can be either the ESCO itself or, more commonly, a separate financial institution (although often one that the ESCO has recruited for the project). With an outside financier, the loan usually is made to the ESCO, although sometimes, especially in public sector deals, it goes directly to the host facility.

This type of financing structure allows the host to acquire energy conservation retrofits by financing them as an expense. While the obligations to pay under third-party financing structures are just as binding as under debt structures, there are critical differences in that the third-party financier assumes the credit risk—although it receives a premium for doing so.

This situation is the most compelling part of performance contracting with third-party finance: Someone else will pay for the equipment, ensure the savings, and transfer control of the equipment back to the host after a period of time, all without requiring any additional money up front. The downside of these arrangements is that they depend on all parties in the transaction having confidence in the contracts that define, and bind, the parties. Moreover, relative to internally financed projects, they are expensive. The projects also hinge on the agreement of the parties to a baseline scenario—essentially, what the consumption (of the facility or the individual project components) would have been if not for the retrofit. With the use of an energy savings performance contract (ESPC), parties must also agree on the method of verifying savings. Without confidence in the technical, financial, and management skills of the parties, and the sophisticated documentation to enforce them (not to mention the court system), these types of arrangements are impossible. In developing countries they generally are only available to the most credit-worthy organizations.

Box 4-5. ESCO Financing in Hungary

Honeywell, the international energy equipment manufacturer, created an ESCO in Hungary in the late 1990s to take advantage of the private sector opportunities in managing energy assets such as district heating facilities. One of the projects they completed was the Siklos Project, which represented the first time a company put together a comprehensive energy efficiency package for a municipal district heating system. The US $700,000 project involved the installation of new boilers with a total capacity of 20MWth, heat exchangers, meters and other new distribution equipment in 60 substations, 1,000 apartments, and 17 public buildings. Honeywell financed these investments with roughly 70 percent debt from a local bank and the rest from its own equity.

Energy Savings Performance Contracting (ESPC)

Perhaps the most compelling form of energy conservation finance for public sector entities is when financing is coupled with performance contracting. In its simplest form, an energy conservation measure (ECM) is designed, procured, installed, and sometimes maintained by an ESCO. This is the classic "win-win" scenario in energy conservation finance, in which all payments for the energy services and equipment are paid from the money saved by those services. Often, and more importantly for the public sector entity, in ESPC performance, risk is borne by the ESCO in the form of a savings guarantee or shared savings arrangement. Because of this, the performance contracting method usually (although not always) involves a turnkey project, from initial audit through project monitoring.

Box 4-6. Canada's Federal Building Initiative

Canada's Federal Buildings Initiative (FBI), despite a modest budget (about US $700,000) and just a half dozen employees, has leveraged private sector funding to make enormous efficiency gains in Canada's federal building stock. After 20 years of existence (through 2013), it counted among its achievements more than 80 retrofit project representing nearly US $300 in private investment and saving close to US $40 million per year in Canadian government buildings.

According to the FBI's former head, John Brennan, the program got its start based on three assumptions about Canada's federal agencies vis à vis energy conservation: They do not have identified funding; they do not have trained staff; and they do not have the necessary energy management knowledge. Given these constraints, the program turned its focus to third-party finance and performance contracting to help it achieve savings.

Several characteristics differentiate the Canadian government's performance contracting program from similar efforts in the United States and other countries. One such feature is the importance the Canadian initiative places on employee outreach. To encourage facilities to develop a sense of ownership of the conservation work in their buildings, FBI requests that participating ESCOs include an employee awareness program in their proposals.

Another element that distinguishes the Canadian performance contracting program is its emphasis on training. In its early years, FBI found that the technical potential of the ESCOs' energy conservation measures was often not realized due to agency building operators' limited understanding of the installed measures. As a result, in addition to providing basic manuals and training on the installed measures, FBI now requires the participating ESCOs to outline a broader energy management training program for the building operators. In addition to the training program, ESCOs are expected to include in their proposals an assessment of the potential for renewable energy use as part of the intended project.

FBI provides an excellent model for governments with undersized energy management budgets. Not only has it successfully overcome the scarcity of its own resources and those of the Canadian federal agencies it serves—by sponsoring a thriving energy performance contracting program—but it has done so in a way that integrates the training and employee awareness elements that fortify and compound those savings.

Sources: NRCAN 2014; Brennan 2003.

Under this scheme, an ESCO—which can be an equipment vendor, an engineering firm, a utility subsidiary, or a dedicated performance contracting company—enters into an ESPC with an energy customer (e.g., a municipality)

to provide energy conservation services and equipment (energy conservation measures, or ECMs), guaranteeing the performance (i.e., savings) of the ECMs over a period of years. The facility owner agrees to pay a specified amount over the life of the agreement. Financing can be undertaken by the ESCO or an independent financier (such as a bank); the latter is the most common arrangement, especially in emerging markets, because most ESCOs do not have the credit capacity necessary to assume the debt from multiple projects. Performance contracting can address specific energy loads or can cover the entire energy use within a facility.

ESPCs are usually structured so that the project's costs (including debt service), any necessary training of the project host's staff, and measurement and verification are all paid from the reduced energy, water, and operations and maintenance (O&M) costs associated with the installed ECMs. Contract periods vary in length, but are usually between three and seven years in developing countries; public sector performance contracts in developed countries are generally longer, up to 25 years. Most contracts come with early buy-out clauses if the facility owner wants to terminate the agreement and assume full control of, and responsibility for, the assets.

There are usually three or four primary parties to a performance contract: the facility owner, the ESCO, the financial institution, and sometimes an independent measurement and verification (M&V) company. The roles of the parties are defined as follows:
Facility owner: The public sector facility owner in these public-private partnership arrangements plays a role that is in some ways very similar and in other ways distinct from its normal position in a contracting relationship. To succeed, the relationship with the ESCO usually needs to be more collaborative than in a conventional contract. The key steps for the facility owner are to:

- Enter into a contract with the ESCO that spells out each party's obligations and expectations for the ECMs. To optimize the potential of this type of relationship, the ESCO and the government need to coordinate on the development of the project. This may take several months.
- Enter into the financial agreement with the financier, assuming the loan is not made directly to the ESCO. In any case, this deal is often conducted with the support and guidance of the ESCO. The loan amount is transferred from the financier to the ESCO on a timetable to match expected expenses. The public entity is then responsible for making the regular specified loan payments.
- Through the energy savings generated (and accounted for either in separate accounts or in general funds), make loan payments. If there is a savings shortfall, the ESCO must make up the difference.
- Operate equipment in a specified way to ensure that savings are not compromised through poor O&M or employee error. Owners must also coordinate with ESCO energy managers to ensure efficient operation.
- Upon termination of the contract or lease, take the conservation assets onto its books (assuming that this does not occur upon installation, as is sometimes done for tax reasons) and enjoy the entire savings stream.

ESCO: The ESCO should be able to provide energy services from auditing to construction, and also help the host facility arrange financing. ESCOs are businesses with the ability to integrate engineering, construction, financing, and operations to maximize energy and financial savings. Their critical roles are to:

- Develop the project concept, often by initiating the energy audit and scoping the size and potential savings of the project.

- Arrange and/or provide engineering, procurement, and construction, and take the project through to its turnkey completion (including commissioning, and sometimes also some O&M services).
- Generate at least the minimum energy savings amounts as specified in the agreement (or if not, where there is a savings guarantee, compensate the facility owner for the shortfall).

Financial institution: The financial institution must grasp the nature of energy services and the concept of reduced costs being equivalent to increased revenues. In other words, it must understand the potential of energy conservation to create cash flow. It also should be comfortable, if possible, with lending against an asset that will have little or no collateral value outside of the facility. The financing institution's main responsibilities are to:

- Agree to loan terms with the facility owner or ESCO. Collateral or pledging agreements are common, but some facilities will seek to service the debt exclusively from cash flow from the ECMs' savings.
- Provide funds for all or a portion of the project, including costs during construction, capitalized grace periods, and performance period expenses (i.e., any of the ESCO's expected costs related to O&M, M&V, training, or repair and replacement during the contract's term) in a way that best matches payments to expected savings.

Measurement and verification firm: An M&V firm is sometimes an additional party to the project. Its functions are to independently ensure that savings are generated and to document the ECMs' performance. This is usually done annually, but can be more frequent. The M&V firm generally begins its involvement before the ESCO's installation process begins, in order to assess the baseline usage of the facility or component systems. Its primary roles are to:

- Establish the baseline(s) against which the savings will be measured.
- Determine the M&V techniques by which the savings will be assessed. There are several options commonly used to do this, more than one of which can be used on a given project (assuming it has multiple ECMs). These are usually specific measurement methods created under the International Performance Measurement and Verification Protocol (IPMVP).[6] They help to standardize the M&V process and avoid conflicts as conditions change.
- Provide periodic verification of the savings and report back to the other parties to ensure that all is proceeding as planned (this can include alerting the facility if ECMs are underperforming due to unsatisfactory O&M by the facility).

Although there are multiple variations of ESPC types, two basic kinds—guaranteed savings and shared savings—are most common. In guaranteed savings contracts the ESCO ensures a defined performance, often assuming the risk for underperformance, while the government is the beneficiary of any savings beyond the guarantee. Guaranteed savings contracts are usually employed when the facility owner, as opposed to the ESCO, is assuming responsibility for the financing. This is more practical in cases where ESCOs are undercapitalized or do not have substantial credit histories, or where facility owners (e.g., municipalities) have better access to low-cost financing (bonds or government loans). Under this scenario, the facility owner enters into two agreements—one for financing and one for the energy services. When financing is from external sources, ESCOs can help arrange it and establish a payment structure that matches savings expectations. However, ESCOs are usually not a party to the financing,

[6] IPMVP is owned and maintained by the Efficiency Valuation Organization, www.evo-world.org/.

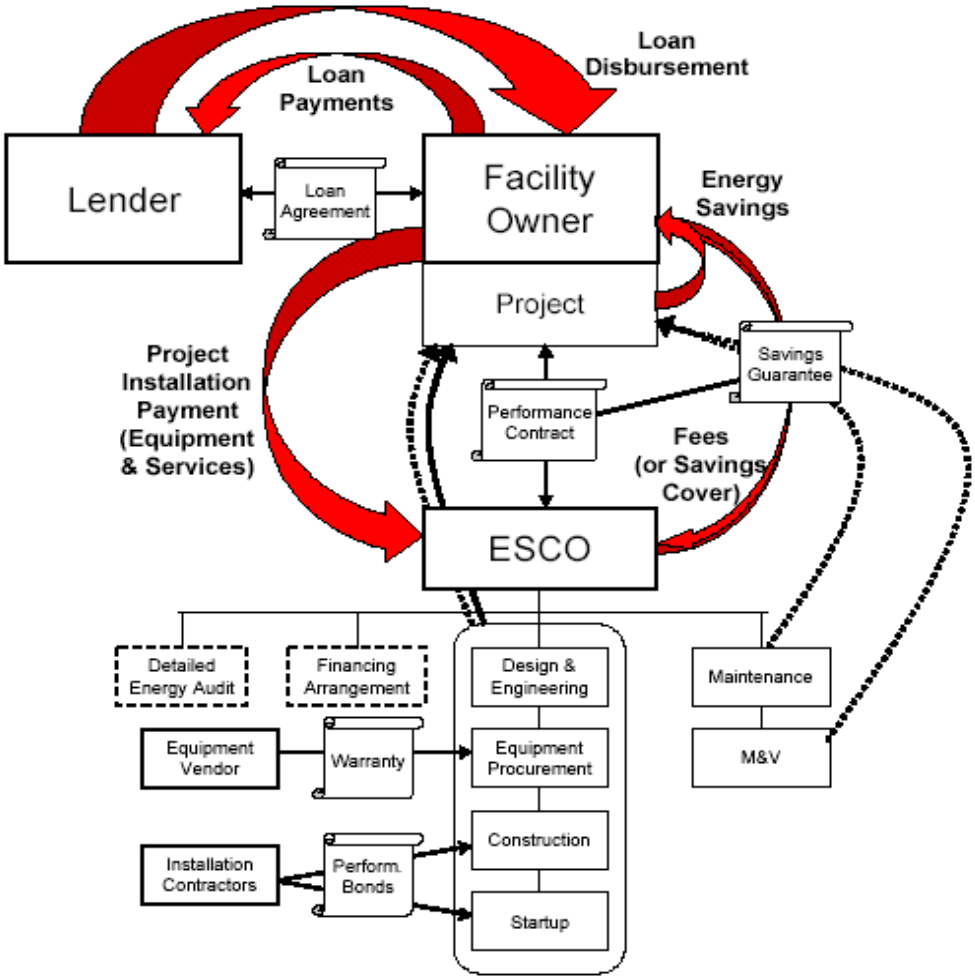
except as a guarantor of the savings. The second contract is between the facility owner and the ESCO for the ECMs and the expected savings. This contract lays out the terms and conditions for services, savings, and payments. If savings fail to match the facility owner's costs, including the financing costs, then the contract can hold the ESCO responsible for making up the difference (or paying a penalty). The ESCO typically provides the energy services on a turnkey basis, which can include all services from initial audit to measurement and verification of the savings (though the latter is often conducted with "witnessing" by the host site).

Shared savings performance contracts are less common than guaranteed savings contracts. They are more typically used if the ESCO is underwriting the financing of the ECMs. Shared savings contracts specify the proportion of the energy savings to be split between the facility owner and the ESCO. Often these agreements set aside funds adequate to cover all of the basic costs of the project (e.g., equipment, finance, O&M) and then stipulate that any savings in excess of these fixed costs will be shared between the host and the ESCO by an agreed upon formula.

- *Advantages*—ESPCs are well-suited to organizations that lack the necessary technical skills, or staff, to undertake the ECMs themselves. These types of contracts also can free up internal human resources that might have been devoted to these projects to do other things (although some facility management and contracting resources are critical to EPC success). EPCs are particularly appropriate for organizations that have limited financial resources they can devote to energy conservation. By packaging ECMs for both the facility owner and the financial institution, the ESCO can help overcome the barriers to investment. Performance risk of the ECMs is shifted to the ESCO, the entity most able and willing to absorb it. The ESCO is then motivated to ensure that the savings are realized for the facility.
- *Disadvantages*—There are many barriers to success in energy savings performance contracting, especially in countries with fragile or ill-defined legal systems and limited capital access. ESPCs are also not appropriate to every kind of project. Since the transaction costs associated with undertaking a performance contract can be quite high, the size of the project must be large enough to justify them. Many full-service U.S. ESCOs consider projects under about US $1,000,000 (in initial project expense) not worthwhile. Performance contracting may also not be appropriate in situations where facilities have unpredictable energy consumption patterns. The greater the stability of energy use, the easier it is to predict, and also achieve, the savings. Other prospective downsides to performance contracting are also worth noting:

    - Risks associated with underperformance of the ECMs can create legal and financial consequences that make this type of arrangement difficult.
    - Because of the greater associated risks, less of the benefit of a successful project accrues to the facility owner during the contract's term.
    - As risks go up, so do costs: A US $1 million project implemented through internal budgets can become a US $1.3 million or greater project under a performance contract once the costs and risks of the ESCO and financial institution (and possibly the M&V firm) are incorporated. This lengthens the payback period and reduces the net benefit to the facility owner.

Figure 4-2. Cash Flows in an ESPC



Source: Nexant 2001.

4.3. Considerations in Selecting a Financing Vehicle

As demonstrated, there are a variety of methods for funding energy savings, but most have some common variables that can be compared prior to selection. Many of these issues are not unique to energy conservation finance; most of them are related to risk. The following is a brief description of the issues (summarized in Figure 4-3) that a public entity should understand in order to make the most informed decision.

Transaction and Opportunity Costs

The cost of money must include the time and expense it takes to generate it. It may be better, in some cases, to pursue more "expensive" money (i.e., with higher interest rates) that can be accessed quickly rather than to pursue cheaper funds that require a great deal of time and/or administrative cost to secure and manage. There have been numerous examples where government agencies had to make difficult choices about whether to proceed with a performance contract—with its ostensibly high cost of financing—or to wait for appropriated dollars that were

expected to materialize sometime in the future. Because lost time—when the ECMs have not been installed and thus are not saving energy—is lost money, this very real "opportunity cost" needs to be factored into the decision making. The energy and financial manager must be able to balance these kinds of considerations to determine the most effective financing strategy.

Figure 4-3. Pros and Cons of Primary Financing Methods

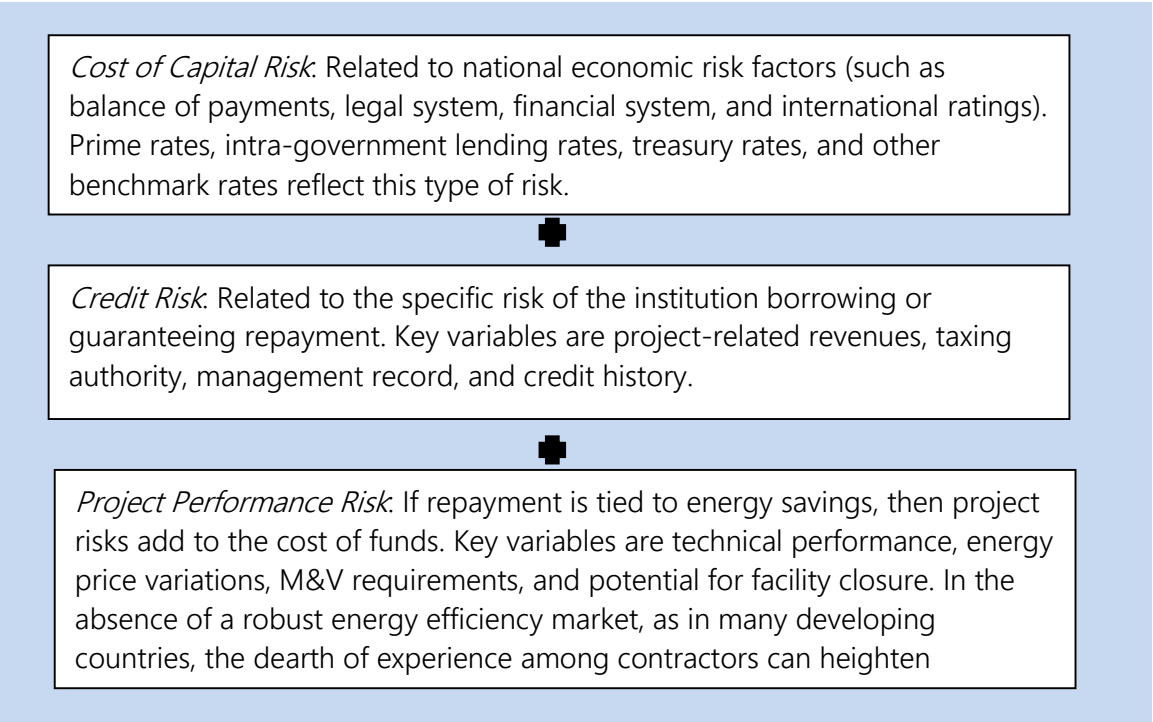
Financing Mechanism	Advantages	Disadvantages
Internal Capital Allocation	Simple administrative process due to fewer decision makers and absence of outside parties. Lower cost of development, M&V, and reporting.	Requires upper management support. Energy projects are in competition with other "priority" projects, so funding may be inadequate or substantially delayed. Difficult to capture and retain savings in many government structures.
Loan or Bond	Projects can be evaluated against objective financial criteria instead of other competing funding needs. Cost of debt can be low if public entity has good credit rating or if a subsidy or outside guarantee (e.g., from an international development bank) is available.	More complex development and administrative process. Savings must be carefully accounted and allocated to loan repayment. Liens or other collateral may present problems for government. Slightly higher overall cost due to higher cost of capital.
Third-Party (Project) Finance	Requires little or no up-front capital from end-user. Typically, the ESCO undertaking the project generates the financing based on solid contract with government and relationship with financier. Payments to financier are treated as expenses for administrative purposes. For an investment of time and some management input, public entity can end up with fully functional project at time of first payment.	Development time is longer, and management and debt costs are higher, due to more complex structure and risks—thereby reducing savings values to public entity over project term. Contract structures can be complex and may require legal input and senior management support. Requires detailed operational terms with ESCO, especially on usage, operating assumptions, and M&V. Total value of savings must be split between lender, ESCO, and public entity. Experienced ESCO with capital to invest may not be available.

Risks

Financial institutions are often blamed for high interest rates or the unavailability of capital for conservation projects. However, in most cases, financial institutions are reactive bodies, merely reflecting the larger risks of repayment that a given loan may bear. Quite simply: The greater the perceived risk, the higher the cost of capital. Risks are often managed as layers above a basic prime level (i.e., the rate available on a very low-risk project to a highly reliable borrower). If a public institution is in a country with stable capital markets and adequate legal protections, and is well managed with a steady revenue base, then the risks to the creditor will more likely be deemed acceptable and rates will be commensurately lower. However, if any of these factors is not in place, absent some governmental or multilateral guarantee authority, the cost of capital will rise with each risk factor.

Once the specific risks associated with an energy conservation project are added, financial costs can rise even further. If there is a third party underwriting some of the risks (i.e., a financial institution separate from the ESCO), this will also likely increase financing costs. While there are many specific risk factors important to project financing, the following three are the most critical (see also Figure 4-4).

Figure 4-4. Layers of Risk



Cost of Capital Risk

Cost of capital risk comprises the market risk on interest rates that affects any loan. The interest rate for borrowed money is related to several factors, some general and some specific. General factors affecting interest rates include prevailing market rates, current and expected inflation rates, and the general health of the legal and financial systems. Factors affecting the interest rates available to specific government institutions include budgetary capacity,

including revenue generation, availability of outside capital, terms of available loans (e.g., repayment schedules, loan lengths, collateral requirements), and the credit capacity of the borrower. For public institutions, the interest rate charged can also be a reflection of their ability to pledge either assets or revenues (although the expected savings stream from the project is generally not considered an attractive source of revenue) to back the loan.

As energy conservation investment moves along the continuum from internal budgeting through debt finance to third-party finance, its success depends heavily on the institutional and legal framework in place in the country. Countries with overall favorable investment climates will have favorable conditions for energy conservation financing. Under performance contracting, for example, legal issues (including the risks inherent in litigation) become more important because the viability of the project financing rests on a network of contractual requirements between the parties.

Each of these risk factors raises the cost of money for an energy retrofit. A US $400,000 energy retrofit with a two-year simple payback to the energy customer may end up as a US $600,000 project with a five-year contract under an ESCO-financed performance contract. Each of these options has its advantages and disadvantages (as described elsewhere in this chapter), but the key government managers should be aware of the real costs associated with each mechanism.

Credit Risk

The credit capacity of the entity assuming the loan responsibility and the specifics of the contract have a great impact on the costs of financing. Where credit ratings are assigned, the task of the lender is considerably easier. These credit ratings are not often available for public entities in developing countries and thus in many cases the prospective lending institution must assess this risk individually. This cost of assessment is often reflected in both the fees and time to set up the loan, as well as in higher interest rates. Uncertainty is expensive—in other words, a poor credit rating is often better than no credit rating.

Other issues related to credit risk are loan security and asset collateral. Generally, public agencies do not have the types of assets that lenders prefer to use as collateral. In many cases, public entities are restricted from pledging physical assets against loans. In addition, commercial banks are usually not interested in taking over public assets. Also, in the case of efficiency retrofits, once the equipment is installed, it has little or no value as collateral against any loans or lease agreements. Additionally, retrofit costs usually include significant design, installation, and start-up costs that cannot be recovered. Finally, there is the problem of securing energy savings from projects as credit support for a loan, which is an alien concept to most prospective lenders. Ultimately, the credit of the organization must be used in most cases.

Another credit risk in a project is that of the service or equipment provider. This is relevant if these entities are the ones borrowing the money (i.e., from a third-party financier), even though the host facility is responsible for paying it back. If the project goes into default, these parties may be deemed culpable; consequently, their creditworthiness is another risk associated with the project.

Project Performance Risk

If financing is tied to the performance of a conservation project, then the risk of underperformance will affect the cost of financing. Performance risk comprises the risks associated with technical performance of the equipment (some of which may be covered by warranty, at least at the beginning of the contract term), construction and installation, operations and maintenance, energy prices, energy usage patterns, and any other variable that may

affect the generation of energy and/or financial savings. Some of these variables— such as energy prices and usage patterns—are contractually fixed (stipulated) at the signing of the contract, and others may introduce little additional risk for the lender.

For example, if a financially sound equipment vendor with a good track record is guaranteeing the technical performance characteristics (and is providing warranty compensation for underperformance) of the project, then this risk may be considered minimal. However, if the organization guaranteeing performance is a small ESCO with uncertain financial assets, then the risk to the lender will likely be perceived as greater and the cost of funding will rise.

Budgetary Advantages and Disadvantages

Different financing mechanisms have different budgetary burdens for a public entity, and the relative merits of each must be weighed for each project or program. For example, a budget allocation for a one-time energy conservation project may be the simplest to administer and will likely generate the greatest return for the public entity, but it must compete against other budgetary demands—such as increased staff, information technology, or non-energy facility or municipal infrastructure upgrades—for its funding. A loan, from either a government or commercial bank, may relieve budgetary limitations and allow for payment terms matched to savings, but it might impede other borrowing, or be limited by statute or government bylaws. A third-party financing arrangement may alleviate the two problems noted above, but it also reduces the net budgetary benefits of the efficiency project over the long term, as most of the savings are devoted to offsetting the ESCO's and financier's risks and other costs of financing.

Management of Different Financing Structures

The benefits of each financing structure must also be weighed against the level of complexity associated with its establishment and management. Transaction costs associated with different financing structures, ranging from researching the various options to administering payments on a loan, vary. A simple budget allocation may be easiest: A facility manager requests funding for new equipment and it is debated internally and approved; the manager procures the installation (including equipment and a warranty) and assumes responsibility for its performance. There is no monitoring required of actual efficiency, nor of the net financial impact on the institution, unless it is specifically requested as part of the requirements of the budgeting process.
If a loan or lease is pursued, the administrative process for securing the loan may be time-consuming, especially if multiple approvals are required. Once the loan is in place, it is likely that any monitoring required will be by the public sector entity itself to ensure that expected savings are being realized.

However, when a performance contract is pursued, particularly with third-party financing, legal contracts must be drawn up and entered into, baselines established, and loan agreements secured. Management may require a matrix of operations and maintenance guidelines, and verification of savings, until the contract is terminated.

Investment Criteria

Each institution must establish a basis for measuring return on investment in order to prioritize efficiency projects. These rates become important in determining the most effective financing method and in deciding which projects receive support. There are several measures of a project's attractiveness and each is useful when employed properly.

Simple Payback Period

Calculating a simple payback requires two measurements—the cost of the project and the expected savings (usually per year). The cost is divided by the annual savings to establish the payback period. For example, if a US $100,000 retrofit is expected to reduce energy costs by US $40,000 per year for 10 years, its simple payback period is 2.5 years.

Obviously, simple payback is attractive in terms of its simplicity to calculate and its immediate intelligibility. However, there are two dangers of using a simple payback period. First, it does not account for the opportunity or borrowing cost of money. Second, considering a simple payback threshold alone may lead to selection of a measure that, while it pays for itself quickly, does not yield significant benefits relative to another more substantial, mutually exclusive, measure. For instance, increasing filter change-outs in rooftop packaged air conditioners from annually to quarterly in a large facility may yield US $1,000 of annual savings (in fan power) for an added cost (in labor and materials) of US $2,000, yielding a simple payback of two years.

Alternatively, converting to water chillers to cool the same space may provide US $50,000 of annual savings for US $300,000 of investment, for a six-year simple payback. However, the chiller changeover will provide much greater savings over the long run (i.e., it has a higher net present value—see below). Thus, the use of simple payback is a decision method that needs to be scrutinized carefully. It is appropriate when comparing non-mutually exclusive ECMs within the same financial environment. In other words, if evaluating multiple measures that could feasibly be implemented together and which would all be financed in exactly the same way (budget set-aside or lease-purchase, for example), then using simple payback is a perfectly acceptable way to prioritize them.

Net Present Value[7]

Net present value (NPV) represents the value today of future cash flows. It is a way of looking at the future value of money (a dollar today is worth more than a dollar in one year), subject to an "internal discount" or "hurdle" rate—the rate of return that represents the investor's (or host facility's) investment criterion (e.g., 5 percent to 30 percent are common). NPV compares future cash flows, such as the savings stream from an energy conservation project, with expenditures on a project (most of which occur at the beginning but some of which may also occur in the future and thus also be subject to discounting).

If a project's NPV is positive, then it meets the required rate of return for the facility and should be pursued. Generally, that hurdle rate is determined by whatever alternative investments with similar risk are available. For example, a project is considered that would require diversion of funds from similar investments that are expected to generate a 10 percent return. When evaluating future cash flows using this 10 percent hurdle rate, if the NPV is positive, it indicates that the project is a better investment than the alternatives being considered. If it is negative, it is a worse investment and the project should be abandoned in favor of the other opportunities. NPV is generally considered the purest and most failsafe financial criterion for judging energy projects against competing projects.

Internal Rate of Return

The internal rate of return (IRR) is the opposite side of the coin to NPV. It will identify what effective rate of return is generated by these future cash flows if one assumes the NPV of a project to be zero. For instance, using

[7] Another closely related concept, "life-cycle cost" (LCC), is used by the U.S. Federal Energy Management Program (FEMP) and others. Hence, the frequently used attribution, "life-cycle cost-effective," is equivalent to declaring that that measure or project has a "positive NPV" given a chosen discount rate.

the same example from above, with a US $100,000 investment that provides US $40,000 in savings per year for 10 years, the IRR is 38 percent; thus if the annual US $40,000 savings is subject to an internal discount rate of 38 percent, it will have an NPV of 0. And assuming that 38 percent exceeds the entity's hurdle rate, the project should proceed. This measure is probably the most commonly used by the financial industry.

Figure 4-5. Common Investment Criteria With $100,000 Outlay and $40,000 Annual Savings

Initial Investment	Annual Savings (for 10 years)	Simple Payback Period	Net Present Value* ($NPV_{10\%}$)	Internal Rate of Return (IRR)
$100,000	$40,000	2.5 years	$132,530	37%

* Assumes a 10 percent internal discount rate.

Sources of Finance Support

An important component of energy conservation finance in developing economies with emerging efficiency finance markets has been the support of the national government and sometimes the national and/or local utility, often with the backing of international finance institutions (IFIs) and bilateral aid agencies. Examples of IFIs are the World Bank, the Global Environment Facility (GEF), and the Inter-American Development Bank (IDB). Prominent aid agencies are generally those found in developed countries, such as the U.S. Agency for International Development (USAID) and the German Organization for Technical Cooperation (GTZ). These institutions can lower the barriers to efficiency projects by helping to establish the precedents and legal foundations that can reduce the costs of implementing energy conservation finance. IFIs and donor agencies can provide technical assistance, financing documentation, M&V protocols, direct loans, and loan guarantees. A public facilities manager should seek out information about any such existing financial mechanisms, and take advantage of them to increase in the likelihood of project success.

In summary, the key factors to consider when deciding which path to follow in financing energy conservation projects are:

- The transaction costs (especially of staff time and expertise) inherent in different financing mechanisms, which tend to be higher with more complex structures.
- The opportunity costs of delaying the project (often a problem with internally funded projects) and/or curtailing its scope to fit a limited budget.
- The risks an agency is willing to shoulder versus the costs to transfer them to other parties.
- The budgetary implications of the financing (e.g., what are the other priorities for internal funding; what constraints are implicit in borrowing for the project; and to whom will the project's savings accrue?).
- The administration of the project (e.g., transaction costs in obtaining a loan and M&V requirements for performance contracts).
- The public institution's investment criteria (e.g., IRR or simple payback thresholds).
- The potential for outside support (e.g., a loan guarantee or utility incentives) for the project.

While there is no simple guideline for making the selection, consideration of these factors will generally narrow the possibilities and reveal the most desirable options. As with many difficult decisions regarding energy projects, it is often the case that merely making a choice (in this case, among financing options) will yield greater savings than remaining frozen by indecision.

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CHAPTER 5—NEW CONSTRUCTION

Key Considerations in Developing a New Buildings Construction Program

1. Because highly efficient buildings typically use 20–50 percent less energy than average ones, the life-cycle savings of energy efficient new construction programs can be enormous, even given the fact that new buildings only represent a small addition to the stock each year. New construction is an opportunity to "lock in" efficiency for the lifetime of buildings.
2. Public sector (especially government) buildings are models for the citizenry they serve. This influence is most prominent through demonstrating construction features and concepts to those in charge of developing buildings, but also is important for educating designers and tradespeople in energy-saving principles and practices.
3. Studies reveal that the perception of a high first-cost premium for energy-efficient and green buildings is largely exaggerated. Average premiums in the 2 percent vicinity have been shown to yield very efficient (greater than 30 percent energy reductions relative to code compliance) and sustainable buildings. Furthermore, integration of energy conserving passive design often permits substantial downsizing of lighting and especially mechanical systems, reducing or eliminating the first-cost premium by lowering equipment requirements.
4. The first step in developing a new construction program is to investigate current practice by reviewing recently erected buildings and their construction processes.
5. When prioritizing efficiency improvement measures, take into account incremental costs versus expected savings as well as factors such as the portfolio of expected construction (e.g., what types of buildings will predominate) and the capabilities of local architects and engineers.
6. One way to jump-start a government-wide initiative is with one or two well-publicized demonstration projects. These should have high visibility and be clearly replicable (i.e., they should not be seen as exotic "one of a kind" projects).
7. Choose the project's architects and engineers based on their demonstrated experience with low-energy and sustainable design, as well as their familiarity with key principles such as life-cycle cost analysis and energy simulation.
8. Insist on charrettes (intensive collaborative multi-stakeholder design sessions) and "whole-building" design approaches for all new construction.
9. Set measurable goals for buildings in the program, such as a specific energy use intensity (usage per area or other relevant parameter) or a percentage of energy savings relative to code requirement.
10. Make sure that the budget procedure for new construction does not hinge solely on first-cost minimization. A life-cycle costing methodology is optimal. At the least, insist on a simple payback period (e.g., five or ten years) threshold.
11. Remember that additional amounts invested in energy-conserving design, including energy simulation, will generally pay off in reduced operating costs. Failing to budget adequately for design costs is a common mistake that usually results in inefficient buildings.

12. Commissioning—A thorough post-construction inspection process to assure that building systems function in compliance with the project's documented design intent—is essential to the proper functioning and energy efficiency of a building. Both systems and whole-building commissioning should be required of all newly constructed buildings.

In industrialized countries, buildings consume about 40 percent of the primary energy and about two-thirds of the electricity generated. Historically, energy use in developing countries has been dominated by the industrial and agricultural sectors, and this is still largely true. However, buildings are a fast growing segment of the energy pie in these countries due to significant economic growth, the increasing use of air conditioning, and design and construction practices that promote inefficient energy use (e.g., glass facades in tropical climates). Additionally, in many developing countries there are few codes or standards to help make buildings more efficient.

Promoting energy conservation and sustainable design in public buildings can a) reduce energy costs and environmental impacts of these buildings, b) demonstrate the benefits of energy-efficient design to owners and designers, and c) help develop expertise in the local design and construction community. New construction is the most cost-effective point at which to institute energy conservation and sustainability, before investments are made in inefficient buildings and wasteful systems (and practices) become embedded and accepted.

5.1. Elements of a Program

Energy conservation is arguably the most important component of sustainable design. The energy used in the operation of a building over its life cycle far outweighs the energy used to produce the building and its constituent materials (Cole and Kernan 1996). Energy-saving features are also among the easiest of green building measures to justify financially, since they directly reduce future operating costs. However, before creating a successful new construction program, it is important to educate planners and funders that have government fiduciary responsibilities, not only as regulators, but also as resource consumers. Increasingly, public entities are being compelled to take on the challenge of energy conservation and sustainability, and this trend is unlikely to change.

Making the Case

The first step in the development of any program is to assess and prioritize its potential impact. One of the objections raised against emphasizing energy-efficient new construction is its scale, which is typically fairly small compared to the existing building stock (2–4 percent on average in the U.S., though considerably higher in some fast-growth developing countries). The question may thus arise: why not just focus on existing buildings? There are several reasons to invest in a new construction program:

- Even a 2–4 percent annual addition to the building stock adds up over time. The average building's life cycle is 50–70 years and even longer for many institutional public buildings. Thus, designing buildings correctly locks in a lower level of consumption for a long time and reduces the need for future energy retrofits.
- The opportunity to affect a building's energy consumption is greatest during its design and construction. According to the U.S. Green Building Council, "in terms of energy costs alone, savings of 20–50 percent are common through integrated planning, site orientation, energy-saving technologies, on-site renewable energy systems, light-reflective materials, natural daylight and ventilation, and down-sized equipment." The U.S. Environmental Protection Agency's ENERGY STAR® Buildings Program, an initiative to promote and

reward energy-efficient buildings, claims that ENERGY STAR-labeled office buildings (those whose energy performance places them in the top quartile among similar facilities) cost an average of 40 percent less per year to operate than the average office building.

- Contrary to common perception, new buildings tend to be more energy intensive, even if they have more efficient heating, ventilating, and air conditioning (HVAC) and envelope components. New buildings are more energy-intensive because they usually have higher occupant densities, more computers and other internal equipment, and wider use of air conditioning.
- While new buildings may be required to meet the latest codes, these codes are still generally designed as a least common denominator for buildings under a wide range of conditions. For the great majority of buildings, the codes do not represent the highest level of energy efficiency that is economically justified. Moreover, most codes do not even address some of the important energy-using aspects of commercial buildings, such as plug load.
- In some cases (e.g., major housing initiatives, Olympic construction, or government restructuring or expansion), a commitment to new infrastructure creates a rare opportunity to affect a multitude of buildings and gain more public visibility for energy efficiency and sustainable design.

In assessing the overall impact of new construction, it is important to understand costs and benefits not only in terms of financial costs (i.e., first costs and operating costs), but also with regard to human health and productivity, and environmental impact. While energy and even some environmental cost savings are readily quantifiable, benefits such as comfort and productivity are more challenging to measure since they rely on data such as absenteeism, retention rates, and work output. However, several studies indicate that increased worker productivity results from an improved indoor environment (Loftness and Hartkopf 2002). A building design that appropriately integrates daylight with electrical lighting can reduce energy use and associated carbon dioxide (CO_2) emissions while also improving occupant comfort and productivity (Heschong, Wright, and Okura 2002).

Other environmental implications of new building construction are also compelling. Locally sourced building materials, aggressive storm water management, proximity to public transportation, easy accessibility for bicycles, and other non-energy environmental features can be a key for any public sector entity considering—and trying to make the case for—an energy-efficient new construction program. While these "green" aspects may not provide the direct cost savings of the energy conservation features, they create high quality built environments, and contribute public relations benefits because of their value to the public good. Contrary to strict economic analysis, these environmental features can sometimes help in maintaining the energy-saving measures in the project, rather than the other way around.

Public Sector Barriers

The public sector itself is often perceived as one of the barriers to green building. A 2002 study commissioned by the Australian-based NSW (New South Wales) Sustainability Advisory Council documented the building industry's perceptions and experience about sustainable construction. In all four categories studied (regulation, integration of people and process, market-based incentives, and awareness/education) all levels of government were seen to present obstacles to sustainable building. Low-bid mandates, poorly executed "value engineering" (a cost control exercise that seeks to minimize construction expense without sacrificing quality), the dearth of design/build contracts for construction, and information shortage or overload all were found to contribute to the building industry's negative experience with, and perception of, government entities around the world.

Despite this negative perception, governments can be key actors in reducing the impacts of energy consumption through sustainable building practices because of their prominence and leadership role.

First-Cost Premium

The perceived first-cost premium is a common barrier to the adoption of energy-saving, sustainable construction practices. However, this is not a predetermined fact, particularly when following a whole-systems approach. Well designed, efficient buildings can often permit significant downsizing of mechanical and electrical equipment, thereby offsetting the increased investments in low-energy design and energy-efficient products.

The magnitude of a first-cost premium, if any, depends on variables such as the base-case construction budget, the skill and creativity of the designers, the familiarity of contractors with energy-efficient construction methods, the bid environment, and the local market for energy-efficient products. Some of these parameters (e.g., the state of the construction economy) may even vary over time in a given location. Therefore, it is very difficult to provide broadly applicable guidance on first-cost premiums for energy-efficient buildings. However, several studies (e.g., Pless and Torcellini 2012) support the argument for the cost-effectiveness of considerably increased energy conservation, revealing that the first-cost premium can be significantly reduced or even eliminated through creative integrated design.

With the growing interest in green buildings, the U.S. Federal Energy Management Program (FEMP) in 2003 commissioned a study on the business case for sustainable facilities. The study compared two prototypical 20,000 square feet (roughly 2,000 square meters) federal buildings—one that met the minimum requirements of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 energy efficiency standard, and one that exceeded the standard by incorporating various sustainable design features. The results showed that energy costs could be reduced below the base case by 37 percent with a package of measures that increased first costs by less than 2 percent and provided a simple payback of 8.7 years (FEMP 2003). Note that these economics include just the energy savings, and do not account for other economic benefits, such as those from improved workplace quality.

The U.S. General Services Administration (GSA), the largest real estate owner in the United States, commissioned a 2004 study on the first-cost premium of meeting LEED (Leadership in Energy and Environmental Design, the most prominent sustainable design rating system in North America and many other countries). A detailed cost analysis was done on two building types, a new courthouse and a major retrofit of an office building. GSA's aim was to assess the impact of green building measures above and beyond those included in its own construction standards, in order to meet various levels of LEED certification. In the case of the new construction, the first-cost premiums (expressed as a percent change to base construction cost) to meet LEED's "Certified" criteria (the lowest level of four tiers of LEED stringency) ranged from -0.4 percent to 1.0 percent. For LEED "Silver" (the next level up) the range was 0.0–4.4 percent, and for LEED "Gold" (the second highest tier) the range was 1.4–8.1 percent (GSA 2004).

A 2007 study by Davis Langdon, a consultant to the construction industry, compared 83 buildings seeking various LEED designations (from Certified to Platinum) with 138 that were not. They found that, while some sustainable features, such as solar photovoltaics, commanded a new construction premium, most of the LEED-seeking buildings achieved their designations without any premium. Their report concluded that, very simply, "there is no significant difference in average costs for green buildings as compared to non-green buildings."

A 2013 study investigating the feasibility of net zero energy office and multi-family apartment buildings in Washington, DC estimated a 1–7 percent premium for 30–40 percent energy savings relative to the buildings that *already* were designed to LEED Premium and slated for greater than 30 percent savings relative to code (New Buildings Institute 2013). In general, integrated "whole-building" design is the key factor that allows for the demonstrated cost-effectiveness. This is discussed in further detail later in this chapter (Section 5.2, "Implementing Best Practices at the Project Level").

Even with these slight premiums, a growing market for energy-efficient and green building systems and components continues to bring down costs. As demand grew following the emergence of sustainable building's popularity in the 1990s, supply for green goods and services initially lagged, which resulted in higher prices. As the supply markets mature, prices have become comparable to conventional products and services. As early as 1999, *Building Operating Management* magazine reported, "The industry has reached a junction where design experience, combined with a reduction in some technology and material costs, makes green building first-cost-effective."

Since energy-efficient products often involve more materials (e.g., additional copper for the windings in efficient distribution transformers and motors or for additional fins for more efficient heat transfer in HVAC equipment), a cost increment for their manufacturing is often inevitable. However, with sufficient economies of scale in production, and competition from other manufacturers, the profit margin on this equipment will ultimately reflect only this added cost of materials, and not a "luxury premium."

In addition, by downsizing some equipment to meet lower heating and cooling loads and lighting needs, the cost premium to the project can often be nullified and even reversed. In 2006, Lawrence Berkeley National Laboratory in California completed a new high technology building (the Molecular Foundry) that, when compared to a comparable lab facility, saved an estimated US $2.5 million in heating, ventilating, and air conditioning equipment by taking advantage of passive design features and appropriate equipment sizing.

Assessing Current Practice and Setting Targets

Each community is in a different state of development, and government planners should take steps to advance a new construction program from that position. For example, when the city of Seattle, Washington explored sustainability, it chose to lead by example through demonstration projects and began by adopting a green building rating system and applying it to an ambitious building program that was already in place (over 40 new buildings were being planned). The city of Portland, Oregon, on the other hand, had no new civic construction projects in the pipeline. Without a portfolio of planned new construction projects that would let it lead by example, Portland nonetheless became a model for city planning by developing sustainable policies and incentives to push the private sector into building green.

In assessing the current state of energy efficiency of public sector buildings—and thus the key focal points in starting a new construction program—consider the following:

- Look at existing construction practice for recent buildings in the portfolio of the public sector entity and identify specific areas for improvement in each major building feature; e.g., spatial planning, enclosure systems, HVAC, lighting, electrical systems, or plumbing. While this exercise may serve also to guide some existing building retrofit work, its primary purpose here is to direct the focus of new construction improvement efforts towards the areas where most savings are likely.

- Use benchmarking to determine the range between typical and best practice for energy efficiency, and identify where government buildings fall within this range (see Chapter 3 for a discussion of benchmarking techniques). Also, assess how actual construction and post-occupancy performance compare with energy efficiency requirements (if any) in building codes. This will provide an indication of the degree of compliance with, and enforcement of, these current requirements.
- If possible, review energy efficiency requirements and practices in other cities, states, and countries (particularly those nearby) to identify best practice in both policies and design/construction that might be incorporated into the program. Determine how applicable these are, or how they might be modified to reflect opportunities (or constraints). Additionally, evaluate green building rating systems for use as design and construction guidelines.
- Conduct an analysis to identify the options for improving efficiency in new building design and construction. For each option, estimate the incremental first cost compared with savings in annual energy operating costs.

Efficiency goals for new construction can be for whole buildings (e.g., 25 percent over code requirements or LEED-Gold), individual systems (such as lighting density thresholds in kW/meter), or a combination of the two. In prioritizing which areas to focus on, pay attention to all uses of building energy, including computers and other plug loads installed after construction. These often constitute 30–40 percent of the electrical energy use in a reasonably efficient new building, and present good savings opportunities (such as choosing efficient task lighting and instituting aggressive sleep mode requirements for office equipment).

In setting efficiency targets it is wise to consult with local architects, engineers, and builders to get their ideas on current best practice and possible new approaches to energy efficiency in buildings, their reactions to proposed new goals, and an understanding of their view of constraints and practical solutions.

It is also important to recognize that, even if technical and financial constraints can be overcome, there may be organizational or administrative obstacles that need to be addressed. For example, incorporating new energy-saving features may not conform to standard operating procedures. In such cases, consider issuing directives that make the process of incorporating energy conservation as easy as, or easier than, conventional approaches.

A major decision vis-à-vis efficiency criteria is how they should be applied, ranging from purely voluntary targets to mandatory minimum standards. This decision has to take into account technical, financial, political, and organizational factors, and should involve all stakeholders. A mandatory approach may result in unambitious efficiency thresholds, while a voluntary program may not provide enough motivation. It is often optimal to have a "push-pull" approach, which incorporates reasonable minimum mandatory standards but adds incentives for increasing levels of voluntary efficiency targets. For example, a policy could state that all buildings have to exceed the minimum requirements of the local building code by 10 percent, and then provide incentives for voluntary targets of 20 percent, 30 percent, and 50 percent improvement.

Demonstration Projects

Demonstration projects can provide a powerful, high-profile proof of concept. The goal here is to select one or two government construction projects that become a proving ground for improvements in buildings; a showcase for technologies and products; and a demonstration of effective design and construction processes. Such projects may

not only aid public sector entities in revising their general construction methods, but also may help develop more energy-efficient building practices for adoption by the private sector.

Successful energy-efficient new construction projects involve setting life-cycle sustainability goals and using a team-based integrated decision making process to achieve them. Section 5.2 of this chapter ("Implementing Best Practices at the Project Level") provides more detailed information on project-level best practices, which are applicable to all new construction projects including demonstration projects. In addition to the guidance provided in that section, planners of demonstration projects should also consider the following guidelines:

- Select projects that have high visibility, but are not too unique. Otherwise they will be seen as "one-of-a-kind" projects whose lessons are not applicable to other construction.
- Consider the prospective buildings' occupants. A highly motivated government agency or ministry might represent a good candidate for a demonstration project, even if it is small relative to other such entities. Such "innovators" and "early adopters" can pave the way for the rest of the public institution.
- Publicize and promote the project from the beginning, in order to keep up the commitment and enthusiasm of all stakeholders.
- Pursue donations "in kind" or at cost from product manufacturers who are looking to promote energy-conserving products. Sometimes it is also useful to showcase alternative products in various parts of the building.
- Since the impact of energy conservation is hard to visualize, consider innovative ways of displaying and describing energy-saving features and their impacts. For example, the Intelligent Workplace laboratory at Carnegie Mellon University has Plexiglas® floor panels to display underfloor systems. Consider real-time data displays of current energy use, associated utility costs, and pollutant emissions in comparison to a conventional building.
- Rigorously document all decision processes, beginning from the early stages of project development all the way through construction and initial occupancy. Track and evaluate both the successes and the problems encountered in order to identify suggested changes in both policies and technical features to be used for new public buildings in the future.
- Account for demonstration-related features (e.g., additional documentation) in the project budget. These features should be separated out in the cost-effectiveness evaluation, since they will likely not apply to subsequent projects. Similarly, if items are donated or provided at cost, the cost-effectiveness calculations should be adjusted accordingly.

Box 5-1. Public-Private Partnership on LEED Platinum Building in Hyderabad, India

Public-private partnerships can help produce demonstration buildings when government resources are limited. The CII-Sohrabji Godrej Green Business Centre, Hyderabad, India, is a LEED Platinum building project made possible through such a partnership. The State of Andhra Pradesh allocated the land and publicly supported the project through its Ministry of Buildings and Roads; the Confederation of Indian Industries (an Indian trade group) programmed, built, and occupied the building; and an industrialist, Jamshed Godrej, donated substantial funding. Serving as a conference center and green business incubator, this demonstration project shows both public and private sector project developers how to design, build, and operate green buildings.

Establishing Policies and Procedures

Public sector entities, for better or worse, are highly driven by policies and procedures, particularly in their construction and procurement practices. A "policy" typically describes intent and goals at a broad level, but its implementation is driven by "procedures." Thus, it is very important to put in place both policies and procedures that enable conservation and sustainability. These policies and procedures need to address numerous aspects (e.g., technical, budgetary, regulatory, organizational) of the building project.

Technical Policies and Procedures

The core technical element of an energy conservation policy is the establishment of criteria and targets, described above. These should be complemented by technical resources that provide detailed information on the design, specification, construction, operation, and maintenance of various energy conservation strategies for new construction to project developers. There is already a vast amount of technical literature on energy conservation that can be used as a foundation for the development of country-specific resources. An effort should also be made to provide access to these resources in a contextually relevant manner. For example, several federal agencies in the United States sponsor the web-based Whole Building Design Guide (www.wbdg.org), which categorizes and summarizes various conservation strategies and provides links to further resources.

One way to ensure that certain energy-conserving components are part of new construction projects is to require the use of "guide" or "master" specifications that include these features. "Guide specs" are the template specifications upon which architects and engineers base their particular building product specifications for a project. They are meant to assure quality and code compliance, but energy-saving and green specifications are available that can hardwire these desirable features into new construction projects. The American Institute of Architects, through the firm ARCOM, offers various energy-efficient and green alternatives in its MASTERSPEC® line of guide specs. Many governments maintain their own set of guide specs within their construction departments. These can be revised, pursuant to procurement policy (or merely by amenable spec authors), to require the use of

energy-conserving products, ranging from windows and roofs to boilers and chillers. Several U.S. federal agencies have taken this approach to ensuring that energy conservation is incorporated into their new construction.

Energy-saving and green design can also be enhanced by the policy adoption of market-leading design, construction, and operations rating standards by agency or government heads (e.g., through executive order or even legislation). Examples of these are the British Research Establishment Environmental Assessment Method (BREEAM), the most common of these standards in the European Union; LEED, popular in the U.S., Canada, and India; the Hong Kong Green Building Council's Building Environmental Assessment Method (BEAM Plus); and Australia's Green Star. Such standards present the opportunity for goal setting and public recognition as well as for reporting to the public about successes by the public sector.

Design assistance is another effective technical tool that public sector energy management programs can use to help reduce information barriers and lower the cost of energy-saving new construction. In the U.S., FEMP has long maintained a design assistance component in the portfolio of energy management services it offers, employing technical experts from the U.S. Department of Energy's national laboratories. Each year it issues a call to U.S. government agencies for requests for design assistance. Because of limited resources, FEMP offers assistance to roughly a third of the requested projects. Selection is based on financial and technical merit, strategic value, implementation plan, and agency support and cost sharing. FEMP also gives training seminars on specific technologies and strategies. Training programs require more preparation to establish, but are likely able to reach more prospective projects than direct technical assistance.

Budgetary Policies and Procedures

Even the most well-crafted technical policies and resources can be undermined by counterproductive budgetary policies. The challenge is not simply a matter of providing adequate budgets, but also one of setting budgeting procedures that are conducive to promoting energy conservation, namely procedures that favor life-cycle costs over first costs. Changing budgeting and accounting processes this way requires the training and commitment of those government professionals with financial control. The separation of construction and operations budgets compounds the challenge, since the incentive of long-term gains in operations and maintenance is absent when those in charge of construction consider first costs only (see the discussion of "split incentives" in Section 2.1 of Chapter 2). For example, specifying higher quality windows and more insulation will entail a higher first cost, but the investment generally pays itself back quickly through energy bill savings. However, that higher first cost does not often fit a conventional construction budget and is "value-engineered" out of the project. A progressive budgeting policy should include these elements:

- A life-cycle cost approach or, at minimum, a simple payback threshold that explicitly permits increased up-front investment to promote future operational cost savings. The policy should require life-cycle cost information on energy, water, and operations and maintenance As much as possible, operational cost projections should be based on standard calculation procedures. In order to ensure a consistent approach across projects, the procedures should provide standard specifications for parameters such as life-cycle evaluation period and discount rate. For calculation and reporting purposes, it is also beneficial to use a standardized life-cycle costing tool (e.g., FEMP's Building Life-Cycle Cost software, which is available for free download through FEMP's website).
- Increased investment in design services that promote energy conservation. For example, standard design fees do not include energy simulation studies, which can be very valuable in the cost-benefit analysis of

energy-related choices. One of the best places to spend an incremental budget allowance for energy conservation is at the early stages of design—this is often an even better investment than spending money on structural or hardware upgrades themselves.

- Allowance for increased investment in commissioning services, especially commissioning of energy-related features. This type of investment ensures that all major equipment, controls, and building elements are installed and working correctly and should also include requirements that on-site staff are trained in how to operate and maintain the equipment.
- The provision that any "value-engineering" (i.e., substitution of higher-cost construction options with less expensive ones) must be done with the same life-cycle costing (or simple payback) methodology used in original project budgeting, so that all stakeholders understand the economic trade-offs. Project review and approval procedures should guard against eliminating those features that will reduce future energy costs, especially at the later stages of a project as budget pressures mount.

Additionally, the policy should consider innovative ways to finance energy conservation upgrades that have higher first cost but lower total life-cycle costs (for more detail, see Chapter 4). These include:

- Energy savings performance contracts (ESPCs) for new construction, in which energy conservation measures are financed from the savings they generate compared to a simulated baseline.
- Equipment leasing, including lease-purchase programs.
- Other favorable project financing options, including revenue bonds, revolving funds, and multi-lateral bank loan funds.

Regulatory and Organizational Policies and Procedures

Beyond technical and budgetary aspects of policy, it is important to have regulatory and organizational policies and procedures in place that promote energy savings in public sector construction. The incorporation of energy conservation features into such policies may not require additional bureaucratic processes, even if they represent a variation from current operating procedures. If variances with construction codes are required, these should be facilitated in policy. For example, some building codes in the United States require a "variance" for the installation of waterless urinals, but effective policies and procedures (such as a simple waiver by a city code official) can ease the process of obtaining one.

Finally, it is important to recognize that public buildings must satisfy many other requirements and policy objectives beyond energy conservation. Attention to energy use in the design process (preferably early in the process, when it is less likely to be obstructive to other features) helps ensure that energy-saving solutions contribute to, rather than compete with, other objectives such as security and aesthetics. For example, energy conservation can improve energy security and grid reliability by reducing peak demand, possibly also decreasing the needed capacity for any backup (or even primary) electricity generation at the site. If an energy-conserving design can be positioned to complement other desired aspects of a prospective building, it will stand a much better chance of being implemented.

5.2. Implementing Best Practices at the Project Level

Each building project is unique, with its own challenges and opportunities. However, experience with energy-efficient and sustainable building projects over the last two decades suggests several broadly applicable best

practices. Since specific technologies and strategies will vary for each project—based on contextual parameters such as climate, energy prices, budget, and local construction practices—this section focuses on process-related best practices whose relevance is fairly universal.

Selecting the Design and Construction Team

Selecting capable, experienced, and enthusiastic individuals to be on the design team could be the most important step in the design process. Some architectural and engineering (A/E) firms have a strong commitment to sustainability and view it as a leading design consideration. However, while acknowledging that green building is desirable, others may not see energy conservation and sustainability as central to determining the design and form of a building. FEMP's guidelines on procuring architectural and engineering services include a checklist for prospective design professionals. According to these criteria, the prospective firm should:

- Reveal familiarity with energy conservation and sustainability principles.
- Demonstrate ability to respond to efficiency and sustainability goals set in program documents.
- Include a sustainability expert in a position of decision-making authority on the design team.
- Cite completed projects that feature workable, cost-effective, energy efficient, and low-energy design principles.
- Demonstrate experience in planning, facilitating, and reporting on design charrettes.
- Show expertise and experience in cost-benefit analysis of energy efficient design strategies for major systems and components, using life-cycle cost procedures and criteria.
- Demonstrate an understanding of, and past experience with, specifying and implementing enhanced "whole-building" commissioning and quality assurance processes.

"Whole-Building" Design

The application of one or more isolated technologies advocated by a champion on a project will not result in an energy-efficient building. Rather, truly significant efficiencies are enabled through an integrated design process that looks at the whole building system and includes all stakeholders, including owners, architects, engineers, commissioning agents, contractors, facilities managers, maintenance personnel, and users. This type of integrated design process is called "whole-building" design. This approach views the design and construction of a building from a total-system perspective and considers the impacts on the whole system when changes are made in any one area. It is an approach in which all aspects of a building's operation are considered, usually from a life-cycle perspective, taking into account interactions among components to create smaller and less energy-intensive systems.

Rather than focusing on individual elements, whole-building design capitalizes on synergistic relationships, since most issues related to site, water, materials, and the indoor environment directly or indirectly affect energy performance. An integrated design approach will produce a much more energy-efficient (and better performing) building than tacking on the latest piece of high-visibility hardware. For example, a solar collector added to an inherently inefficient building will need to be larger (and more costly) to serve the same proportion of load as one installed at a building where care has already been taken to reduce thermal and/or electrical requirements. The Rocky Mountain Institute headquarters building in the U.S. state of Colorado installed super insulation, high-performance windows, and other energy-saving features that eliminated the need for mechanical heating and

cooling systems in the building, despite climatic extremes spanning 55° C (100° F). Without these systems, the building cost less to build than comparable buildings using conventional construction techniques (Hawken et al. 1999).

A collaborative whole-building design process allows all stakeholders to contribute to the identification and development of energy-saving and sustainable design strategies in multiple domains (e.g., siting, water use, and energy use). Box 5-2 provides a partial list of such strategies listed in Dubai's "Green Regulations & Specifications."

Box 5-2. Dubai's "Green Building Regulations & Specifications"

Ecology/Planning

- Access/Mobility
  - Preferred Parking (for low-emissions vehicles and carpools)
  - Enabled Access (for special needs users)
  - Bicycle Storage and Changing Rooms
- Ecology/Landscaping
  - Local Species
- Neighborhood Pollution
  - Exterior Light Pollution and Controls
- Microclimate and Outdoor Comfort
  - Urban Heat Island Effect
  - Green Roofs
  - Light Colors on Building Exteriors
  - Orientation of Glazed Facades
  - Hardscape
  - Shading and Public Access Areas
- Responsible Construction
  - Impact of Construction, Demolition, and Operational Activities
- Environmental Impact Assessment

Building Vitality

- Ventilation and Air Quality
  - Minimum Ventilation Requirements for Adequate Indoor Air Quality
  - Air Quality During Construction, Renovation or Decoration
  - Air Inlets and Exhausts
  - Isolation of Pollutant Sources
  - Operable Windows
  - Indoor Air Quality Compliance – New Buildings
  - Indoor Air Quality Compliance – Existing Buildings
  - Inspection and Cleaning of HVAC Equipment
  - Parking Ventilation
  - Environmental Tobacco Smoke

- Thermal Comfort
- Acoustic Comfort
- Hazardous Materials
  - Low Emitting Material: Paints and Coatings
  - Low Emitting Material: Adhesives and Sealants
  - Carpet Systems
- Daylighting and Visual Comfort
  - Provision of Natural Daylight
  - Views
- Water Quality
  - Legionella Bacteria and Building Water Systems
  - Water Quality of Water Features

Resource Effectiveness: Energy

- Conservation and Efficiency: Building Fabric
  - Minimum Envelope Performance Requirements
  - Thermal Bridging
  - Air Conditioning Design Parameters
  - Air Leakage
- Conservation and Efficiency: Building Systems
  - Energy Efficiency—HVAC Equipment and Systems
  - Demand Controlled Ventilation
  - Elevators and Escalators
  - Lighting Power Density—Interior
  - Lighting Power Density—Exterior
  - Lighting Controls
  - Electronic Ballasts
  - Controls for HVAC Systems
  - Controls for Hotel Rooms
  - Exhaust Air Energy Recovery Systems
  - Pipe and Duct Insulation
  - Thermal Storage for District Cooling
  - Ductwork Air Leakage
  - Maintenance of Mechanical Systems
- Commissioning and Management
  - Commissioning of Building Services—New Buildings
  - Re-commissioning of Building Services—Existing Buildings
  - Electricity Metering

Resource Effectiveness: Water

- Conservation and Efficiency
  - Water Efficient Fittings
  - Condensate Drainage
  - Condensate Recovery
  - Water Efficient Irrigation
- Commissioning and Management
  - Water Metering
- Onsite Systems: Recovery and Treatment
  - Wastewater Reuse
  - Water Consumption for Heat Reduction Including Cooling Towers

Resource Effectiveness: Materials and Waste

- Materials and Resources
  - Thermal and Acoustical Insulation Materials
  - Certified/Accredited Timber
  - Asbestos Containing Materials
  - Lead or Heavy Metals Containing Materials
  - Ozone Depletion Potential Material Management
  - Recycled Content
  - Regional Materials
  - Composite Wood Products
- Waste Management
  - Construction and Demolition Waste
  - Bulk Waste Collection
  - Waste Storage
  - Waste Collection
  - Recyclable Waste Management Facilities

Source: www.dewa.gov.ae/images/greenbuilding_eng.pdf

The whole-building approach must begin at project inception. Analysis of sustainable building projects shows that opportunities to green a project are greatest at the predesign stage, when the least amount of effort can yield the most significant results. Effort increases with diminishing levels of results as the project moves toward construction. Therefore, the project budget must allow for adequate design services, such as charrettes and energy modeling, during the early phases of design.

The term "charrette" is used by the architectural community to describe an intensive design workshop that includes all stakeholders. It is acritical part of the whole-building design process, in which concepts and solutions are shared in an environment where all ideas are welcome. Changing the way buildings are designed not only requires the inclusion of a greater variety of individuals in the design process, but also depends on how those individuals think and solve problems together; the charrette is a way to instigate a constructive teaming process from the project's

inception. Charrettes should be conducted several times during the early phases of the design process, from predesign to design development. The U.S. DOE's National Renewable Energy Laboratory maintains a guide on how to conduct charrettes ("A Handbook for Planning and Conducting Charrettes for High-Performance Projects"), which is available on its website.

Establishing and Tracking Efficiency Goals

It is important to establish sustainability and energy use targets at the project's outset. The targets may be adjusted during the course of the project, but projects that set aggressive targets at the very beginning, at the conceptual stage of the project, are much more likely to succeed than those that do it during design development. To be effective, sustainability and energy use targets should be measurable and verifiable, for example, exceeding the relevant building code by 30 percent or obtaining a certain number of points on the LEED rating system. Make sure to identify certification and testing measures that will be used to ensure compliance.

Energy efficiency targets should be set for the whole building and, ideally, for individual systems (e.g., lighting and HVAC). For example, Table 5-1 indicates various metrics for setting targets for laboratories (an energy-intensive building type common in schools and universities). Such metrics are useful to architects and engineers in setting design targets for HVAC, lighting, and electrical systems.

Table 5-1. Energy Metrics for Laboratory Buildings in the U.S.

System	Energy use metrics*	System/load efficiency metrics*
Whole Building	kWh/sf-yr (electric) Btu/sf-yr (site) Btu/sf-yr (source) Utility $/sf-yr	Peak W/sf Energy Effectiveness Ratio (Ideal/Actual)
Ventilation	kWh/sf-yr	Peak W/cfm Peak cfm/sf (lab) Avg cfm/peak cfm
Cooling	kWh/sf-yr	Peak W/sf Peak sf/ton
Heating	Btu/sf-yr	
Lighting	kWh/sf-yr	Peak W/sf
Process equipment	kWh/sf-yr	Peak W/sf

** 1 sf (square foot) = .093 sq. meters; 1 cfm (cubic feet per minute) = .028 cubic meters; 1 BTU = .293 Wh; 1 ton = 12,000 BTU = 3.516 kWh*

Source: Mathew 2007 (*www.i2sl.org/documents/toolkit/bp_metrics_508.pdf*).

Building Energy Simulation

Energy simulation is an important tool for whole-building energy analysis. Whole-building energy simulation (using tools such as DOE-2, Energy Plus, Equest, Energy-10, and TRYNSYS) can help direct decisions ranging from materials selection to building orientation to mechanical systems choices. It shows the interaction among measures—such as windows and heating and cooling systems—allowing an optimization of systems and the whole building. Simulation analysis of design alternatives should be performed regularly as the design evolves to

determine relative efficiency, to identify gaps, and to make targeted improvements, rather than waiting to analyze the final design. Ideally, to ensure that this happens and that the design intent is met, a commissioning agent would be charged with documenting and tracking these targets as the design evolves. In the more common case where a commissioning agent is not yet hired for the project, someone else from the design team should be assigned this task. Note that targets may change during the course of the design process. The design intent behind these changes should be consistently documented, and should be included in the operations manual for the building.

Life-cycle-based Budgeting

Life-cycle cost analysis (discussed previously in Section 5.1, "Budgetary Policies and Procedures" and explained in more detail in Chapter 4), allows for rational trade-offs between initial investments in energy-saving features and future savings of energy costs and related operating expenses (e.g., maintenance), subject to discounting to reflect the time value of money. The building owner must make a commitment to life-cycle cost analysis at the outset, and should adopt project review and approval procedures to ensure that features that will reduce future energy costs are not eliminated as a result of budget pressures.

Maintaining Commitment to Energy Efficiency throughout the Project

After setting goals and targets, the team needs to revisit and reaffirm these targets throughout the project design and construction stages. Energy-efficient and green building projects can fail not only due to funding constraints, but also because of the loss of commitment to sustainability at the time of value engineering, budget cutting, or changes in the project team. By developing project review and approval procedures that guard against their elimination, sustainable features can be retained throughout the design and construction process. The following suggestions can enhance the chances of such success:

- Write specifications that clearly and accurately describe the performance criteria of the product or system.
- Reaffirm commitment to energy conservation and sustainability throughout the project with training (on specifics), education (on principles), and tracking of targets.
- Monitor construction changes, and beware of "or-equivalent" substitutions (i.e., replacement of one model for another, with a sacrifice in efficiency) and value-engineering changes.
- Maintain energy conservation on the agenda during start-up commissioning, acceptance, and building-operator training.

Integrating Commissioning Into Design and Construction

The Building Commissioning Association states that, "The basic purpose of building commissioning is to provide documented confirmation that building systems function in compliance with criteria set forth in the project documents to satisfy the owner's operational needs." Sometimes described as the process of assuring that the building's design intent has been met, commissioning can more simply be defined as a process that makes sure things are running the way they are supposed to. Basic building commissioning usually involves two elements:

- Systematically evaluating all pieces of equipment to verify that they are functioning according to specifications. This includes measuring temperatures and flow rates from all HVAC devices and calibrating all sensors to a known standard.

- Reviewing the sequence of operations to verify that the controls are providing the correct interaction between equipment and the building environment, as well as among different (especially integrated) systems and equipment within the facility.

Conventionally, building owners have seen these activities, or at least the results, to be the responsibility of the general contractor. Commissioning, as a separate third-party scope of work, was often deemed to be an easily avoidable expense and eliminated during budget cutting—in those instances where it was even part of the project in the first place. However, commissioning has become more common in the developed world, most likely in response to numerous studies revealing the considerable underperformance of newly constructed buildings relative to their design intent and expected performance (both from a thermal comfort and an energy-efficiency perspective). Many building owners and government agencies are now requiring proven quality management tools, like International Standards Organization (ISO) 9001 and 50001 and ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Guidelines 1 and 4, to help guide them in commissioning. Commissioning of basic systems (e.g., HVAC and lighting) is required to achieve the U.S. Green Building Council's most basic LEED designation (Certified), while more thorough whole-building commissioning provides additional LEED credit towards the higher levels (Silver, Gold, and Platinum).

Commissioning has been demonstrated to have a significant effect on energy use. A recent meta-study of 77 new construction buildings revealed a median 13 percent cost savings from commissioning based on energy savings alone, explicitly excluding the often substantial non-energy benefits (e.g., increased thermal comfort and equipment longevity) that generally accrue from the process. Aside from easily measurable direct energy savings, commissioning at the beginning of a project will generate data from the testing and balancing process that can be used for comparison of design and performance throughout the life of the building to maintain and improve energy savings.

Although commissioning is primarily a post-design process, it needs to be a strong consideration from the outset of building design. Successfully commissioned buildings are often ones in which a commissioning "team" is designated early in the project's formulation. In addition to any third-party firm hired specifically for commissioning, the team should include individuals from the architecture and engineering staff designing the building, as well as in-house government staff who will be responsible for the building's operating performance. By assembling the commissioning team early in the project, the facility's design intent will be made clear to the group, increasing the likelihood of effective commissioning.

Many factors influence the cost of commissioning, including a building's size and complexity. Mills found a very broad range of commissioning costs, but with a median of US $1.16 (in 2009 currency) per square foot (roughly US $12.50 per square meter). This was about 0.4 percent of the median total construction cost and translated to a median simple payback period of 4.2 years.

5.3. Beyond the Public Sector

Governments and other public sector institutions can play a major role in moving their communities toward energy conservation and sustainability. They can disseminate information about best practices through demonstration projects, in addition to making those practices standard in all of their own new buildings by incorporating them into their specifications and design guidance. In this way, they are influencing design and construction practices throughout the economy by using the government's initial demand for energy-conserving and sustainable design to

create a local base of well-qualified, enthusiastic "green" architects and builders. Furthermore, public sector energy conservation programs can create a broader impact through support for the development and adoption of energy-efficient design standards, such as LEED and BREEAM, and energy-efficient building codes.

The inclusion of representatives from all design and construction industry sectors in the development of LEED has enhanced its acceptance, as has the fact that LEED is not only built upon valued industry reference standards—such as those developed by ASHRAE and the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)—but also evolved to include standards developed by the U.S. Environmental Protection Agency. A "leading by example" demonstration by the United States General Services Administration, with the goal that all federal buildings be constructed to LEED Silver initially (and Gold, starting in 2010), has had a significant impact on the U.S. building industry. Design professionals, building trades personnel, and product suppliers contributing to government projects now not only learn about green construction, but also carry these lessons to their next projects. No doubt this had an impact on Washington, DC's being the first major city in the U.S. to adopt a green construction code, initially requiring that all buildings over 50,000 square feet (roughly 5,000 square meters) achieve LEED certification (and LEED Silver for public sector buildings). This has since been augmented and tightened (Sustainable DC 2015).

Within three years of being introduced, LEED had penetrated 4 percent of U.S. new commercial construction or approximately 8.5 million square meters (90 million square feet), and by the end of 2013, there were 56,000 participating buildings representing over 10 billion square feet (roughly one billion square meters), spread out over 147 countries and territories.

The existence of voluntary standards, which do not have the force of law, should not preclude the "greening" of mandatory building codes. Defining a baseline below which construction is illegal has proven to be essential in developed countries. However, public sector facilities should not just match what is asked of all buildings; they should set an example in energy conservation and sustainability. Surpassing the codes and demonstrating the success that results paves the way for incorporating energy-saving and other green elements into future iterations of the codes. This is achieved both by showing the cost-effectiveness of these features and also by familiarizing and educating the designers and contractors who are ultimately responsible for implementing them (and who play roles, directly or indirectly, in code development).

Government office buildings, courthouses, civic centers, jails, maintenance facilities, border stations, park facilities, national training centers, city halls, universities, hospitals and convention centers have all been public sector projects recognized for their sustainable construction. As Rick Fedrizzi, founding chair of the U.S. Green Building Council, has stated, "No individual, no company, no government who has gone down the green path has ever turned back. A turnabout would mean a public statement that they would rather waste resources, continue to contribute to degradation of the environment, and be uncaring of the human beings living and working in the building."

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CHAPTER 6—PURCHASING

Key Considerations in Developing an Energy-efficient Products Purchasing Program

1. Government spending represents a substantial proportion of all economic activity (10–25 percent in most countries), and accounts for a similar proportion of purchases of energy-using products. Since the great majority of energy-related purchasing occurs outside of dedicated energy-saving projects, building an energy-efficient products procurement program can have a significant impact and should be a key focus of any public sector energy conservation program.
2. The efficiency standards and labeling infrastructure in a country (or state) are integral to any effort to promote efficient purchasing. A first step in developing an energy-efficient products purchasing program is to determine whether most energy-consuming products have standardized efficiency ratings (and standardized test methods for ensuring compliance). It is also critical to assess the degree to which end-use customers have information about these rated efficiencies, via labels, nameplates, manufacturers' literature, or other means.
3. Another important step in embarking on a purchasing initiative is to research the types and quantities of energy-using products actually purchased in the government. Identify the biggest total energy users and the ranges of efficiencies available in the market for those products compared to what is customarily purchased.
4. Other existing efficient product programs—such as green labeling initiatives or utility rebate programs—can provide terrific opportunities for synergy with government purchasing programs, and may also serve as valuable sources of information about prevailing markets for energy-using products.
5. When setting qualifying levels for products in the program, balance savings potential against higher prices to ensure that the purchase of specified products is cost-effective for government consumers. A maximum simple payback period threshold (e.g., four years) is one option.
6. A comprehensive background research effort for a purchasing initiative, as well as the setting of qualifying efficiency levels, could exhaust infinite resources. Use common sense in all these steps, weighing added benefits against added costs.
7. Dissemination of the program's information is as critical to the campaign's success as the quality of the information itself. Understand the time and knowledge constraints of the audience, and keep the message simple.
8. For broad acceptance, deliver program promotion in both a bottom-up and top-down fashion; i.e., both to end-users and policy makers. Identify key influence points, such as large-volume buyers and those responsible for creating government purchasing specifications.
9. Encourage feedback from the program's "customers" and adjust the initiative accordingly.

Existing buildings, new construction, vehicle fleets, public transit systems, and even energy-using public infrastructure systems like water supply and street lighting are obvious targets for energy savings in the public sector, and are given extensive, separate attention in the chapters of this guide. But it is likely that a great deal of

energy-using equipment is routinely purchased for governments, hospitals, schools, etc. that is not targeted by conventional energy-saving initiatives. Energy-efficient government purchasing initiatives target the government's routine, everyday procurement of energy-using products—from light bulbs to office refrigerators to industrial-scale chillers.

Box 6-1. FEMP's "Buying Energy-Efficient Products" Program

In the early 1990s, the U.S. Department of Energy (DOE)'s Federal Energy Management Program (FEMP) had a vibrant, ambitious staff implementing promising initiatives in renewables, design assistance, building audits, and performance contracting. It had the ear of legislators (who reinforced and fortified its plans by passing the 1992 Energy Policy Act) and annual increases in funding to support its efforts.

However, research into the government's energy usage revealed a big hole in FEMP's approach: an estimated US $10–20 billion was being spent each year to buy energy-using products in government facilities. These products ranged from office copiers and light bulbs to large chillers, and FEMP was barely affecting any of them. For every one building being audited and retrofitted as part of an energy-saving project, a hundred more were purchasing inefficient energy-using products every day.

This realization was the impetus for FEMP's energy-efficient products program. Started in 1996, the program was supported by U.S. Executive Orders 12902 (1994), 13123 (1999), and 13221 (2001), along with the Energy Policy Act of 2005, which made FEMP's recommendations mandatory. The program's mission is to inform federal buyers of what constitutes "efficient" for any type of commonly purchased energy-using product and then influence them to buy these more efficient models. It covers dozens of different products, ranging from water-cooled chillers for high-rise office buildings to fryers and steamers for commercial kitchens. FEMP works closely with the ENERGY STAR labeling effort to recommend products to federal users that are widely available, but also represent roughly the top quartile (25 percent) of efficiency for similar products on the market. Unlike FEMP's other initiatives, the target audience for the products program includes federal employees, such as procurement officials and office managers, who may have no training in energy but are affecting their facilities' consumption with everyday purchases.

This energy-efficient government purchasing strategy has been employed in a number of countries, including the U.S., Mexico, Korea, Japan, and several European Union countries (sometimes as part of larger "green" purchasing efforts also encompassing environmental products not related to energy). It takes advantage of the fact that governments are generally very large purchasers. In most countries, public sector spending (from the municipal to the federal level) represents between 10–25 percent of all economic activity, and energy-using equipment is a

significant component of this procurement. In the U.S., for instance, the annual expenditure by the federal government on energy-using products is estimated to be a staggering US $15–25 billion, and this represents only about a quarter of that spent, in aggregate, by the U.S.'s 50 individual state governments. As a result, FEMP estimates that the savings potential of its "Buying Energy-Efficient Products" program (see Box 6-1, above) is over a half of a billion dollars per year (Taylor and Fujita 2012).

6.1. Whether (and When) to Start a Program

Despite some of the appealing features of purchasing programs—such as their focus on everyday procurements that are being made anyway—their development and success are predicated on the existence of other national efficiency initiatives. This section provides policy makers with important considerations about the advisability of pursuing a purchasing program.

Transparency and Consistency of Efficiency Information

The most critical prerequisite for an energy-efficient purchasing program is the existence of a means to differentiate among different models of a given product type based on energy efficiency. For this to occur, there generally must be a standardized method by which the product is tested for its energy performance—a national (or international) measuring stick to fairly compare different models. In the U.S., these test methods exist for several dozens of products, which helped make FEMP's job of differentiating models much simpler; similar testing programs exist in many countries around the world. In addition, there are numerous international standards associations, many of which are government sponsored. The most prominent is the International Standards Organization (ISO), which maintains test methods for a multitude of products. Many countries employ ISO test methods directly, or at least use them as a basis to develop or improve their own test methods.

Beyond a means to assess the energy performance of products, an additional key prerequisite for government purchasing programs is the dissemination to prospective buyers of the results of those tests. This can occur via dedicated efficiency labels, through energy information provided on general consumer information labels, in product manuals, or even on the product itself. In Mexico, for instance, most residential and some commercial and industrial energy-using equipment carries the government's yellow "Eficiencia Energetica" label. The U.S. uses a similar label, EnergyGuide, and most lighting products must provide their energy performance information (e.g., lumens and watts) on their packaging or on the products themselves; for commercial heating and cooling products, the information is usually published in the product manual. What is critical is that buyers have easy access to this efficiency information to enable them to differentiate among models for sale based on their efficiency. The ability to make an informed choice cannot be assumed, especially in developing countries with minimal efficiency "infrastructure" (such as codes and standards). Without accessible efficiency information, any purchasing initiative is likely to be futile.

The one exception to this need for a standardized efficiency test method and labeling is in cases where an energy-efficient product is distinguishable from less efficient models by virtue of its distinct technology or other obvious physical feature. Some examples are:

- Electronic ballasts for linear fluorescent lamps (as opposed to magnetic ballasts)
- Light-emitting diode or compact fluorescent lamps (as opposed to incandescent models)
- T-5 linear fluorescent lamps (as opposed to the thicker T-12 or T-8 models)
- Water-cooled (as opposed to air-cooled) condensers (for chillers)
- Ground-source (as opposed to air-source) heat pumps

Although the potential impact of this exception is limited, since it can apply only to product types where more efficient models are physically differentiated from their less efficient counterparts, a program that focuses on such products can provide a simple entrée for energy-efficient purchasing for a government and may complement a more conventional test method and label-based approach for other products (i.e., where test methods and labels exist for some targeted products but not others). However, an additional downside to this method is that it does not allow differentiation among the qualifying models (e.g., the various LED offerings) if these products are not identified with efficiency information. Some models may have other quality problems (e.g., pre-mature product failure, poor lighting quality, etc.) that counter-balance any efficiency benefits.

6.2. Choosing Which Products to Cover

After ensuring that a group of products are available on the local market that have had their energy performance tested and results made readily available to prospective consumers, the next step is to select which products to cover under the program. The ultimate aim of this exercise is simple: select the products that can save the most energy and money, and determine the order in which to address them. Selecting the group of products that would save the most was FEMP's guiding principle during most of its program development, but the execution of it was not always straightforward (see Box 6-2). To accurately determine which products have the largest savings potential, it is necessary to collect data on the number, capacity, and efficiency of the units recently purchased (preferably for the most recent year or two), along with the average efficiencies and operating hours of those models already in place in government facilities. An accurate assessment of the achievable savings will also require information on the range of efficiencies currently available on the market for these products, as well as the price increments of the more efficient offerings relative to standard-efficiency models.

It is quite likely that *none* of these data will be fully available, and reasonable to proceed with what is available. It is generally possible to select a good group of products to begin a program based on the knowledge and common sense of those involved in the program planning, along with a network of others who may also possess some understanding of the government facilities' operations.

Going With the Obvious

In many cases, the choice of products for a pilot program is obvious. In Chile, a new information labeling program was rolled out in 2007, initially covering incandescent light bulbs, CFLs, and refrigerators. Because the Chilean government was eager to embark on a purchasing program and there was no "endorsement" labeling program (i.e., labels that highlight the most energy-efficient products, such as ENERGY STAR®) in Chile, the most sensible path was to begin the program by focusing just on the two relevant product types—CFLs and refrigerators (since incandescents are not an efficient lighting choice, they were excluded). The program heads also considered including some ENERGY STAR-labeled office equipment (all of which is imported in Chile and most of which is manufactured for international sale).

Similarly, China began its purchasing program by promoting a handful of products that were already part of an endorsement labeling initiative (although extensive analysis was conducted to identify which of these products had the least incremental cost or greatest savings potential for the government). For Mexico, the challenge to develop a program was complex because both an information and endorsement labeling program existed and numerous different products were labeled when a purchasing program among municipalities began in 2004. Consequently, the program designers focused on promoting efficient high-usage lighting products (lighting is responsible for roughly half of the government's electricity use in Mexico) that carried the country's energy-efficiency endorsement label, "Sello FIDE," as well as a suite of ENERGY STAR-labeled office equipment. Motors, light-duty vehicles, and split system air conditioners were later added to the program, following the surveyed preferences of participant cities.

Box 6-2. FEMP's Selection of Products

It is instructive to consider the U.S. experience in determining which products have the greatest savings potential. FEMP first contacted the two federal government supply agencies (the General Services Administration and the Defense Logistics Agency) to tap their knowledge and sales data, as well as to enlist their support in the eventual program. These agencies provided helpful data on government demand for some products, mostly lighting and appliances, but had less data on installations and purchases of larger commercial equipment, which they do not generally supply.

FEMP next turned to the interagency network of energy managers that it regularly convenes and formed an ad hoc Products Working Group. This group was able to help instruct FEMP on which products were the most prevalent in their agencies, and identify the biggest energy users and the best candidates for large-scale purchases. Though their input was largely anecdotal, the breadth of feedback from these energy managers was extremely helpful in selecting and prioritizing the products for which FEMP then generated purchasing recommendations. For example, based on feedback from the Product Working Group and other government energy and facility managers, FEMP focused on commercial building products (such as chillers, boilers, and distribution transformers) in the late 1990s, rather than residential products for the nearly 300,000 government-owned residential housing units.

FEMP also looked at data from product manufacturers and their trade groups to determine which types of products had broad ranges of available efficiencies in the market. For instance, FEMP found that the range of efficiencies for commercial ice makers was very wide, while that for residential clothes dryers was negligible (at least when considering gas and electric models separately). This helped inform the decision to cover the ice machines and not dryers.

FEMP's research effort also considered the efficiency of products for sale compared to the installed baseline. This led to coverage of several plumbing products (showerheads, toilets, and urinals) for which the current market's products used much less water than those installed in almost all existing facilities. (FEMP's management decided that water-using products would be included in the purchasing program, along with straight energy users, due to the connection between water and energy use, as well as the savings potential.)

When researching, it is important to utilize resources in a way that will target products with the potential to save the government significant amounts of energy and money. There are numerous resources that can possibly assist with this, from experienced facilities managers to industry trade groups to government purchasing data. The key is to use what is readily available and not expend resources that can better be devoted to other aspects of the program.

6.3. Setting Qualifying Levels

Once a group of products has been selected for inclusion in the program, the next task is to determine the efficiency levels to recommend or require, if the program is in response to a mandate. First, the range of efficiencies available in the models for sale sets the bounds for a recommendation. To achieve significant savings and exert a positive influence in the market, the qualifying level for a given product should be in the more efficient half of the market (FEMP aims for the 75th percentile of models for sale). Other considerations might include:

- Synergy with an endorsement labeling program or other efficient product purchasing initiative in the country or region.
- The incremental savings and costs associated with higher efficiency models.
- The number of different manufacturers with models among the higher efficiencies (sufficient competition should be maintained).
- The proportion of domestic vendors (manufacturers or other suppliers) represented among the qualifying models, relative to their proportion in the entire market (in order to avoid discrimination against these suppliers).

Each of these is discussed below.

Capitalizing on Endorsement Labeling and other Related Programs

In the U.S., Mexico, South Korea, and China (as well as many states and cities, ranging from California to Wuppertal, Germany), the presence of an endorsement labeling program has made the job of setting complying levels much easier. After a simple analysis of the endorsement label's levels, program managers often adopt them as their own (in a couple of cases, FEMP recommended to the ENERGY STAR program that the level be raised). The presence of the label holds two advantages. First, program managers can refer prospective buyers to the label as an easy way to spot models qualifying for the specification. Second, by adopting the level of an existing program, the purchasing initiative and the other program reinforce one another. By allying with the labeling programs in this way, the U.S. and Mexican purchasing programs were able to exert more influence over qualifying levels for the labels, as well as which new products are covered.

Alliances with other (non-labeling) purchasing programs can also be worthwhile. In the U.S., a large group of electric and gas utilities use the Consortium for Energy Efficiency (CEE), a group of utilities and efficiency advocates, as a source for their rebate programs. CEE does the market research and establishes tiers of efficiency (usually two or three) for a broad range of energy-using products. The utility incentive programs then refer to CEE's tiers, offering their rebates for those models meeting one of CEE's levels (or sometimes offering progressively increasing rebates for models that meet higher CEE tiers). FEMP and CEE have traditionally collaborated on many of the products they cover, resulting in several identical recommended efficiency levels for jointly covered products. As with the utilization of endorsement labeling in many purchasing programs, the cross-referencing by CEE and FEMP adds credibility and prominence to both efforts.

Added Efficiency versus Higher Cost

Another area to investigate as part of the level-setting process is the added expense to consumers for greater levels of efficiency. In some cases, the cost difference between conventional and efficient models is significant. For instance, the additional installed cost of a 90 percent efficient condensing residential gas furnace (relative to a non-condensing 80 percent efficient model) in the U.S. can range from US $200 to $300 in areas where they are most prevalent (e.g., in the northernmost states) to as much as $1,000 in other areas. Since there are virtually no models between a few percentage points above the required standard efficiency of 78 percent and the 90 percent minimum one finds with condensing models, both ENERGY STAR and FEMP initially chose to set 90 percent as their qualifying level. FEMP addressed the cost implications by providing considerable guidance to potential buyers in its recommendation, warning of the added cost and offering guidelines for conducting a cost-effectiveness calculation.

In other cases it is much less problematic to set ambitious specifications. If there is little or no first-cost trade-off to consumers for greater efficiency, a more stringent specification makes sense. The China Standards Certification Center chose several of its initial set of nine products based primarily on the very minimal price premiums for higher-efficiency models. One product that FEMP and ENERGY STAR began covering in the mid-1990s, exit signs, showed such small cost increments among lower wattage models that setting an ambitious specification was an obvious choice.

Ensuring Manufacturer Diversity and Domestic Suppliers among Complying Models

One crucial aspect of setting qualifying efficiency levels is assuring that product models meeting the chosen efficiency cut-off are available from a diversity of manufacturers. The purpose of this is to maintain market competition and avoid granting a de facto monopoly to one manufacturer. The FEMP program generally requires that models from at least three different manufacturers comply with its proposed levels; if this is not the case, the level is then relaxed until it allows for three manufacturers. In the development of one government's national purchasing program, sales data indicated that only one manufacturer offered motors at the originally considered efficiency levels. Consequently, the government chose to initially promote somewhat lower efficiency levels.

While this accession to manufacturers may be seen as a compromise of values, it is important to understand that a key goal of these purchasing programs should be to make the acquisition of energy-efficient products easy and cost-effective. Setting specifications such that complying products become difficult to locate or exorbitantly expensive can jeopardize both of these principles.

A related consideration is the inclusion of domestic manufacturers among the suppliers of complying models. If this is an area of concern, as it was for the Chinese purchasing program, a simple way to assess the impact on domestic manufacturing is to compare the proportion of domestic suppliers in the overall market with the proportion among the qualifying products above a given efficiency threshold. If the two proportions are reasonably close, this indicates that there is little or no systematic exclusion of domestic suppliers that will result from the recommendation. If the proposed efficiency level looks as though it would largely exclude domestic manufacturers, and if this conflicts with other government policy goals, the qualifying levels may need to be relaxed.

Peer Review

Once an efficiency level has been chosen for a product, the next step is to subject that level to review by key stakeholders: people in the energy conservation field, major users of the product, and most importantly, the

agencies, ministries, etc. being targeted by the program. In a few cases where its information base was weak, FEMP even chose to share its draft specifications with representatives of the product's manufacturing industry. In another case, government policy makers for a lighting procurement program in Maharashtra, India, insisted on getting buy-in from India's main lighting manufacturer trade group as a condition of adopting a recommended specification. This appeal to the relevant industry may be inadvisable in some cases, since potentially affected manufacturers, and those representing them, are not unbiased reviewers. Generally, though, exposing the draft specification to others will serve to both ensure its reasonableness and enhance its enthusiastic support by these groups once it is finalized.

6.4. Disseminating the Information

The final step in launching an energy-efficient purchasing program is communication of the efficiency thresholds to prospective buyers. At a minimum, this can be done by a simple correspondence, preferably coming from a high level in the government (see Section 6.5, "Getting Recommended Products Purchased"). It should list the covered products and their efficiency criteria (probably via an internet link). However, it may be effective to present more information—both for credibility and to increase compliance with the recommendations.

Printed Recommendation Sheets and Manuals

FEMP chose to produce a series of two-page guides for each product. Along with providing the complying efficiency thresholds, FEMP's "Product Efficiency Recommendations" also included:

- A "Where to Find" section, informing prospective buyers of any federal sources that offer efficient models (there are two U.S. government supply agencies).
- A "Buyer Tips" section, covering issues such as proper sizing, benefits and drawbacks of various product features (with regard to efficiency), and technology options (e.g., for residential water heaters, there is guidance on choosing gas versus electric models, as well as a discussion of tankless and solar-assisted models).
  A "Cost-Effectiveness" example, which uses expected product lifetimes, average usage profiles, and typical federal energy prices to compare standard efficiency models with recommended and "best available" ones. The "bottom line" of these examples is the estimated dollar savings (discounted to present value) that a facility could expect over the lifetime of the product; there are also conversion aids to help users adjust the modeled savings for different product capacities, energy prices, and usage profiles.

Mexico's program developed similar cost-effectiveness examples (capitalizing on the fact that most cities participating in the program pay identical electricity rates) to help show the speed at which incremental costs could be recouped. The Mexican program also provided a "Factors to Consider" section with useful suggestions for optimizing efficiency in selection and use of the products, similar to FEMP's "Buyer Tips." All this material, along with several case studies on the successes of some of the participating cities, and a template (and example) of municipal purchasing regulation was included in a bound (and web-accessible) program manual. During the program's first few years, this was distributed to all participating cities, usually at semi-annual program workshops.

FEMP's recommendations were originally designed to fit into a dedicated loose-leaf binder, which also included material about government policies on energy-using products, case studies, life-cycle cost analysis guidance, and other sources of information on efficient products. The initial binders, covering just a dozen products, were

published in early 1997. Update packages, with new and amended recommendations, were distributed twice annually to subscribers, who numbered almost 4,000 by 2003. In 2004, FEMP switched to an all-electronic format for distributing this material. More than 60 products are now (2014) covered.

Advantages of Web-based Communication

Simultaneous to its initial release of the binders, FEMP developed a website, similar to Mexico's, to provide html and pdf versions of all its recommendations. Along with the same cost-effectiveness example as in the hard copies, the website also provides "cost calculators" for many of the products. These permit users to enter their own site-specific data (e.g., energy prices, hours of use) and to compare annual and lifetime (discounted) energy costs for models with various efficiencies.

Broadcasting of this information over the web has been very successful in both the U.S. and Mexico. Visitors to the sites always see the most recent versions of all information and changes to program recommendations can be communicated almost immediately.

The Chinese government's purchasing effort took advantage of the internet by posting on the program website lists of all complying models of the products covered. In conjunction with the endorsement labels that the products all carry, this makes identification of complying models by end-users very easy—a big benefit. The ENERGY STAR program also publishes products lists, which FEMP broadcasts to its federal customers.

If product purchasing is largely over the Internet, an additional opportunity opens up to use coding (e.g., logos of endorsement labels) to identify complying products. The U.S. and Denmark have both succeeded with this approach. Some countries are even considering the idea of restricting any offering of covered energy-using products to models that comply. The advantage of these electronic purchasing schemes is that although purchasing is largely a decentralized function, they permit a simple educational message to be communicated to all prospective buyers.

Constructing and maintaining a website requires some investment but it is generally substantially cheaper than printing and distribution through the mail, especially when the necessary updates—which require maintaining a user database—are factored in. Identification of complying models through web-based purchasing, the next step, also makes program compliance easier and thus even more likely.

6.5. Getting Recommended Products Purchased

Once a set of product-specific purchasing recommendations is in place and a communication method is established, the next (and perhaps greatest) challenge for a procurement program is getting buyers to actually follow the recommendations and purchase the efficient products.

There are a number of reasons why this poses such a difficulty:

- Most purchasers operate under a budget that they try to stretch to achieve the most they can *during that period*; consequently, their tendency is to buy the least expensive item that meets their needs.
- Public sector purchasing is usually executed by many different actors, many of whom know little to nothing about the energy conservation aspects of the products they buy.
- The person responsible for purchasing an energy-using product is often not the one who has responsibility for the facility's energy bill and, therefore, may not be motivated to buy an energy-saving model (this is often referred to as the "principal-agent" or "split-incentive" problem, as discussed in Chapter 2).

- Buying a more efficient product often means asking for something that is not exactly like the product that it will replace, and may result in some investigation regarding its fit, cost-effectiveness, and ability to perform like the product usually purchased.
- Buying the cheapest product is always defensible, while purchasing one that is more expensive sometimes requires an explanation, which may or may not be well received by management.
- Public sector purchasers, especially in large governments, frequently feel burdened by the number of requirements and preferences already facing them and often do not welcome additional constraints, assuming they are even aware of them.

High-Level Policy Support

To overcome these varied problems, a multifaceted approach is warranted. Probably the most valuable first step is to get the attention and support of people at the highest levels of the government, particularly in the form of a government policy. In China, program administrators at the China Standards Certification Center were successful in getting a government directive urging compliance with their recommendations. FEMP's "Buying Energy Efficient Products" program was given tremendous momentum by President Clinton's Executive Order 13123 (1999), which very explicitly called for government purchasers to buy products that were either ENERGY STAR-labeled or in the top 25 percent of energy efficiency "as designated by FEMP." A similar directive occurred in the "Federal Acquisition Regulations" governing U.S. government procurement. Finally, the directive for federal purchasers to buy ENERGY STAR or "FEMP-designated" products was incorporated into U.S. law through the Energy Policy Act of 2005. Though each of these policy tools permitted some leeway by allowing exceptions based on cost-effectiveness criteria, their origin at the highest levels of government made them instrumental in getting the attention of people with the power to execute them.

Even agency-level policy can be a sufficient motivator. FEMP was able to convince some of the U.S. federal agencies to change their own specific purchasing guidance to cross-reference E.O. 13123 and urge compliance with it by their purchasers and specifiers. Often the direction from a given agency carries equal (or more) weight with that agency's employees as directions from higher levels of government.

Finally, FEMP sought for many years to "reverse the burden of proof" on purchases. Instead of having to justify spending more up front for more efficient products, purchasers would have to justify the purchases of products that do *not* meet recommended efficiency levels to procurement heads. For instance, a purchaser could provide the justification that an order of incandescent light bulbs was primarily for closet lighting (where the bulbs would be turned on infrequently), or for an area subject to disruption or vandalism, causing the bulbs to be broken regularly. This goal was finally achieved through the Energy Policy Act of 2005. Frankfurt, Germany also maintains such a policy, along with other complementary provisions such as savings retention and required life-cycle cost analysis for large energy-related procurements.

The ultimate success in an energy-efficient purchasing program, of course, is simply to make compliance both mandatory and inescapable by means such as prescribing the use of framework contracts or a central source of supply that procures and distributes only complying models. The Danish Ministry of Finance has taken this approach for various types of office equipment and the Chinese government instituted in 2008 a procurement regulation mandating the purchase of models that are listed in the government's energy-efficient purchasing initiative (Fridley 2009).

Energy Cost "Assignment"

A number of other means can be effective in motivating compliance with purchasing guidelines. One such approach is to make those in charge of selecting energy-consuming products also responsible for paying the utility bills, in order to undo any "split incentives" that are in place. The city of Modena, Italy successfully implemented this payment structure. Montpelier, France, although it did not modify the "split incentive" structure per se, communicates utility consumption and cost information to all user facilities at regular intervals.

While re-assigning costs requires wholesale changes to the agency procurement structure, one effective and creative solution is an incentive program that rewards purchasers (along with facility managers, when the two are different) for declining energy expenses. FEMP explicitly included purchasing as one area eligible for its high-profile annual awards and then made sure to nominate agency personnel who had achieved distinction in their efforts to promote energy-efficient product procurement.

Appealing to Product Specifiers

FEMP achieves perhaps its greatest success in getting efficient products into federal buildings by targeting the authors of agency-wide "guide specifications." These specifications, maintained by several of the larger U.S. agencies, direct the architects and engineers of agency facilities to ensure quality and consistency in the selection, design, and installation of products and systems for new construction and major renovation projects. While most public entities do not maintain their own set of guide specifications, there is usually some sort of guidance document that directs architects and engineers on how to design and construct new buildings. Identifying the personnel in charge of such documents and promoting energy-efficient purchasing recommendations to them has enormous leveraging potential, since this guidance may direct a large proportion of the entity's construction and renovation work.

In summary, there is a multitude of ways to take a program from policy to practice, a subset of which has been described here. Getting the attention of high-level officials and targeting the personnel in charge of specifying large purchases of energy-using equipment are general strategies that are likely to pay off in greater implementation.

6.6. Updating the Levels

Once a procurement program is established and covers a group of commonly purchased products, the next challenge is the inevitability of the recommended product specifications becoming out of date. This can occur because of technology changes, manufacturing advances, new efficiency standards, successful market transformation programs (including the one you are running), and other factors.

Specification review: can be addressed either by setting a regular interval (e.g., every three or four years) at which time each specification will be revisited, or conducting the review on an as-needed basis. The goal of the updating protocol should be to a) continue to ensure good savings relative to costs for buyers, and b) try to stimulate the technological advance of the market. Slavishly assuring that program levels meet some percentile cut-off in the market is unnecessary, but continuing to stay at the front of a progressing market is important. Making sure the government gets a good deal is critical.

The advantage to choosing the regular interval approach is that specifications will never become too out of date; however, there are two problems. The first is that some specifications may obsolesce in advance of their scheduled review. For instance, because of the onset of updated national minimum efficiency performance standards (MEPS),

FEMP has revised certain products' specs by pushing them higher, in parallel with the new MEPS, after only two years. Without this modification by FEMP, the existing specs would have become largely meaningless.

The other pitfall of regular-interval updating is that it will likely entail some wasted effort. Some levels will not need modification, and the effort to conduct the research to confirm that, in addition to re-releasing published or web material that does not need updating, could be used more productively on other aspects of the program.

FEMP uses the as-needed approach, with the explanation that the people involved in the program are already intimate with the markets for the products they cover (at least vis à vis efficiency). However, some of the FEMP recommendations have suffered from obsolescence at times.

The best approach may be a hybrid: to update specifications as necessary, but at least every four or five years, to ensure that no recommendations get too out of date. This method is probably worth any added effort it may require—it provides the program's audience with a sense that recommended levels are regularly reviewed and avoids the credibility loss that occurs if even one recommendation is perceived as obsolete.

6.7. Savings Potential

Given that establishing an energy-efficient purchasing program will require a significant effort, a policy maker's natural response is to ask about savings potential. Very little effort has been devoted to assessments of such potential, but studies that have addressed the issue present an impressive outlook. Taylor and Fujita estimated that over US $559 million (2011 dollars), roughly 8 percent of the U.S. government's annual building energy expenditures, would be saved due to the FEMP purchasing program in their "full compliance" scenario (Taylor and Fujita 2012). In that model, 95 percent of all purchases, starting from the time that FEMP first issued a recommendation on the product, were assumed to be compliant.

Another study, the 2003 "PROST" (Public Procurement of Energy Saving Technologies) report, estimated that an incremental investment of €80 million per year in efficient products for the entire European (EU-15) public sector (including all levels of government, hospitals, schools, public universities, etc.) would yield an enormous savings of between €9 and 13 billion annually by 2020 (all currency expressed in 2001 euro). This reduction is from a projected business-as-usual public sector energy budget of €52 billion in 2020 (in 2001 the figure was €47.4 billion), so represents a savings potential of roughly 20 percent.

An assessment of the Chinese government's new purchasing initiative found that the ten-year cumulative savings from the inaugural group of energy-saving products in the program could amount to over US $1 billion. Another dozen or so products were added to the program in 2006, so this savings figure probably understates the potential substantially.

The studies cited above are based on top-down analyses of entire sectors. Another study (Coleman 2000) estimated the impact of energy efficiency improvements that had been made to U.S. government agency guide specifications. An Army Corps of Engineers guide specification change for water-cooled chillers was estimated to save approximately US $7.5 million per year by 2010 (given ten years of installations at normal stock turnover rates). FEMP's annual budget for the purchasing program that spurred the change was roughly US $500,000 (2000 currency). The comparison with the US $7.5 million savings makes an extremely compelling argument for FEMP's program: specifically, one action by a convinced specifier of one product produced a 15-fold return on government investment, without taking into account all other savings the program generates.

Spillover Effects

One additional source of (indirect) savings from FEMP's program has come from U.S. cities and states that have adopted the FEMP program's levels in legislation or regulation requiring efficient product purchases for state facilities. This had occurred in at least 15 states (including California and New York) and six large cities by the time the program was only seven years old (Harris 2003). Although the savings in these states and cities cannot be attributed fully to FEMP, the ability of the states to adopt or draw from FEMP with very little incremental effort is a substantial indirect benefit of the program. Other national governments may want to consider this adoption potential, whether by subsidiary states or even other countries in their region, as they weigh the prospect of embarking on a purchasing program.

6.8. Conclusion

An energy-efficient purchasing initiative can be a valuable component in a government energy management program, capable of yielding very impressive savings. However, reliable and easily accessible efficiency ratings are prerequisites to establishing a program. Without these elements already in place, any effort to promote efficient purchasing will likely be misspent. Additionally, many program elements, from selecting which products to cover to distributing the recommendations to users, can be complicated, and there are no guarantees that merely disseminating the information will result in compliance by purchasers. Nonetheless, in most cases, purchasing initiatives will make sense, especially at the national government level where procurement volumes are large. Initial studies indicate that program savings, even excluding the indirect benefits from greater accessibility and lower prices for efficient products across the economy, can dramatically outweigh costs.

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CHAPTER 7—PUBLIC INFRASTRUCTURE

Key Considerations in Developing Resource-conserving Public Infrastructure Programs

1. Increased efficiency in public infrastructure typically produces a high return on investment and attracts investors that may also support desired system expansions.
2. Municipal water systems offer many cost-effective opportunities both on the supply (e.g., leak detection and efficient pumping) and demand (e.g., water conservation awareness campaigns and plumbing fixture replacement programs) sides. Since most measures save both energy and water, the combined payback periods tend to be short.
3. Public lighting efficiency programs can provide the dual benefit of financial savings and increased safety and security. As with municipal water systems, the cost savings from efficiency gains can sometimes be used to leverage system expansions.
4. District heating systems are usually characterized by extensive leakage in their distribution systems. Correcting this problem, and taking advantage of opportunities for cogeneration and alternative fuel use- or even system de-centralizations—make district heating an attractive target for an energy initiative.
5. Building institutional capacity through training, recognition, and other managerial initiatives is a critical step to improving the efficiency of public works systems. In some cases (e.g., demand-side programs for conservation of water or district heat), including the public in this educational activity is also important.
6. Developing performance baselines (e.g., energy per delivered liter or lumens per watt) and benchmarking against comparable systems will help identify where intervention is most warranted.
7. Cost-effective opportunities in water supply (particularly in pumping systems) are generally available, whether loads are constant or variable. Where time-of-use rates are in effect, off-peak pumping is often an attractive measure.
8. Public lighting retrofits are frequently cost effective, as are timers, sensors, and other measures to turn lighting fixtures off during the day or when not needed.
9. As with water supply systems and public lighting, low-cost, quick-payback measures in district heating systems, such as simple weatherization or preventive operations and maintenance on boilers and distribution equipment, can help make the case for greater levels of additional investment.
10. Policies and rate structures that stimulate end-use conservation are critical to system efficiency in water supply and district heating. Assigning costs to responsible end users and reducing or eliminating subsidies can help incentivize energy- and water-conserving behavior.
11. Private sector involvement in public works systems can provide benefits, but care should be taken to structure contracts so that private sector operators are motivated to capture system efficiencies on both the supply and demand-sides.

Municipal services—ranging from road paving to sewage treatment—are at the heart of any country's infrastructure; however, growth and development initiatives often overlook the potential for energy and water savings in these systems. The inherent conservation opportunities can be very attractive to municipalities, and local

and global investors are also often motivated by the prospective returns. Because of the potential for outside investment, governments experiencing tight budgets can sometimes transform efficiency opportunities in these systems into infrastructure improvements that would not otherwise be possible.

This chapter focuses on three municipal services: water supply, public lighting, and district heating. The chapter provides policy makers and managers with examples of how energy efficiency in these three systems can bring significant savings to municipal budgets while advancing other development objectives.

There are four general approaches for achieving energy savings in the provision of these municipal services:

- Improve management through activities such as training, information exchange, goal setting, and prioritizing opportunities.
- Implement technological strategies to enhance energy efficiency, such as metering, leak prevention, pressure management, and various end-use efficiency technologies.
- Create conducive policy climates for energy efficiency by strengthening regulatory mechanisms and creating economic incentives for conservation.
- Promote diverse financing options by ensuring favorable conditions for investment.

7.1. Overview of Energy-Saving Opportunities and Their Impacts

As governments seek to improve their infrastructure, they often focus on services generally associated with substantial utility expense—water, street lighting, and district heating. Not only do energy and water conservation make sense because they provide a strong financial return, but these high returns may also attract project funding to expand these important services. Funding from international sources like development banks can also be leveraged for programs that include effective management of resources, like water.

Municipal Water Provision and Treatment

In the developing world, the cost of energy to pump and supply water may easily consume half of a municipality's total budget. Moreover, it is not uncommon to have 50 percent or higher rates of water loss, generally due to system leaks and theft. Fortunately, the potential to save both water and energy in almost all municipal water systems is substantial. Opportunities on the supply side (i.e., reducing water and energy losses due to leaks, inefficient equipment, or improperly sized systems) are nearly universal and are often not difficult to identify.

Considerable energy and water savings can also accrue to the water utility from programs promoting conservation measures aimed at end-use customers, such as low-flush toilets, and low-flow showerheads. Since the ability to tap into this demand-side potential varies according to factors such as the expertise and capacity of the public service institutions, the regulatory climate, and available funding, these opportunities tend to be more elusive and are captured less frequently than supply-side efficiencies. Competing priorities, ranging from development needs to stadium construction to political positioning, can also cause these opportunities to be overlooked.

Experience with water conservation measures has proven that combining supply- and demand-side opportunities in municipal water systems can deliver substantial savings. Aside from saving water directly, demand-side reductions permit the installation of smaller, less energy-intensive pumping systems. In addition, the efficiencies gained through simple, low-cost efforts (ranging from pump impeller trimming to proper maintenance of pressure-reducing valves) can often yield energy savings of 10–25 percent.

Public Lighting

Public lighting for streets (including traffic lights), parks, and walkways offers a significant savings opportunity for governments. In addition, the lifestyle and safety improvements that result from better lighting of public thoroughfares and more reliable traffic control provide residents and the local economy with added benefits.

Increasing economic prosperity almost invariably spurs an increase in the purchase and use of motor vehicles, highlighting the importance of both the energy savings and collateral benefits of street lighting efficiency. For instance, during Vietnam's economic boom from the 1980s into the early 2000s, there was a 25 percent average annual increase in the number of motorcycles on the nation's roads, reaching a total of 8 million by 2004. Roadways are often hastily paved to keep up with the onslaught of new vehicles in these situations. Without the cost savings possible through energy efficiency, these roads may remain inadequately lit, if at all.

Since public lighting systems are often installed in an *ad hoc* manner, underfunded local government agencies tend to select lighting options with the least initial capital cost. Later, the agencies are burdened with excessive operating costs at the same time that they need to expand the public lighting infrastructure.

Public lighting energy efficiency provides an excellent opportunity for governments seeking savings, as well as a means to help relieve the financial strain of system expansion required by urban growth. For example, efficient public lighting installed in 2004 in Vietnam was estimated to decrease the electricity consumption for this service by 20 percent. Although simple fixture change-outs will usually provide 20–30 percent savings, more comprehensive programs can generate even better results, as seen in the case of the Portuguese municipality of Vila Nova de Gaia (Box 7-1).

Box 7-1. Tackling Efficient Street Lighting in Vila Nova de Gaia, Portugal

ENERGAIA, the Energy Agency of Gaia, Portugal, reported in 2004 that Vila Nova da Gaia had experienced an average annual increase in electricity consumption of 7 percent between 1990 and 1998, and was expecting that rate to continue to grow. Spurred by this projected growth, the implementation of an energy-efficient street lighting program—covering more than 1100 circuits and totaling 2.5 GWh of dedicated street lighting—yielded annual savings of €21,900 (from a reduction of 270 MWh of electricity) and avoided 135 tons of greenhouse gas emissions.

In order to achieve these benefits, EDP Distribuição SA, the managing agency, had to first identify and then address the problems and barriers to an effective program. Among the broad issues identified were large and dispersed street lighting systems that were growing almost daily, the expense of higher-efficiency equipment, and an inadequate municipal management model. There were also technical problems, such as the variation in lamp types and power usage. Less technical barriers included the absence of an obvious source of funding, contracting issues between the city and EDP, and the limited level of importance traditionally given to energy management in the city.

EDP developed a comprehensive action plan that included:

- The development of a complete street lighting data registry
- Promotion of efficient luminaires
- Effective control of operating hours and illumination levels
- Monitoring of energy consumption
- New maintenance practices

EDP and the City of Gaia were able to find solutions to each of the identified problems. Technical solutions included connecting similar loads and promoting the use of high-pressure sodium lamps; non-technical solutions included funding the project with third-party financing and loans, engaging expert technicians to negotiate the contractual difficulties, and developing related pilot projects to raise awareness about energy efficiency.

This project resulted in a new management model, a guide to best practices and standards for street lighting, an internal team devoted to public lighting, and the dissemination of information to promote efficiency in management.

Source: MUNEE (The Municipal Network for Energy Efficiency).

Energy-Efficient District Heating

Unlike water supply or street lighting, the provision of district heating is not common to all municipalities. Yet district heating provides roughly 50 percent of the heat and hot water in Russia, Ukraine, Latvia, and many other countries in Eastern and Central Europe and Central Asia. As the main system of centralized heat production and distribution for urban areas in many of these northern climate transitional economies, district heating not only provides residential and commercial space heating and hot water, but also provides process heating to many industries.

One of the main benefits of this type of heating system is the possibility of cogeneration (simultaneous production of electricity and heat), which can dramatically raise the overall efficiency of district heating. In addition, district heating systems can be fueled by biomass (e.g., industrial wood waste, straw, and other waste-wood products, as seen in the Baltic countries and some others). Consequently, it has the added potential benefits of being more environmentally benign than other methods of heat generation, and providing a more secure source of energy.

District heating systems in the transitional economies of Eastern and Central Europe and Central Asia are generally very inefficient, with high distribution losses. In Russia, low-efficiency boilers and poorly maintained heating systems represent a largely untapped energy-saving and financial opportunity since district heating accounts for approximately 5 percent of the gross domestic product (GDP). Because of this economic prominence and the degree of inefficiency and indebtedness of many of these systems (common where central governments once subsidized the systems), district heating has the potential to bankrupt cities in Russia and other countries if the problem is neglected. This is especially true where bill collection rates from customers are low, as is the case in many countries that comprised the former Soviet Union.

Box 7-2. Development Banks Invest in Efficient District Heating in Bulgaria

In 2002, the European Bank for Reconstruction and Development (EBRD), the World Bank, and the Sofia and Pernik municipal district heating companies, run by Toplofikacia AD, jointly started the Sofia and Pernik District Heating Rehabilitation project. The project included installation of new substations, rehabilitation of critical parts of Sofia's district heating plant, installation of insulated piping, and other institutional and policy measures. Energy savings of roughly 30 percent per connected household were achieved, well above expectations, even while the percentage of city households connected to the system and collection rates increased markedly; the household savings were especially valuable given the run-up in energy prices in the 2000s. Particulate and carbon emissions dropped substantially, as well. Moreover, both systems were able to cease their operating subsidies. The total cost of the project was US $132.7 million (2008 currency), which was split among the three organizations.

Source: World Bank 2008.

Efficiency improvements to district heating systems have been funded by various sources, including international development banks (see Box 7-2). However, the indebtedness of inefficient systems can be a barrier to development

funding. For example, debt remediation in Romania became a precondition for future lending by the International Monetary Fund. Thus, increasing the efficiency of district heating systems can help transitional and developing economies obtain much-needed development lending.

7.2. Management Strategies to Achieve Savings

Although Chapter 9 addresses the general concepts of employee outreach, training, and incentives, this section provides some examples of the types of capacity building specific to achieving energy savings in water, public lighting, and district heating systems. Improving energy efficiency in these sectors requires human resource capacity and appropriate analysis and planning.

Building Institutional Capacity

Training of municipal public lighting and district heating managers in energy conservation is most effective when coupled with concrete investment projects, since most efficiency gains in these sectors occur through specific interventions rather than operational improvements. When combined with actual initiatives, training in energy conservation motivates personnel while illustrating how the financing, procurement, and construction management work together to achieve savings.

Training management staff in energy conservation can be one of the best investments a water utility can make. Training in energy conservation allows engineering staff to find new ways to provide better service while conserving operating costs, often with little capital investment. Technical courses not only upgrade skill sets but also can increase interactions among the various disciplines within a water utility. Additionally, a training program geared toward promoting more effective interaction with consumers, especially in cases where there is little tradition of customer service, will help the effectiveness of end-user conservation initiatives.

Box 7-3. Metering Partnership in Veracruz, Mexico

The Alliance to Save Energy collaborated with the company Badger Meter to train water utility staff in Veracruz, Mexico. Badger Meter delivered an educational, residential training program and installed flow meters, while the municipality provided the meeting space, historical data on the system, and staff availability. Since these municipalities lacked the financial resources to install permanent flow meters, Badger Meter personnel instructed the utility operators on the installation of temporary meters (which the company loaned), data collection, and system maintenance. Data collected during this training was used later in an energy audit of the distribution systems in these municipalities. During 2004, the partnership of the Alliance to Save Energy, Badger Meter, and the Veracruz Water and Wastewater Utility reduced energy consumption by 22 percent within one of Veracruz's main pumping stations. Combined water and energy conservation efforts had the added benefit of reducing customer complaints, from over a hundred a month to almost none. This improved customer morale increased the utility's collection rate, allowing Veracruz to continue upgrades to its infrastructure and operations.

Training the End Users

Along with system operators and managers, end-use customers should be the focus of energy conservation outreach and training. Addressing this overlooked audience can generate unexpected benefits. For example, a 1996 residential water audit initiative in the township of Thokoza, South Africa, undertaken by Rand Water and the South African electricity provider Eskom, successfully conserved 195 million liters of water and 2 million South African Rand (US $250,000) per year, highlighting the immediate benefits of water efficiency to the more than 2,000 audited customers. The program also generated 24 township entrepreneurs who were encouraged to start their own small businesses in plumbing and leak repair. And once public awareness of the program grew, partnerships between some of these nascent businesses and several local flower nurseries resulted in a water-conserving method of gardening and showcased water and energy conservation to customers in drought-prone regions of the country.

The Thokoza and Veracruz, Mexico experiences (see Box 7-3) underscore the potential value of demonstration projects in raising public awareness and support for efficiency programs. However, other types of promotional efforts can be less concrete but just as visible. Marketing campaigns can have widespread visibility through aggressive promotional efforts that may incorporate the use of logos, mascots, and even music to get the message out. In some cases, public entities have opted to develop these types of extensive public relations campaigns and direct them at school children and their instructors (see Box 7-4). Where successful, such campaigns can change attitudes about energy and water conservation among generations of consumers.

Box 7-4. Mascots to Promote Water Conservation in Brazil

Fortaleza, the capital of the Brazilian state of Ceará, is a city of more than two million people. CAGECE, the state water and wastewater company, is the third largest energy user in the state. Due to an estimated 20 percent electric power shortfall in 2001, Fortaleza faced potential blackouts. In an effort to reduce the impact of the electricity shortage, the state identified CAGECE as a major potential source of electricity demand reductions. CAGECE decided to develop a proactive training and efficiency program to improve operations and reduce costs. This was coupled with a waterwaste reduction outreach campaign focused on educating school-aged children. The program used two water efficiency mascots, Pingo and Gota d'Agua, to convey to even the youngest school children the benefits of using water efficiently. Shaped like water-drops, these two energy-saving heroes are featured in lesson plans, colorful posters, coloring books, and T-shirts made available to schools. As part of this effort, CAGECE personnel participate regularly in community events, speaking about ways the public can become more efficient in their daily water use. Some of the specific groups included in this outreach were industry, hotels, private firms, and housing complexes. Given CAGECE's statewide focus, this message was taken well beyond Fortaleza, reaching CAGECE customers throughout the state of Ceará. These ongoing public education programs continue to help CAGECE to increase general awareness of the need to conserve both water and energy.

While it is difficult to single out which programs were responsible for which results, the overall water-saving initiative in Fortaleza—including some investments in infrastructure along with "soft" campaigns such as this one—was successful in generating annual water and energy savings of US $2.5 million by the end of 2004. Perhaps most impressively, during this same three-year period, 88,000 additional households were connected to water supply—an increase that underscores the potential to simultaneously promote conservation and development.

In district heating initiatives, printed public-relations materials, studies, and recommendations seldom have the impact of concrete projects. The ineffectiveness of these materials may be due to the fact that many Eastern and Central European and Central Asian district heating customers have seen numerous brochures promising benefits without experiencing results. Consumers tend to be more motivated by results they can see and actions they can take that will lead to tangible, meaningful improvements.

Unlike the situation with most municipal water and district heating systems, the general public does not pay directly for public lighting. Generally, public lighting is paid out of municipal funds, although the public ultimately pays for this service through taxation. Consequently, the focus of energy-saving public lighting initiatives can focus on officials and other representatives of municipalities. Training operators in the proper technology and its appropriate application may be sufficient to build the institutional capacity for improving efficiency.

Analyzing the Current System and Establishing Priorities

As Chapter 2 describes, setting goals and priorities for any public sector program, and then monitoring progress, is critical to success. Economic analysis is central to this endeavor and should be undertaken for water, public lighting, and district heating systems. Even when significant funding is not readily available, the analysis may reveal savings opportunities to both justify and invite investment. Thorough planning should identify short-, medium-, and long-term strategies that can be implemented as both funding and program capacities grow. Both supply- and demand-side options should be explored, as well as comparisons between less and more centralized forms of service (e.g., calculating the savings achieved through removing some facilities from the district heating steam loop and instead installing dedicated load-serving boilers).

A vision of low- or no-cost measures, as well as medium- and long-term opportunities, will enable the management team to set a timeline for energy conservation initiatives. Additionally, the economic analysis and planning processes can incorporate the environmental costs and a range of societal benefits that often make the difference when seeking funding from international development sources.

Establishing Performance Baselines

Many of the principles for buildings described in Chapter 3—e.g., baselining (establishing existing consumption rates) and benchmarking (normalizing those figures and comparing them to those of other, similar facilities)—also apply to water systems, street lighting, and district heating. This section will discuss further refinements to establishing baselines and benchmarks in these sectors.

It cannot be overstated that monitoring a system is critical to proving that the program has been worthwhile and is delivering the intended financial (and other) benefits; this is possible only by establishing an accurate baseline. Benchmarking energy consumption data for these systems is also valuable, primarily to gain an understanding of the best areas for improvement. For instance, are leaks in a municipality's water supply or district heating system high relative to leaks in other cities' systems? Are illuminance levels or lighting efficacy (lumens/watt) low in your city's street lighting compared to others in the country? Utilities can compare overall energy usage figures (generally per unit of output, e.g., energy/liter delivered) and, if possible, also those on a smaller scale (e.g., energy consumption per run-hour of a pump and motor assembly).

Data collection for establishing baselines should be as comprehensive as possible. For water systems, the data should include all costs to treat and deliver water and to collect and treat wastewater—including costs for operations and maintenance labor as well as costs for treatment chemicals. The focus should be on the whole system, from intake to customer discharge (see Box 7-6). If there are environmental costs, such as erosion remediation or fish re-stocking, these should also be reflected in this baseline since system improvements designed to conserve energy and water may also affect these costs.

For public lighting or district heating, the data collection should be similar: estimate all equipment, operations, and maintenance costs, and also include environmental costs (e.g., for ballast or lamp disposal).

When possible, collect additional data for district heating systems. Even if energy consumption and/or bills have not varied significantly within or between systems, service is an important variable. Measuring average day- and night-time temperature in a sample group of apartments will help assess service problems. Where possible, also document related infrastructure effects (e.g., what was spent to repair a sewage line that exploded due to it being insufficiently heated).

Following collection of the raw data, the next step is to put them into meaningful form. This generally means reflecting the energy usage and costs as a function of delivered services. Valuable metrics include:

For water systems:

- Electricity use (and cost) per liter of water delivered or treated.
- Water delivered per water produced (subtracting this from one hundred percent provides the system loss ratio).

For district heat:

- Fuel use per kilogram of steam produced or per energy content of heat and hot water delivered.
- Energy consumption per area of heated space.
- Emissions (of CO_2, SO_2, NOx, particulates) per unit of heat produced.
- Emissions (of the same) per unit of electricity produced (if combined heat and power is used, such that electricity is a product, along with heat).

For public lighting:

- Lumens (or, ideally, illuminance at street level) per watt.
- Lumens (or illuminance, in lux or foot-candles) per kilowatt-hours consumed. (In addition to incorporating the lighting efficacy (lumens/watt) metric, this figure also measures the success with which fixtures are being turned off during daylight hours.)

7.3. Applying Strategies for Energy Conservation

The appropriate energy-saving technologies to apply in municipal systems vary according to factors such as best available technologies, product availability, and price, as well as organizational capacity (e.g., whether the technology will be understood and fully utilized) and technical factors. However, simple low-cost measures can often be introduced immediately and, in some cases, a replicable model can be developed.

Water Systems

Both water supply and wastewater treatment systems generally offer a host of savings opportunities, especially in pumping. Where loads (flow and head) are constant, efficiency can be increased with proper pump sizing such that the load approximates the pump's "best efficiency point." When loads are variable, there are a number of ways to achieve improved efficiency. Two common methods are:

- Using dual (or multiple) pumps, placed in parallel and sized to handle both normal and high-load conditions, respectively.
- Using multi-speed pumps or variable speed drives to avoid pump throttling (i.e., artificially lowering flow with the use of valves instead of modulating the load on the pump).

Some water system measures are less intuitive. For example, where time-of-day electric metering exists, water pumping can be accomplished during low-demand, low-cost hours and stored in reservoirs for delivery during times of high demand. Box 7-5 lists water system efficiency measures broken down by expense.

Box 7-5. Efficiency Measures in Water Systems

No- or Low-Cost Measures

- Operational changes (e.g., tank filling sequence; use of standby mains, transformers, or pumps)
- Pump impeller trimming
- Reduction in contracted demand
- Demand shifting to take advantage of off-peak rates
- Maintenance of pressure-reducing valves

Medium-Cost Measures

- Pump and motor system replacement
- Installation of pressure-reducing valves for loss reduction from pressure management
- Installation of capacitors to improve power factor
- Implementation of automation measures for energy efficiency

Higher-Cost Measures

- Pipe replacement or lining to lower C-values (reduce friction losses)
- Installation of variable speed drives
- Water reclamation and reuse schemes
- Design and installation of an integrated SCADA (Supervisory Control And Data Acquisition) distribution automation system

Source: Alliance to Save Energy 2000.

Public Lighting

Substantial savings can often be achieved in public lighting merely through simple fixture change-outs to higher-efficacy lighting technologies. For example, Vietnam's Energy Efficient Public Lighting (VEEPL) program demonstrated simple measures that can be undertaken in cities that use outdated lamps for street lighting. In three demonstration cities, VEEPL replaced incandescent lamps with compact fluorescents and replaced mercury vapor lamps with high-pressure sodium vapor models. These demonstrations showed energy use reductions of up to 50 percent and reduced maintenance requirements due to the longer lifespan of the new equipment (Sathaye 2004). As a result of these projects, the VEEPL program was awarded US $3 million in funding by the United Nations Development Programme (UNDP)/Global Environment Facility (GEF) for a five-year plan to upgrade public lighting, beginning with outdoor lighting (streets, roads, parks) and then progressing to indoor lighting (for schools, hospitals, and other public buildings).

Another short- to medium-term measure for public lighting is installing light sensors or timers to shut lights off during the daytime when they are not needed. Savings can be substantial, especially if the lights are normally left on all day.

Longer-term measures include full fixture replacements rather than mere lamp replacements. For traffic signals, the transition is usually from incandescent lamps to light-emitting-diode (LED) signals. The latter offer not only

dramatically lower wattage and greater visibility, but much longer life (generally about ten years, compared to the roughly six-month longevity for incandescents). Whole fixtures as well as individual signals (i.e., red, yellow, or green) can be retrofitted; the red and green lamps usually have shorter payback periods than the yellow lamps due to their lower cost and greater time in use. For street lighting, fixture change-outs generally involve an upgrade from various predecessor technologies (such as mercury vapor, high-pressure sodium, or metal halide) to LED models.

Timers for lighting feeders (permitting large sets of lights to be controlled at once) are another long-term measure that may be attractive. Finally, adding controllers to reduce the voltage (and thus the watts) in lighting systems can be a cost-effective option, particularly where voltage is consistently higher than necessary for lamp operation.

District Heating

Once a system audit is completed, it may be necessary to implement the least expensive solutions first (as was the case in the Vietnamese street-lighting program) in order to make the case for more comprehensive approaches. Box 7-6 lists examples of both low-cost and medium- to high-cost measures that can improve efficiency in district heating systems.

Technologies like ultrasonic or infrared imaging which can pinpoint leaks in underground water pipes in municipal water-efficiency projects, are also very useful for detecting leaks in district heating systems. However, although investment in these technologies may be paid back rapidly, they are expensive and may be difficult to justify before a program has demonstrated initial successes. Where potential exists for simple investments in metering and diagnostics, the easy savings can often be used to fund more expensive projects. For example, after the installation of heat meters in the Russian municipality of Ryazan, district heating service providers found that actual heat consumption was 30 percent lower than the consumption regularly invoiced by the heat supplier (COWI 2004). This resulted in immediate savings that allowed the city to finance other programs.

Box 7-6. Efficiency Measures in District Heating Systems

Lower-Cost Measures

- Operational and maintenance changes (e.g., regular cleaning of all generation and distribution equipment, and computer-based monitoring of the system's operational efficiency).
- Reduction in contracted demand if there is overcapacity.
- Restructuring tariffs to give consumers an incentive to save heating energy (metered billing if possible, offering peak and off-peak rates to shift demand and reduce peak load).
- Shifting to meter-based billing instead of billing according to area of heated space.
- Low-cost weatherization of buildings (using thermal reflectors for radiators, sealing windows and doors and keeping them closed to maintain heat in conditioned spaces, and insulating attics, roofs, and basements).

Medium- to Higher-Cost Measures

- Operation of district heat system using lower water temperature and higher pressure in pipelines.
- Replacement of pumps, motors, flow meters, steam traps, and pressure valves.
- Installation of automated controls in heat supply system.
- Improved treatment of water circulating through heat networks.
- Installation of building meters to be used as basis for billing consumers.
- Installation of heat-cost allocation and/or thermal regulation valves in heated facilities and homes.
- Pipe replacement using pre-insulated pipes, and shortening pipeline length if feasible (typically in newer systems).
- Intensifying of furnace heat exchange.
- Retrofit or replacement of boilers (replacement generally recommended for boilers with efficiencies below 65 percent if capacity < 1 Gcal; if capacity is larger, replacing just the burners with high-efficiency models is usually sufficient).
- Switching to cleaner, more efficient fuels.
- Introduction of combined heat and power (feasibility studies are necessary to determine the efficiency of this option in a given market and policy environment).

7.4. Creating Policies Conducive to Energy Conservation

Chapter 2 outlines general issues surrounding the assessment of existing regulatory frameworks for any government program; this section focuses on examples of such policies that are specific to water supply, public lighting, and district heating. For example, municipal water or electricity utilities may offer programs to cover some of the costs of end-use water- or energy-saving equipment and installation. In the case of water utilities, common equipment types covered under these programs are low-flow faucets, low-flush toilets, and efficient washing machines for apartment buildings (see Box 7-7). Electric utilities may subsidize efficient ballasts and lamps, or controllers (e.g., photosensors and timers) for public lighting. From the utilities' perspective, investments of this kind can be

weighed against the cost of constructing new supply infrastructure, such as additional electric generating plants. The ability of utilities to fairly balance these costs against each other depends on the regulations with which they must comply, some of which are more conducive than others. In some cases, regulation mandates such tradeoffs (e.g., through "integrated resource planning" requirements or rate-of-return regulation that disconnects ("de-couples") profits from revenue so that conservation is not disincentivized). As ratepayers, public sector entities generally can—and should—take advantage of utility incentive programs where they exist.

Box 7-7. Toronto Reduces Water Usage Through Demand-Side Measures

In the early 2000s, the city of Toronto projected that new demand resulting from population growth would put increasing pressure on their water system infrastructure. Because reducing per capita water needs through demand-side efficiencies can postpone or eliminate the need to invest large amounts of money in new water facilities, the Toronto City Council in 2003 adopted a goal of reducing average water demand and wastewater treatment by 15 percent by 2011 through its Water Efficiency Plan. This translates into a reduction in consumption of 220 million liters of water per day (roughly the amount of water used daily by half a million citizens).

Toronto worked towards achieving this goal through a cost-effective, socially acceptable, and easy-to-implement plan. The water utility efficiency plan is primarily a demand-side program, but it does include some supply-side efficiency improvements such as a major leak reduction effort targeted to save 30 million liters of water per day. The specific measures included in the plan were selected from a list of measures implemented in other cities. Originally, Toronto considered 70 possible measures; these were narrowed down to 21 after an initial review that screened the measures for relevance to Toronto's conditions and to the scope of the plan. The review team selected seven measures based on technical feasibility and ease of application, and then tested several to verify program costs, results, and social acceptability.

Some solutions adopted for residential areas include low-flow toilet rebates, promotion of horizontal-axis clothes washers, and a policy requiring summer peak-load lawn-watering reductions. The seven selected efficiency measures were estimated to cost only one-third of the cost of building comparable additional capacity.

An early 2011 staff report from Toronto Water reported that the average annual water demand on the city system in 2010 had actually exceeded the 2011 goal by 10 percent. Even adjusting for lower-than-expected population growth, the plan had generated 14 percent average volume savings.

Sources: Alliance to Save Energy 2002; Toronto Water 2011.

Regulation ensuring that district heating companies are allowed to sell their power and heat can enhance the value of such measures as heat recovery or cogeneration. Regulatory mechanisms that encourage private sector involvement in district heating or water services (particularly in transitional economies where these utilities may have been centrally operated) will need to be somewhat flexible both in the timeframe for the transition towards privatization as well as in the approach to this market transformation. Nonetheless, implementing policies that attract private investment to this sector—such as increased installation of end-use metering to permit the proper assignment of costs among users—will generally assist in strengthening service to customers, whether or not private control is ultimately sought.

7.5. Seeking Funding for Projects

Leveraging Low-Cost Investments

Initially, a utility may hesitate to allocate a portion of its budget for energy conservation measures because managers are skeptical of the returns. However, no- and low-cost measures may prove the opportunity for savings and a return on investment comparable to larger, more ambitious investments. For example, in Galati, Romania at the turn of the century, a consulting company estimated that the quickest payback measure in the municipal water supply was leak detection and repair. Because the parts to fix the leaks (e.g., washers, seals) were inexpensive, the pilot leak detection and elimination program was predicted to achieve a short payback period of about 2.5 years. After the investment was found to pay for itself in less than a year, the utility expanded it and the system quickly accrued savings that allowed the company to undertake more ambitious projects with capital requirements (Alliance to Save Energy 2002).

A dedicated budget for water and energy conservation programs is important, even if its size only permits small investments. Small initial efforts might be in the areas of metering or monitoring, performing system-wide audits, training staff in efficiency techniques and tactics, or conducting highly cost-effective retrofit projects. The key is to make the initial investments successful, increasing the likelihood that future budgets will increase.

There are also creative solutions available for overcoming small budgets for conservation programs. A non-governmental organization, the Tata Energy Research Institute (TERI), devised a plan for Hubli City, India in 2003 whereby energy-saving measures requiring no capital cost could be immediately implemented. The plan permitted the stream of "revenues" from savings to fuel measures requiring capital expenditures that would otherwise not be funded.

Among measures proposed for Hubli City's street lighting retrofit was the installation of 36-watt fluorescent tube lights in place of the existing 40-watt lamps. This simple "inventory control" measure—no ballast or fixture changes were necessary—conserved 10 percent of the fixtures' prior energy consumption. The watt reduction per lamp saved a total of 36 kW across the roughly 9,000 fixtures in Hubli. The annual savings captured through this simple inventory control measure was Rs. 5.18 lakh (roughly US $11,500) with no installation cost and an instantaneous payback period.

The VEEPL public lighting project in Vietnam, discussed earlier (Section 7.3), is a good example of the power of leveraging funds to improve public lighting. Not only did this project receive US $3 million in funding from the UNDP/GEF, but it also obtained municipal co-funding of US $8 million and local government funding of US $1.4 million. In addition, it leveraged another US $2.7 million in private sector funding over five years. When multiple

sponsors fund an initiative in this way, each can have ownership over the project results despite contributing to only a portion of the cost. This is frequently attractive to funding agencies.

Encouraging Investments and Market-Based Solutions

Chapter 4 discusses general issues about obtaining funding from international development banks and utilizing third-party financing through performance contracting. This section highlights some projects in which investment has been encouraged in municipal water systems, public lighting, and district heating, and considers some of the specific issues surrounding investment in these areas.

The ability of public utilities, municipalities, and the private sector to borrow funds for energy conservation investments varies by country. Developing economies may rely more on overseas development aid or bilateral funding agencies to provide "seed" funding for energy-saving projects. Two types of measures—removal of energy and water subsidies, and decentralization/privatization of utilities—can help encourage investment in such projects, as can focusing on the collateral benefits of energy-efficiency improvements in project proposals.

Subsidy Removal

Price distortions like subsidies and below-cost tariffs encourage inefficient energy and water use. As municipal water and district heating systems are forced to become more responsive to market principles (see Box 7-9), end-users are increasingly billed based on metered consumption. This allows prices to approach levels where they cover the full cost of service. Although a case can be made for maintaining some subsidies for the community's most needy citizens, aligning services and costs will generally be a critical step toward generating outside investment in efficiency. The reasons for this are that: 1) customer payments constitute the revenue source to pay back any loans, and 2) charging end-users for the actual cost of the resource provides the motivation to conserve that is necessary for the success of demand-side initiatives.

Privatization and Decentralization

Privatization (where state-controlled functions become private sector ones) and decentralization (where governing authority shifts from national to local levels) are economic trends in many parts of the world. These changes often represent an opportunity to integrate and incentivize efficiency.

There are many ways to involve the private sector in government services, from short-term contracts to complete privatization of assets (e.g., a municipal bus system). However, any changes in ownership or management structure of energy infrastructure require a long-range perspective, since these systems (e.g., electric utilities) often need large, long-term investments to maintain services and keep pace with growth in demand. The process of privatizing a utility or other municipal service should be performed through an open process with clearly stated objectives and responsibilities (see Box 7-8).

Box 7-8. Lessons Learned in Moving to Market-Driven Principles.

- Strive to balance focus between supply and demand in municipal services (like water and district heating) to optimize efforts on a "whole system" basis.
- Encourage demand-driven business practices whenever possible. This may be achieved by such means as eliminating subsidies, enforcing good payment practices, and installing meters and controls.
- Even if the system is not privatized, when setting the prices for services, use full long-term cost recovery as a guiding principle.
- If privatization is chosen for a given system, the competition must be fair, transparent, and resistant to corruption.

In addition to political decentralization, the disaggregation of budgets is often critical for providing savings incentives—along with ensuring that any budgetary savings achieved are retained by the responsible parties. It is frequently the case that government budget accounting methods do not allow a reduction in "overhead," such as energy costs, to be retained by the responsible entity and then used as a capital investment. If there is no budget disaggregation allowing a municipality or department to "realize" its own energy savings as a potential source for funding new energy efficiency investments, there is little incentive for it to invest in a change. Worse still, there is often an actual disincentive to saving: in many cases, entities that reduce "overhead" expenditures (e.g., through energy conservation), find their budgets commensurately decreased in subsequent years. Where perverse incentives in accounting practices such as these are present, ESCOs can sometimes be used as third-party funding to remedy this problem, since they represent a way for project savings to be exchanged for infrastructure improvements. For more on financing with ESCOs, see Chapter 4.

The decentralization of transitional economies—when central governments cede both their budgets and their authority to the local levels—can also be a driver for energy conservation. This was the case in the state of Karnataka, India, where a partnership between an efficiency advocacy organization and the state-level Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC) led to the establishment of a state-run Energy Management Cell (EMC). This cell serves as a clearinghouse for information related to water and energy efficiency within the state, and has ultimately led to energy-saving projects and sponsored technical training that has reached more than 125 institutions. The work performed through this innovative partnership—energy audits and technical assistance provided by the EMC to water and public lighting energy-efficiency projects—resulted in annual energy savings of 8 million kWh (US $500,000).

Collateral Benefits

As government agencies undertake energy efficiency improvements in their service-provision sectors, local funding can often be matched by outside investment, often from abroad. Whether dealing with an international banking institution or a bilateral donor agency, identifying the additional benefits of an energy conservation project will add value to the project proposal. Some additional, less obvious, benefits that can be highlighted are:

- Capacity building (in terms of facilities, staffing, or equipment provided to the project).
- Social benefits (e.g., when public lighting, heating, or water services are provided to previously unserved areas).
- Health and safety impacts (e.g., with potable water provision and increased public lighting).

- Energy supply security (e.g., if locally sourced biomass is used to provide district heating).
- Poverty alleviation (e.g., when lighting extends work hours so that poor families may increase income-generating activities in their household).
- Economic development (i.e., showing the "big picture" of how energy efficiency benefits the country's growth in a positive way).

Sustainable operations of municipal services can be a fulcrum for development in any country. As the potential for enhancement is revealed, investment by outside sources will increase. The overall socio-economic benefits of secure and sustainable public services provided in an energy-efficient manner can be realized for generations.

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CHAPTER 8—PUBLIC TRANSIT AND FLEETS

Key Considerations in Developing Public Transit and Vehicle Fleet Programs

1. Implementation or expansion of a public transit system will likely increase government energy consumption, unlike other policies recommended in this guide. However, the overall impact to the region should be reduced energy use as well as air pollution, traffic congestion, and population spread.
2. Greater wealth, population and employment decentralization, and increased variability in work schedules are among trends that tend to favor private vehicle ownership over public transport. Planners need to consider these factors when designing new systems or major expansions.
3. There are multiple ways to measure transit system efficiency. Energy use per passenger distance traveled is probably the most valuable, since it addresses both equipment efficiency and the ultimate goal of any public transit system: passenger transport.
4. A thorough energy comparison of different prospective transport modes should include an analysis of the life-cycle energy use of each option, including its infrastructure development, as well as variables such as expected capacity and existing usable infrastructure.
5. Designing a successful, resource-conserving public transit system requires consideration of geographical, technical, economic, and environmental factors.
6. Key steps in the planning process for a new or substantially expanded public transit system are assessments of occupant density profiles and trends, technical evaluations of alternative transit modes, right-of-way analyses, and economic assessments of riders' willingness to pay and the municipality's likely costs.
7. Bus rapid transit (BRT) systems offer some of the dedicated right-of-way features of trains (both in boarding and en route), and thus generally allow faster transport than conventional city buses.
8. Light rail systems—with frequent stops and simple boarding for passengers—provide a more accessible and cheaper-to-construct alternative to conventional city trains and subways.
9. Even when a municipality relies on private transit operators, it can use its licensing and regulatory role creatively to promote efficiency without jeopardizing customer service.
10. Procurement of fleet vehicles provides an opportunity for significant savings—through increasing fuel economy as well as using alternative fuel vehicles. Care needs to be taken, however, to ensure that other needs are not sacrificed in the pursuit of energy savings.
11. Vehicle maintenance protocols that focus on fuel economy, such as routine tire inflation checks and the purchase of low-rolling-resistance replacement tires, offer an easy way to promote energy savings while providing ancillary benefits, such as improved safety and fewer breakdowns.
12. Fleet driver-training programs have demonstrated 5 percent and higher fuel savings with modest effort and limited off-duty time for drivers.

Transportation consumes over one quarter of the world's energy, and accounts for roughly the same proportion of total CO_2 emissions. Government policies at all levels have enormous influence on transportation energy use in general, through their taxing of vehicles and fuels, regulation of air pollution, land-use decisions, permitting of

building construction, regulation of vehicles and parking in urban areas, and public investments in roads and transit systems. This chapter is focused on this last category: How government decisions, mainly at the local level, can directly affect the energy efficiency of public transit systems and vehicle fleets.

8.1. Public Transport

Public transport systems offer opportunities for both direct and indirect energy savings. Aside from their own inherent potential for efficiency, they also are likely to decrease dependence on private vehicle use, and the concomitant problems of road congestion, air pollution, and population sprawl. Unlike other energy-reduction approaches advocated in this guide, the increased use of public transport will generally *increase* a government's overall energy use. However, the net energy savings to the region as a whole—along with the aforementioned other benefits—make focusing on these systems a worthwhile endeavor for governments.

Discussions of public transport—also sometimes referred to as public transit or mass transit—often focus on rail and bus service. However, wider definitions include ferries, various forms of contracted taxicab services, and even sometimes scheduled airline flights—in short, any system that transports members of the general public in large numbers in vehicles not privately owned by them.

Several combinations of inter-modal transport exist. For example, in some large, developed cities like London and Washington, D.C., the underground trains (metros) and bus services effectively dovetail in order to meet public transport needs. Even more effective inter-modal combinations are seen in Singapore and Hong Kong, where greater emphasis is placed on the convergence of multiple transport modes (perhaps stimulated, in part, by the low proportion of car owners in those cities).

In many cases, ownership and management of the various transport modes within a municipality are spread among different parties. Thus, while it is important in transit planning to try to optimize the entire system, it may be pragmatic for planners to also design system upgrades that offer benefits to each of the various players.

Challenges in Public Transport Systems

Public transit systems are an important part of the entire transport sector. However, it is a continuous challenge for these systems to remain as viable alternatives to private transport—most prominently, automobile ownership. Among the benefits of public transport to its users are its low cost, generally high reliability, and the absence of driving responsibility for the rider. Private ownership of automobiles, on the other hand, offers immediate availability, easy access, greater flexibility, and door-to-door delivery. Public transport systems, therefore, face a number of challenges in maintaining and growing market share, improving operational efficiency, and continuing patronage support.

In the latter half of the twentieth century, countries with historically strong urban public transport—such as most western European countries, the United States, and Canada—generally lost ridership (in percentage, if not absolute numbers) in their public transit systems. Some of the factors contributing to this trend were the decentralization of work and living opportunities to include more non-urban employment, and the accompanying dissolution of high-density mobility corridors; and increased wealth of the population in many countries, permitting more widespread automobile ownership. Many cities and even whole countries are now in the process of trying to reverse that trend, both by broadening the scope (geographically and temporally) of their transit systems and by increasing their "user-friendliness" (e.g., with simpler ticketing, easier physical access, and greater promotion).

Other trends in the urban passenger transport sector over the same time period have included a greater variability in work schedules, and a growing awareness and acceptance of user charges as opposed to government subsidization (which likely has contributed to decreased ridership). Finally, both developed and developing countries have experienced increasing privatization of road and rail networks of public transit systems. However, even in these cases the licensing function—and hence, the ultimate role in planning—still rests with government.

Efficiency Indicators

Public agencies involved in the transport field generally have two over-riding goals: first, to meet the transport needs of their citizenry and, second, to minimize the costs of doing so. Embedded in the second goal is the need to use energy efficiently. There are various indicators of the effectiveness and efficiency of public transport systems, including:

- Passengers carried over time (passengers/day)—while this measure provides a good indicator of system volume, it does not address distance traveled per passenger, nor energy consumed.
- Carbon intensity or energy use per unit distance (e.g., CO_2-equivalent/km or TOE/km)—these figures are valuable in that they allow comparisons among different fuel sources, but they fail to address the effectiveness of moving passengers, the primary goal of public transit.
- Carbon intensity or energy use per passenger distance traveled (e.g., CO_2-e/passenger-km or TOE/passenger-km)—this measure provides the most comprehensive view of system energy performance.

Table 8-1 illustrates that the optimal decision about which mode of transit to pursue with regard to energy use depends on whether the basis of the decision includes the full life cycle (including manufacturing and infrastructure development) or looks solely at the energy consumed in transport. In addition, the carrying capacities and capacity factors (percent occupied) of different modes have a substantial impact—for instance, cars use less energy per distance traveled than buses, but considerably more per passenger distance traveled. It is important to note that these are average numbers; the analysis for any given municipality may change due to local factors, such as existing track infrastructure (which reduces the life-cycle energy use compared to localities where tracks must be built from scratch) or high capacity factors (which drives down fuel use per passenger distance traveled). As suggested in the next sections, a combination of modes may be the most effective path to an efficient transport system.

Table 8-1. Performance Indicators of Different Public Transit Systems (Kalenoja 1996)

Type of Transport	Energy consumption per passenger distance traveled, over the life-cycle (including manufacturing, etc.) and in direct transport only			
	Life Cycle (MJ*/Km)	Life Cycle (MJ/Person-Km)	Direct Transport (MJ/Km)	Direct Transport (MJ/Person-Km)
Car	0.6	0.286	0.21	0.154
Bus	0.1	0.006	0.66	0.050
Local train	15	0.152	2.37	0.026
Express train	18	0.152	2.78	0.021

* Megajoules

Key Issues in System Design

The development of a successful public transit system requires consideration of factors such as geographical spread, town planning, technology availability, capital investment costs, and environmental impacts. The key factors in designing a public transport system, broken down into four major categories, are identified in Table 8-2.

Table 8-2. Factors in Public Transport System Design

Geographical	Technical	Economic	Environmental/Social
• Spread ("sprawl") of the urban area and population • City and regional plans • Zoning regulations • Land use patterns	• Availability of technology to cost-effectively implement system • State of indigenous technology • Availability and relative cost of fuels • Technical knowledge for the creation of necessary infrastructure	• Capital investment required • Funds availability and borrowing rates • Projected revenue streams • Number of people using private transport	• Air quality conditions • Environmental concerns of people • Community participation • Likely ecological damage

Decision Model for Proposed Systems

In designing a scheme for the creation or expansion of a public transit system, a number of questions need to be considered:

- What are the set of criteria used to evaluate and justify a specific plan and how broad-based should the evaluation be? Should it include factors like long-term population forecasts and emissions reduction benefits?
- What are the commercial and social consequences of the plan (e.g., does it address municipal development plans or equity issues of different rider classes)?
- Is there a market for the proposed service? Is the plan feasible given the revenue stream likely available to pay for it?
- What are the risk profiles of the various alternatives?
- What are the impacts on different stakeholders?

Based on these questions, Figure 8-1 presents a decision model that can be used by policy-makers to design an efficient public transport system (whether uni- or multi-modal).

Figure 8-1. Proposed Decision Steps in Designing Public Transit Systems

1. Assess the expected total occupancy and densities in the municipal service area.
    a. Evaluate demographic occupant/density profile and trends.
    b. Consider land-use planning implications.
2. Conduct a technical evaluation of the desired transit mix given population densities.
    a. Evaluate the technology and cost for various transport mode alternatives.
    b. Assess environmental impacts of individual transport modes.
3. Analyze right-of-way to determine feasibility of desired paths and modes.
4. Evaluate economic viability of uni- or multi-modal public transport.
    a. Study willingness-to-pay of prospective riders and conduct a benefit-cost analysis for municipalities.

Examples of Efficient Solutions in Public Transport

Two important types of efficient public transport systems that have been employed in both developed and developing countries are bus rapid transit (BRT) and light rail. BRT is a versatile form of public transport developed as an alternative to light rail, subway systems, and conventional bus operations. Compared to light rail and subway systems, BRT systems require less money and time for establishment. Compared to conventional bus systems (which require less infrastructure and planning), the main benefit of BRT is the speed and efficiency of transport. The examples of Curitiba, Brazil and Bogotá, Colombia are cited here as well established BRT success stories.

Light rail—an urban rail transportation system using electric-powered rail cars along exclusive rights-of-way at ground level, on aerial structures, in subways, or occasionally in streets—has become increasingly common in cities around the world, especially in North America. Light rail systems not only share the benefits of subway systems—e.g., reducing congestion and increasing trip speeds—but also are appealing for their easy accessibility to passengers and lower infrastructure costs. In the U.S., the experience of the city of San Francisco (see Box 8-3) demonstrates the efficiency of this form of public transit.

Bus Rapid Transit

BRT requires less investment in infrastructure and equipment than rail alternatives. It also provides faster operating speed, greater service reliability, and increased convenience relative to conventional bus transit when implemented in most municipal settings. BRT systems include most or all of the following features:

- Separate bus lanes dedicated exclusively to system buses.
- One or more streets in the city center where at least one lane (and possibly all) is exclusively for buses.
- Preferential treatment of buses at intersections, involving accelerated transition to green lights upon detection of the approaching bus.
- Longer distances between scheduled stops than conventional bus service, supplemented with local services that feed into the BRT system.

- Low-cost infrastructure like bus turnouts, boarding islands, and curb realignments to increase the speed of the bus service.
- An alternative to on-board collection of fares to reduce delays in the boarding process. Alternatives can include collection of fares at the enclosed bus station or prepaid cards for automated fare collection.
- Changes in bus or platform design to make boarding faster and easier; for example, low-floor buses or raised platforms or a combination of both.
- Improved facilities and services, such as bus shelters and stations that furnish information such as printed routes or electronically transmitted schedules. Such stations can also generate revenue for the system by leasing space to convenience services (e.g., newsstands, beverage vendors, or shoe-shine operations).

Conventional bus operations in a typical urban area are subject to several types of delay caused by passenger stops, traffic signals, left turn delays, and general congestion. The essence of the BRT is the enhanced speed and reliability of its operations, resulting from preferential treatment at traffic lights, dedicated bus lanes, and less frequent stops—all of which help reduce or eliminate these delays.

One of the best operational examples of BRT is the bus system in the city of Curitiba, Brazil (see Box 8-1). The bus service in Curitiba embodies all the characteristics of an efficient and well-managed BRT, providing a model of how to integrate sustainable transport into business development, road infrastructure, and local community development.

Box 8-1. Bus Rapid Transit in Curitiba, Brazil

Curitiba is a renowned model of sustainable development. The city's BRT system is one of the most heavily used, yet low-cost, transit systems in the world. It offers all of the key features of a well-designed BRT system—freely flowing bus service unimpeded by traffic signals and congestion, quick passenger loading and off-loading, and fare collection prior to boarding. The residents of this city enjoy largely congestion-free streets and pollution-free air.

In Curitiba, transportation was used as a tool to dictate the growth of the city along the structural north-south transport arteries, according to the city's master plan developed in 1965. The BRT system was developed along these arteries, helping it to achieve speed, efficiency, and reliability.

Curitiba's master plan integrated transportation with land-use planning, including zoning, housing development, and parking along the transit arteries. The popularity of Curitiba's BRT system has brought about a modal shift from automobile to bus travel, in spite of the high incomes and high rate of car ownership of the city's residents relative to the rest of Brazil. Based on a 1991 traveler survey, it was estimated that service improvements resulting from the introduction of BRT had attracted enough automobile users to public transportation to cause a reduction of approximately 27 million auto trips per year (saving about 27 million liters of fuel annually); in fact, 28 percent of bus service users previously commuted by car. Compared to eight other Brazilian cities of its size, Curitiba uses about 30 percent less fuel per capita because of its heavy transit usage.

The transport system's overall effect on growth patterns in the city has been dramatic. Residential patterns have changed to better take advantage of the BRT, bringing bus access on the major arteries to an increasing proportion of the population. Between 1970 and 1978, when the three main arteries were built, the population of Curitiba as a whole grew by 73 percent, while the population along the arteries grew by 120 percent. 80 percent of the travelers use either the express or direct bus service, while only 20 percent use the conventional feeder buses. In addition, the BRT system has resulted in indirect benefits—e.g., reduced emissions and diminished congestion—which also contribute to Curitiba's pleasant living environment. Finally, Curitiba residents spend only about 10 percent of their income on travel, which is low relative to the rest of Brazil.

Sources: Rabinovitch, 1995; Horizon, 2003; Goodman, 2005.

In recent years, BRT has been implemented in many cities in a way that exemplifies both "inter-modality" and energy efficiency. Box 8-2 below describes how the city of Bogotá, Colombia, increased passenger transport while simultaneously decreasing travel time and pollution through the introduction of a BRT system.

Box 8-2. TransMilenio, Bogotá's BRT System

Between 1998 and 2000, Bogotá, Colombia developed and implemented a BRT system called TransMilenio. The system consists of exclusive busways on central lanes of major arterial roads. Trunk-line stations are enclosed facilities with one to three berths, and are located roughly every 500 meters. Trunk lines use articulated two-or three-car diesel buses with capacities of 160 or 270 riders, while single 80-passenger buses operate on the integrated feeder lines.

To maximize capacity, some trunk lines operate express service, stopping at selected stations only, in conjunction with local services that stop at all stations. Bus service is operated by private consortia of traditional local transport companies (some backed by national and international investors). These franchises were procured under competitively bid contracts on a gross cost basis.

TransMilenio supports roughly 1.5 million trips per weekday, without operating subsidies, and at a ticket cost of roughly US$1. Smart card pre-entry charging from the raised (bus entry level) stations help to quicken and smooth the transport experience, and extensive bicycle paths and bicycle parking at terminal stations further complement the system.

Particulate emissions in the bus corridors were reduced by up to 30 percent, and passenger travel time was cut by a third, compared to pre-TransMilenio readings. Fatalities from traffic accidents also decreased.

Sources: UNDP/World Bank 2001; Olivera, 2012.

Light Rail

According to the U.S. Transportation Research Board, light rail is "a metropolitan electric railway system characterized by its ability to operate single cars or short trains along exclusive rights-of-way at ground level, on aerial structures, in subways or, occasionally, in streets, and to board and discharge passengers at track or car-floor level." Maximum speeds of light rail trains normally reach about 100 km/hr, while heavy rail trains can usually operate at significantly higher speeds. The distance between light rail stations is generally much shorter than with heavy rail systems, which provides easier accessibility in urban settings. When not on dedicated rights-of-way, light rail trains may operate in mixed street traffic (urban areas) or downtown malls, or in the middle of major thoroughfares, where trains cross intersections in the same manner as other vehicles (though sometimes with preferential treatment at lights, as with many BRT systems). Due to these factors, the average speed of light rail trains is significantly lower than that of heavy rail systems.

Light rail trains operate either singly or in multiple car configurations, with passenger capacity of each car as high as 250 (including both seated and standing passengers), though usually considerably less. The number of cars that can be operated in a cluster is limited by several factors, such as station platform length, traffic logistics within the city, and the operational capabilities of the control cab. Compared to heavy rail, light rail can be very practical for urban areas due to its ability to operate in mixed traffic settings—which can substantially reduce construction costs of an urban rail system. At the same time, light rail trains have the ability to travel at relatively high speeds when out of these mixed traffic settings, either in a separated street-level right-of-way, on elevated tracks, or on subway tracks.

There have been many success stories using light rail. Both developed and developing countries—including the United States (see Box 8-3), United Kingdom, Argentina, Brazil, China, and India—have completed light rail projects in major cities.

Box 8-3. San Francisco's "Muni"

San Francisco Municipal Railway—Muni—operates one of the most extensive original urban electric railway systems in the United States. In addition to its modern light rail system, Muni also manages an extensive fleet of motorbuses, electric trolleybuses, and the city's signature historic cable-car system.

Muni's light rail system, the third largest in the U.S., has a total route length of over 71 miles (almost 120 km) with nine subway stations and 151 cars running over seven lines. Weekday ridership is almost 180,000 with a cost of US $2 per ride (2014). Muni's light rail integrates well with its own other transit modes, as well as with other area public transit systems such as the Bay Area Rapid Transit (BART) commuter train system, illustrating the contribution that a small light rail system can make in an integrated transport scheme. Muni not only provides accessibility links with other public transit networks like BART and Caltrain, but also allows passengers to benefit from Clipper®, a universal "smart card" payment system for almost all public transit modes in San Francisco's Bay Area. "Route Planner," a feature available to the riders at the Muni website, provides inter-system (often inter-modal) route optimization.

Source: San Francisco Municipal Transport Agency 2014.

Non-Technological Solutions in Public Transport

While the preceding examples from Curitiba, Bogotá, and San Francisco focus on a largely technological response to the challenge of municipal public transit, sometimes solutions may be found in economic and regulatory reform. Among the alternatives available to municipal authorities are running their own transit systems, allowing private franchises, or permitting the private sector to respond to perceived demand. The example below, from Santiago, Chile, demonstrates the success of one city in selecting from these options.

Box 8-4. Implementing Competition in Santiago, Chile

Until the late 1970s, public road passenger transport in Santiago was provided by a public sector operator with about 700 large (90-seat) buses, along with a number of tightly regulated private associations operating more than 3,000 slightly smaller (78-seat) models and 1,500 "midis" (40-seat buses). The public operators were losing money and service was mediocre. Between November 1979 and June 1983, both entry to the market and fares were de-regulated. The public sector operator was driven out of the market and total capacity more than doubled. However, by 1985, regular bus fares had tripled and the average age of the bus fleet had increased from 7 to nearly 12 years. Competition concentrated on routes to the center of the city, which became congested and polluted by poorly occupied buses.

Initial attempts to rectify the situation included restricting 20 percent of the bus fleet from operation each day of the week, and banning buses over 22 years old. These measures, however, gave little relief. In the early 1990s, Santiago's municipal government introduced a system of competitive bidding for franchises to operate buses on routes entering the city center. The total market capacity was thus constrained by municipal authorities. The fare to be offered was a main criterion in selecting franchisees, as were the environmental characteristics of the vehicles offered. Congestion, air pollution, and fares all fell dramatically by the mid-1990s, and this improved service has endured into the 2000s.

Source: UNDP/World Bank 2001.

8.2. Fleet Management

Fleet management is one of the most overlooked areas in public sector energy management. For public sector entities with substantial fleets—e.g., municipal buses, ambulances, trash trucks, school buses, or government passenger cars—this is an area with significant savings potential. This section focuses on the three key areas of fleet management with considerable energy-savings potential: vehicle procurement, operations and maintenance (O&M), and driver training.

Vehicle Procurement

The procurement of efficient public sector vehicle fleets is one way to conserve fuel and money. Including fuel economy as one of the selection criteria in purchasing a public entity's vehicles is seemingly straightforward. Indeed, it is certainly possible, for whatever type of vehicle is being sought, to issue a request for quotes or proposals with a specification indicating a minimum fuel economy rating (e.g., 15 kilometers per liter) using a standardized test method. This absolute designation provides a simple means of ensuring an energy-efficient fleet. It is only necessary to conduct enough research to confirm a sufficient availability of complying models—and thus competition—for the procurement, given the fuel economy threshold and any other requirements. In addition, the advent of gasoline-

powered hybrid electric vehicles of different types (sedans, SUVs, and pick-up trucks) allows fleet operators to specify even better fuel economy.

However, a greater challenge lies in weighting the fuel economy relative to other factors, such as cost and capacity requirements, especially in those cases where the public entity does not purchase enough vehicles to affect the prices and other features offered by suppliers. One possible weighting method is to assign points for various features, such as fuel economy, price, vehicle volume (e.g., for passengers or garbage), and ease of maintenance. Each vehicle can be rated from –2 to +2 on each factor. The model purchased would be the one with the highest total score (e.g., Truck 3 in Table 8-3).

Table 8-3. Weighting Desired Features in a Truck Purchase

	Truck 1	Truck 2	Truck 3	Truck 4
Haul Capacity	1	-2	0	-1
Fuel Economy	0	-1	+2	+1
Ease of Maintenance	-1	+1	0	-1
Parts Cost	1	0	+1	+1
TOTAL	**1**	**-2**	**3**	**0**

Alternative Fuel and Hybrid-Electric Vehicles

Alternative fuel vehicles (AFVs)—such as those powered by natural gas, electricity, ethanol, and other fuels instead of gasoline or diesel—are readily available in some countries, especially where tax incentives or other policies have helped promote them. AFVs can save energy, reduce unwanted emissions, and in most instances cut overall operating costs significantly. AFVs also can be a practical option for fleets because part of the procurement process can include the incorporation of their on-site fueling (or charging) infrastructure (especially in cases where the intended fuel is not commonly available). In addition, since these vehicles generally travel a consistent (and relatively short) distance each day, they can be re-fueled exclusively at these owner-installed fueling stations without sacrificing expedience.

Making the choice to procure AFVs should involve factors as wide-ranging as price and operating cost to a public entity's desire to demonstrate the viability of AFVs and help transform the market. The best choice of AFV type will depend, in part, on location, since some fuels are more readily available in some areas (continents, countries, and regions) than in others. In South America, for instance, where ethanol from sugar cane is economically produced in some areas (primarily Brazil), ethanol-fueled vehicles may be a good choice, especially since compatible vehicles are also relatively common.

In areas where gasoline prices are particularly high, hybrid (including plug-in hybrid) electric vehicles—not technically AFVs, since they run on gasoline—may be the best option since they permit considerably higher gas mileage than comparable gasoline-only vehicles.

Operations and Maintenance

While the essential lessons of resource-conserving maintenance practice—ranging from reactive to preventive and predictive approaches—are detailed in Chapter 3, some additional points relating specifically to vehicles merit mention.

Maintenance Scheduling

The determination of frequency of maintenance procedures—from oil changes to transmission overhauls—should take into account both the distance traveled by the vehicle and the time elapsed since the last servicing. In addition, since the greatest wear on vehicles tends to occur during start-up, acceleration, and braking, the prevailing type of driving for a given vehicle should be a consideration in the scheduling of preventive maintenance procedures. Generally, the more local and "stop-and-start" driving the vehicle performs, the more frequent the maintenance routine should be. As experience grows with a vehicle model, these cycles of maintenance can be adjusted. To adjust the schedules optimally, it is important to garner feedback from the vehicle mechanics, and possibly to conduct some analysis of failures and lifetimes.

Tire Choice and Inflation

Since tires are important to a vehicle's fuel economy, there are some special maintenance considerations with tires. Most importantly, tire inflation affects fuel economy: On average, for every 17 kPa (2.5 psi) of decreased pressure (in all the tires on a vehicle), there is a 1 percent decrease in the fuel economy. For a fleet of 100 cars driving 20,000 km per year at 13 km/liter, this mere 1 percent average deflation translates to over 1,500 additional liters of gasoline used per year. For this reason, at least monthly checks of tire pressure are warranted (in addition to visual inspection by drivers). Particular vigilance is recommended at the onset of cold seasons, since every 5°C (9°F) decrease in temperature will deflate tires by about 7 kPa (1 psi). Proper tire inflation also extends tire life, adding to the benefit of these regular inspections.

Some technological advances may aid in the maintenance of tire inflation. Tire pressure monitoring systems can alert drivers of tire deflation. Additionally, systems that actually maintain tire pressure (e.g., using the hydraulic brake system in trucks) are becoming more common and reliable.

Low rolling-resistance (LRR) tires, which reduce road friction (without a concomitant decrease in traction) are another fuel-saving opportunity in fleets. In markets where fuel economy standards are imposed on vehicles for sale, these are generally the tires that originally come with new cars (since they help manufacturers meet these standards). However, LRR tires may not be widely available as replacements in some markets. They need to be specified by the buyer, and there is usually a price premium, which fleet managers may want to weigh against the expected savings over conventional tires.

Driver Training

Even within the often overlooked area of energy savings in fleet management, driver training stands out as a particularly under-utilized initiative. This is unfortunate, since fuel savings of 5 percent and higher are generally reported from these programs. It can be instituted for public fleet drivers, but also offered as an initiative to the population at large. The training can be structured in a number of ways (see Box 8-5 for one example, in Kerala, India), and there are ample descriptions of different initiatives available with a simple Internet search, but some critical ingredients of any successful program should be:

- On-road sessions with drivers both before and after any classroom training.
- Focus on fundamental vehicle mechanics to explain the wastefulness of driving behaviors such as rapid acceleration (i.e., "jack-rabbit starts"), hard and frequent braking, excessive speeds, failure to shift up promptly, and vehicle idling.
- Scheduled follow-up sessions, especially where mileage data show old driving habits returning over time.

This low-cost initiative can be executed creatively, and is best instituted in conjunction with some form of recognition for participants, especially those who achieve significant improvements in fuel economy. An awareness effort to remind trainees of the key principles is also advisable (see Chapter 9 for more on recognition and awareness programs). These will generally increase program savings, as well as ensure greater persistence of the results.

Box 8-5. Bus Driver Training in Kerala, India

Energy efficiency in the transport sector has traditionally been a neglected area in the Indian state of Kerala, despite a rapid rise in energy use. As attention to the sector increased in the late 1990s, some of the explanations for this growth in energy consumption were:

- Low quality, poorly maintained public transport systems.
- An increasing share of cars and other personalized modes of transport in passenger traffic.
- A decreasing share of both freight and passenger movement via more efficient rail transport.
- Lack of emphasis on, and accountability for, fuel efficiency in public transport.
- Direct pass-through of fuel cost increases to passenger (and freight) fares, relegating energy efficiency to a "back seat" role from the transit agency's perspective.

Accordingly, Kerala began to focus on the energy consumption of state-owned transport vehicles. An outgrowth of this heightened attention was the establishment of a training program for bus drivers in the state (including those employed by parastatals, schools, and other public sector-affiliated organizations, along with publicly owned municipal bus operations). This initiative was jointly organized by Kerala's Energy Management Centre (an autonomous organization under the

Government of Kerala's Department of Power) and the Indian government-sponsored Petroleum Conservation Research Association (PCRA). PCRA continues to sponsor a similar program for many public sector entities across India.

The "Transport Clinic" is administered to the drivers on the road and through classroom segments supported by audio-visual aids. No more than ten drivers participate in any given session. The training program lasts for three days, as outlined below.

Day 1

A suitable route (preferably one similar to the drivers' daily route) covering a distance of 5 to 10 km is chosen. A special calibrated diesel tank to measure the exact fuel consumption on the specified route is fitted inside the bus (so that each driver can read the scale and assess his performance in real time). Diesel supply to the engine comes only from the calibrated tank.

Each driver drives the bus on the selected route as per his usual driving habits. A skilled and PCRA-trained driving instructor sits near the driver, observing and taking note of the driving habits on a standard form. Diesel consumption, distance traveled, and time taken are recorded for each driver and are revealed to them after completion of the on-road driving test. Fuel economy (in kilometers per liter, km/l) is also calculated and communicated to the drivers.
As one driver completes his turn and joins the other team members, the next one takes the wheel and repeats the route. Drivers on the bus compare their relative performance and discuss good and bad features of their own driving skills during and after the trials.

Day 2

- *During the first half of the second day, a classroom session is conducted to explain and discuss the rationale for the training and also to describe the desired "best practices." Topics include:*
  Economic significance of diesel conservation
- *The energy-environment nexus*
- *Factors affecting fuel economy of vehicles, ranging from failure to shift up promptly to excessive idling (see full check-list, below)*
- *Maintenance problems caused by bad driving habits*

On the afternoon of the second day, there is a hands-on participatory session that includes an analysis of individual driving habits (from the Day 1 trials). Also addressed are practical barriers in achieving fuel efficiency to the desired extent and pragmatic solutions to these problems. Videos

on "Driving for Diesel Economy" and "Fifteen Points on Maintenance of Trucks & Buses," produced by PCRA, are shown. PCRA booklets on diesel conservation are distributed to all drivers.

Day 3

The driving trial from Day 1 is repeated using the same bus on the same route under the supervision and guidance of the PCRA driver instructor. The instructor monitors each driver's performance and (in contrast to Day 1) corrects him on -the-spot, wherever warranted. At the end of the day, the fuel economy achieved by individual drivers is discussed. There is also a time for questions and clarifications.

Example from the City of Thiruvananthapuram (capital of Kerala)

Driver	Day 1 – Before Coaching				Day 3 – After Coaching				Improvement in Km/l
	Km	HSD* (liters)	Km/l	Time (min.)	Km	HSD* (liters)	Km/l	Time (mins.)	
1	5	0.90	5.56	7.5	3	0.50	6.00	6.0	8%
2	5	1.30	3.85	7.5	7	1.30	5.38	10.0	40%
3	5	0.75	6.67	8.0	3	0.50	6.00	8.5	-10%
4	5	1.00	5.00	8.0	5	0.80	6.25	7.5	25%
5	5	0.90	5.56	8.0	5	1.10	4.55	7.0	-18%
6	5	1.10	4.55	9.0	5	1.00	5.00	8.0	10%
7	5	1.50	3.33	7.0	5	1.00	5.00	8.0	50%
8	5	1.10	4.55	7.5	5	0.90	5.56	8.0	22%
Avg.	5	1.07	4.9	7.8	4.8	0.89	5.5	7.9	12%

* HSD – high speed diesel

Driving Habit Analysis Checklist

- *Jack rabbit movement or releasing clutch pedal with heavy jerk*
- *Clutch riding*
- *Single de-clutching or gear changing without use of clutch*
- *Racing and longer travel in low gears*
- *Fast rise to top gear resulting in overloading of the engine and poor pick-up*
- *Sudden and erratic acceleration*
- *Delayed gear changing or delayed acceleration*

- *Tendency to speeding and unnecessary brake application*
- *Poor defensive driving (rough, rash, not abiding by traffic rules)*
- *Poor anticipation of stops and violent brake application*
- *Poor anticipation of curves and road obstacles and sudden shifting to low gear at high speed*
- *Unnecessary idling*

Source: Harikumar, 2005.

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CHAPTER 9—OUTREACH, TRAINING, AWARENESS, AND RECOGNITION

Key Considerations in Developing Outreach, Training, Awareness, and Recognition Initiatives

1. Outreach, training, awareness, and recognition are the often underappreciated "soft" components of a program. They are essential for building the base of knowledge for success, and also for providing motivation.
2. The development cycle for any prospective program can be summarized as: a) planning and design, b) implementation, c) evaluation and reporting, and d) modifying and sustaining the initiative. A substantial portion of the effort should be in the first stage—planning and design.
3. The first activity in planning and design is to identify the audience and their needs. The target of a specific program may range from building maintenance staff to high-level managers.
4. Depending on the particular information being conveyed and the people to whom it is directed, there are a variety of effective communication options—ranging from refrigerator magnets to annual conferences. Although person-to-person interactions are often the most valuable, the internet and other electronic media allow for inexpensive accessibility to geographically dispersed audiences. These issues of communication media should be considered and resolved as part of planning and design.
5. Where budgets for these programs are tight, it is sometimes possible to leverage activities (e.g., training courses), educational material, and direct support from other agencies and organizations.
6. Implement outreach, training, awareness, and recognition programs with guidance from the planning and design effort. Checklists and step-by-step protocols can help ensure a comprehensive program.
7. Evaluation of these types of programs will generally need to rely on proxies, since attributing direct energy savings is usually difficult or impossible. Surveys, verbal feedback, and website monitoring (e.g., to determine numbers of visitors) can provide good indications of how these programs are being perceived.
8. As a last step in the cycle, use the feedback from evaluations to modify the initiatives. Persistence of these programs is essential for continuing and increasing energy savings.

Outreach, training, awareness, and recognition programs are all designed to increase knowledge about energy conservation and to reward success in order to motivate people to initiate and maintain energy-conserving programs and behavior. People need to be supported in their efforts on a daily basis through outreach and training; to be alerted to and reminded of resource-conserving behavior; and to be congratulated in a meaningful way for their successes.

Outreach is the sharing of information about energy management through conferences and expositions, case studies, special events, electronic media, newsletters, magazine articles, and other activities. Typically, outreach efforts are aimed at those who are responsible for some aspect of a program that affects energy use, such as procurement, operations and maintenance, or construction.

Training is offered to energy management practitioners to help them become proficient in the knowledge and skills required to run an energy management program and to select energy-efficient equipment. Training courses can address topics as varied as financial analysis and boiler control optimization.

An awareness program is usually directed toward a less specialized audience, such as the tenants of an office building, the residents of government housing, and others who are not necessarily knowledgeable about energy conservation. The goal of an awareness program is to motivate people to change their habits so that they save energy. When communicated effectively, the inherent benefits of saving energy, such as money savings and the reduction of air pollution, can become substantial motivators for behavioral change.

Recognition consists of monetary and honorary awards, certificates, public acknowledgement, and other methods to publicize individual and group contributions to energy conservation. Recognition, at some level, can and should be a part of all outreach, training, and awareness activities.

The development of outreach, training, awareness, and recognition programs can be approached with a four-part action strategy:

- Plan and design the activity
- Implement the program
- Evaluate the results
- Modify and sustain the effort

Rather than designing and developing programs as stand-alone initiatives, it is important to understand how they overlap and influence each other. This interdependency can be used constructively to create stronger and more sustainable energy conservation programs.

9.1. Planning and Design

Outreach and awareness programs can consist of a variety of products and activities, including newsletters, guidebooks, case studies, articles, e-mail blasts, conference presentations, exhibitions (e.g., at conferences or expositions), competitions, or special events. Training programs can also be an important part of conservation efforts, and can include classroom training, computerized interactive sessions, on-line/on-demand courses, and hands-on practical workshops. Recognition of training completed or improvements made in energy conservation-related practices or performance (e.g., certificates or awards—see Box 9-4) is another important element for sustaining conservation programs.

In order to decide which of these activities to incorporate into an initiative, try to answer the following questions:

- Who is the audience and what information do they need?
- What is the best way to convey this information?
- What is the budget and who is available to help?

Identifying the Audience and Their Needs

The audience for an outreach, awareness, or training program may include energy engineers, operations and maintenance staff, procurement officials, budget directors, facility managers, upper level managers, and general

employees. In cases where a facility, agency, or government already has established energy conservation goals, some of the audience may already be attuned to, or at least aware of, such issues. These programs should make it clear to each target audience how they can contribute to meeting the goals and benefit from their involvement.

The needs of different audiences will vary:

- Energy engineers, operations and maintenance staff, and facility managers need to understand best practices and new technologies. They may want to learn about success stories and case studies in order to incorporate lessons learned into their work.
- Procurement officials need to learn how to identify and procure energy-efficient products and, possibly, how to use alternative financing mechanisms such as innovative leasing and energy savings performance contracts (ESPCs).
- Budget directors will benefit from learning about life-cycle cost analysis and alternative financing mechanisms.
- Upper level managers need to learn about energy conservation goals and how they can help their agency or government achieve those goals.
- General employees should learn how they can use energy wisely (not only in the workplace but also at home).

Often, the best way to determine what information an audience needs is to ask them through surveys or focus groups. In other cases, the information required may be dictated by legislation, executive order, or other decree (see Box 9-1). In some cases, a professional association or university has already assessed the needs of a particular type of audience and prepared an appropriate curriculum. For instance, in the U.S., the Association of Energy Engineers offers a multitude of courses—both in person and through webcasts—on different energy management topics, as well as professional certifications for such topics as general energy management, measurement and verification, lighting efficiency, indoor air quality, and building commissioning.

Box 9-1. Training Requirements of the U.S. Energy Policy Act

The Energy Policy Act of 1992 requires that federal agencies employ "trained energy managers" who have demonstrated proficiency or completed a course of study in the following:

- Fundamentals of building energy systems
- Building energy codes and applicable professional standards
- Energy accounting and analysis
- Life-cycle cost methodology
- Instrumentation for energy surveys and audits

As a result of this legislative requirement, the U.S. Federal Energy Management Program has traditionally made available a series of free training courses on these subjects and others.

Conveying the Information

An effective outreach program should consider using a variety of communication methods (see Box 9-2). A periodic newsletter to government facility managers is a good method to communicate new policies and procedures, success stories, training and conference schedules, and other current information (see Box 9-3). Such newsletters should include contact information for energy managers, and encourage readers to communicate among themselves to learn from each other's experiences. An annual workshop and exhibition is a good way to help the community of energy professionals learn about energy-efficient products and practices and to showcase new technologies.

Box 9-2. Communication Channels

Communication channels for outreach programs can include:

- Newsletters
- Webcasts
- Give-away promotional items, such as refrigerator magnets and pens
- Posters and brochures
- Articles in organizational newsletters and local newspapers
- Lunchtime discussions
- Booths, displays, and talks at conferences and expositions
- Email reminders
- Web pages
- Social media communications
- Guidebooks and case studies

Training programs can also be delivered in a variety of ways. Traditional classroom training allows for interaction with the instructors to work through the execution of complicated tasks. Classroom training, including hands-on practice with the relevant software, energy-using equipment, or diagnostic instruments, is the best way to develop required skills. However, the Internet provides multiple easy and inexpensive means to disseminate information to larger and more geographically diverse audiences. Interactive on-demand training courses can provide strong skill development while allowing people to participate at their own desks, avoiding the time and cost of travel. Webcast training courses can include communication in real time to allow for interaction with the instructor(s). This approach, adopted by FEMP to provide training to a U.S. federal audience on its alternative financing and other programs, can provide nearly the same value as in-person instruction at a small fraction of the cost, especially for shorter courses (less than two hours).

Box 9-3. Spreading the Word in South Africa

In South Africa, the Department of Environmental Affairs and Tourism (DEAT) in the early and mid-2000s produced a newsletter called *Cities for Climate Protection (CCP)*; this is also the name of an international municipal campaign, spearheaded by ICLEI—Local Governments for Sustainability, in which DEAT participated. The newsletter was part of the South African CCP information campaign to encourage cities to reduce greenhouse gas emissions through energy conservation and other means. CCP used the newsletter to showcase current pilot projects, such as the Energy-Efficient Retrofitting of Municipal Buildings initiative. *Cities for Climate Protection* also announced relevant upcoming regional, national, and international symposia and conferences and provided up-to-date contact information and website links to associated organizations and networks.

The newsletter, distributed to local and state governments, nongovernmental organizations, and international CCP partners, was just one element in the South African CCP awareness campaign. In 2003, CCP Cape Town hosted a "media launch" with stakeholders, officials, CCP partners, and the media, in which the City of Cape Town was awarded a plaque from one of its partners celebrating the successes it had achieved to date. Both the print media and two radio stations provided prominent coverage of the ceremony.

For awareness programs, where the goal is to motivate people to change their behavior to use energy wisely, information should convey a no more than a few simple actions they can take to save energy or water. One effective strategy is to develop motivational themes, messages, and slogans (e.g., FEMP's "You have the power!") that provide a lure for the program, and to place these messages on simple handouts—such as book marks, refrigerator magnets, or small posters. Distributing these materials at promotional events or putting up ad hoc displays can help spread and reinforce the message.

Establishing a Budget and Identifying Additional Resources

Producing high quality promotional materials, training initiatives, and rewards programs requires both financial and staff resources. An extensive budget can allow the development (research, writing, editing, designing, and printing) of a variety of materials, training courses, and other outreach vehicles. A more limited budget will constrain these types of activities, but substantial outreach is still possible through creative alternatives: consider calling on individuals to volunteer their time and using materials donated from other organizations. If the means are not available to provide training courses, another option is to help people identify where they can obtain the training elsewhere, particularly on-line.

The recognition element of a program—such as the printing and distribution of achievement certificates—need not be expensive and can still be meaningful. Given sufficient resources, one effective option is a formal awards ceremony (see Box 9-4).

Box 9-4. U.S. FEMP's Annual Awards Ceremony

Each year, the U.S. Federal Energy Management Program (FEMP) issues nearly two dozen awards to individuals, small groups, and organizations for their outstanding achievements in promoting energy conservation and renewable energy. Federal employees throughout the country compete for these respected awards, helping to motivate their continued efforts. The awards ceremony is held each October—"Energy Awareness Month" in the United States—usually in a prestigious setting such as the National Press Club. Guest speakers have included various government dignitaries, including the U.S. Secretary of Energy.

FEMP recognizes achievements in the following categories:

- Energy and water efficiency and conservation
- Renewable energy implementation
- Fleet and transportation management
- Sustainable practices for high-performance buildings

A panel of judges evaluates each nomination and only the most highly scored nominations receive awards. The judges consider the following evaluation factors:

- The amount of energy or water savings (or, for renewables, the amount of energy produced on-site)
- The cost-effectiveness of the project
- The use of sustainable or "whole building" design
- Any environmental or non-energy benefits
- The institutionalization and transferability of the project approach
- Outreach activities to disseminate project benefits
- Innovative new technology and technology transfer benefits

Just as the award categories reflect federal energy management priorities, these evaluation factors represent what the U.S. government considers to be the important components of energy management implementation.

9.2. Implementing the Program

The decisions made during program planning and design will guide the implementation of the initiative. Implementation involves scheduling activities and training sessions, developing and producing materials, and holding events.

For instance, if outreach efforts include the production and distribution of newsletters, implementation steps will include the following:

Decide on the frequency of the newsletter (e.g., monthly or quarterly).

- Determine the types of articles and features that will be included in each issue.
- Solicit authors to provide articles, success stories, and features (or designate a staff person to write the text).
- Design the newsletter logo and layout.
- Print and distribute the newsletter (via hard copy, web posting, and/or by email).

A training program involves a different but parallel process, including the following steps:

- Decide which training courses will be developed and choose the format (e.g., classroom, on-demand, webcast) for each.
- Develop the course or contract for course development.
- Produce course materials.
- Schedule training and locations; prepare the logistics.
- Develop a training catalog and advertise training sessions.
- Register participants.
- Conduct the training and obtain feedback from participants.
- Provide each participant with a certificate recognizing successful completion of the training.

When preparing to implement a program, it is helpful to write out the steps and develop a written schedule of all activities. A checklist of activities will make implementation efforts run much more smoothly and ensure that important details are not forgotten.

9.3. Evaluating the Results

In an ideal situation, success would be measured by how much energy and money was saved as a result of outreach, training, awareness, and recognition initiatives. However, such quantifiable results are generally not available for these programs, since they usually do not directly correlate with specific, measurable energy-saving actions (e.g., facility improvements or purchases). Nonetheless, while it may not be possible to precisely measure the amount of energy saved as a result of the programs, a number of proxy measures are available to assess their effectiveness.

For example, outreach materials (e.g., newsletters or displays) can include a short survey to collect feedback about the program, which can be used both to measure its effectiveness and to improve the materials. Similarly, participants of training programs can be asked to complete an evaluation form; the resulting ratings and comments provide information with which to assess, as well as improve, the usefulness of the training. With awareness materials, one can track the quantity of materials that have been distributed and also solicit feedback on the effectiveness of the message from the audience. Website visitations can be monitored easily, providing a measure of overall popularity of a site, as well as trends. With recognition programs, feedback from award recipients on what

the award means to them can help determine its motivating ability. (The selection and design of some of these evaluation techniques is discussed in Chapter 10.)

9.4. Modifying and Sustaining the Effort

Sharing the results of these evaluation efforts with the managers of a facility, agency, or government—as well as with the audience—can help maintain both management and public support for outreach, training, awareness, and recognition programs. Equally important is the value of this information in helping to improve the initiatives in the future. Most comments received—especially those repeated by multiple respondents—deserve to be incorporated into the design of the next round of the program. Common, helpful customer feedback often addresses issues of thoroughness (e.g., a module of the training was too brief), clarity (e.g., part of the e-mail message or brochure was confusing), and relevance (e.g., the message may have been accurate, but it is not applicable for the audience). In some cases, where consistent negative feedback is received, the audience comments also may result in major changes to a program.

For any outreach, training, awareness, or recognition activities, repetition is critical. This is sometimes counter-intuitive to program managers in charge of designing and administering the program, because *they* are getting tired of the message and its delivery. Ongoing efforts in each of these areas need to be institutionalized to ensure continuous motivation for energy-saving behavior and programs. Consistent and periodic outreach maintains the cohesiveness of the community of energy professionals; regular training updates skills and provides abilities to newcomers; ongoing awareness programs motivate employees to maintain their energy- saving behavior; and recognition efforts (even modest ones) motivate people to continue their high performance.

Bolstering the intrinsic motivation that exists in many people to behave in a resource-responsible fashion will go a long way towards sustaining a program and achieving the long-range goal of a more sustainable, and less costly, use of energy.

CHAPTER 10—EVALUATION

Key Considerations in Evaluation of Programs and Projects:

1. Program evaluation is critical not only for assessing a program's direct effects (i.e., energy and cost savings) and indirect effects (e.g., environmental and market transformation), but also for improving the program itself.
2. The first step in effective program evaluation should be a determination of objectives. Evaluation objectives may range from establishing the savings that resulted from an energy savings performance contract, to obtaining credit for activity to reduce greenhouse gases. The objectives will help direct the evaluation.
3. There is almost always tension between the amount of information required for accurate evaluation and the cost to collect and analyze it. While the large number of prospective data types that can be collected can seem overwhelming, it is important to remember that some evaluation is better than none, and that some information (e.g., government purchasing data) may be already assembled or easily collected.
4. With some energy-saving measures, such as most lighting retrofits, a good deal of information can be collected with very little effort—for instance, by using manufacturers' literature, applying engineering estimates, or sampling only a few representative retrofits. In these cases, the majority of evaluation resources can be saved for assessing more complex measures.
5. Establishing a baseline is the first step in analyzing the energy savings from a project or program. Energy use before the implementation of the program only provides a rough idea of what consumption would be without the intervention. This is because changes in facility use, weather, and other factors can sometimes have impacts of similar magnitude to that of a program. Consequently, creating a useful baseline may involve using trends or simulation models to project future consumption in the absence of the program.
6. Indirect performance indicators are proxies that can help determine program effectiveness. Data on factors such as numbers of web site visitors, brochures requested, or adoption of policies by other governments, can all be used to gauge a program's success. These indicators are especially helpful in assessing information and outreach programs where direct energy savings are often impossible to measure.
7. Once energy savings are determined, the next evaluation step is to translate them into financial savings (and sometimes emission reductions). For this task, it is critical to understand your facilities' utility rates, which may disproportionately reward savings during certain seasons or times of day. In general, valuing energy savings at *marginal* rates gives a more accurate estimate of savings than using average rates.
8. Evaluation results can be used for program improvement, documentation of pollution reduction credits, gaining continued program support from funders, and assisting the replication of the program's successes by others.

Once public sector energy conservation programs are in place, it is important to evaluate their effectiveness. Two types of evaluation are important. The first type, impact evaluation, documents the final results achieved from a given program in terms of: 1) direct energy and cost savings, 2) environmental benefits (e.g., reduction of air pollution and greenhouse gas emissions), and 3) the indirect effect of public sector leadership on other buyers and suppliers of energy-saving products and services. The second type of evaluation, process evaluation, identifies areas of weakness in the program design and implementation so that these can be strengthened.

Improving energy efficiency in government facilities can also have a positive or negative effect on the quality of the living or working environment, including health, comfort, safety, and productivity. For example, the installation of LED traffic lights not only saves energy, but can also improve road safety since signal visibility is usually improved and burn-outs are very infrequent compared to incandescent models. In most cases, well-chosen energy efficiency measures have positive ancillary effects on the workplace; these "non-energy benefits" should be identified and documented as a part of evaluations wherever they are suspected to be significant.

Finally, some government energy conservation programs are also designed to influence the larger market, for instance, by:

- Setting an example for others to follow.
- Introducing market actors (e.g., architects, construction firms, or other contractors) to new technologies and methods.
- Creating an initial market for domestic suppliers to introduce more energy-saving products and services.

These effects, while indirect and often hard to measure, can be even more important to governments than the direct savings in energy costs and reduced pollution. Surveys, interviews, and indicators of market-wide trends can all be used to shed some light on this leadership role of energy-saving actions by government.

All of these impacts should be weighed as part of the justification for allocating public funds to current or future energy conservation projects. Unfortunately, evaluation of public sector programs is not always given adequate attention or resources in the initial stages of program planning. Preparing for evaluation at an early stage of the program allows for:

- More effective program design.
- More timely and efficient data collection.
- An early opportunity to make the key decision-makers aware of the importance of future evaluation findings, and thus more likely to be receptive to them.

Evaluation can be undertaken at many different levels of effort and expense. Within the resources available, evaluators and policy makers need to set priorities for evaluation based on the expected value of the information at different levels of accuracy.

10.1. Types of Evaluation

As noted above, evaluation studies can focus on the process of a program and/or on its energy savings and other impacts. The best evaluations typically include both process and impact components.

Process Evaluation

Process evaluation is often qualitative in nature and measures how well the program is functioning. Unfortunately, policymakers sometimes see process evaluation as less important than impact evaluation. In reality, both elements are critical to the successful implementation of a program, as well as to learning from experience in order to design effective programs in the future.

Process evaluation elements may include:

- Surveys of key program participants and stakeholders to obtain their feedback. These might include policy-makers, employees to whom the program is directed, and program managers.
- Indicators and benchmarks of administrative efficiency and effectiveness, such as timely achievement of program goals or proper training of staff.
- Fiscal auditing to verify that funds were spent efficiently and for the intended purposes.
- Program peer reviews by experts from other agencies or departments, or even external reviewers.
- Compilation of best-practice examples of program design and management, both internal and external to the public institution.

Impact Evaluation

Impact evaluation is used to determine the energy, environmental, and other important impacts of a program. Data on program impacts can also be combined with program cost data to assess cost-effectiveness.

For cost-effectiveness results to be valid and meaningful, it is important to define appropriate and consistent time frames for both costs and benefits. Proper adjustments for general inflation and discounting of future benefits (or costs) to present value are also usually warranted to make cost-effectiveness evaluations comparable with other financial analysis conducted in the government. The cost-effectiveness analysis must also be consistent in defining the scope of costs and benefits—e.g., is the analysis limited to costs and benefits to the public entity, or are consequences for others also taken into account?

Impact evaluation elements may include:

- Compiling regular reports (e.g., annually) from agencies or departments on their progress toward meeting energy-savings targets, actions taken, and any notable problems encountered—along with proposed or implemented solutions.
- Tracking changes over time in billed energy use, energy costs, and peak electricity demand for individual public buildings or other facilities (with appropriate adjustments for changes in weather, operating hours, and other occupancy effects).
- Developing and tracking performance indicators—for example, for buildings (e.g., weather-adjusted energy use per unit of floor space or per occupant), fleet vehicles (e.g., liters of fuel per passenger-kilometer), street lighting (e.g., kWh per pole or per meters of lighted street), or water systems (e.g., kWh per million liters delivered or treated).
- Benchmarking the energy performance of new or existing facilities against those of other facilities that serve the same function (e.g., office buildings, water supply systems, housing) and provide similar levels of service and amenity.
- Comparing predicted energy savings with actual savings (e.g., for new or retrofitted buildings or vehicle fleets).
- Conducting post-occupancy or post-retrofit evaluations of new or retrofitted buildings, including surveys of employee satisfaction.

- Monitoring trends in government purchasing practices, such as the percentage of products purchased that meet energy efficiency criteria.

A useful reference source for general guidance and specific methods for measuring and verifying energy savings in public facilities is the International Performance Measurement and Verification Protocol (IPMVP). The IPMVP offers various methods by which savings can be measured, including ones that are geared toward specific energy conservation measures ("retrofit isolation" options) as well as "whole-building" options.

Both impact and process evaluations should occur at regular intervals over the life of public sector energy conservation programs, and especially during the initial period of program implementation.

There are four general steps to properly evaluate energy conservation programs:

I. Establish evaluation objectives

II. Identify data needs and resources, and collect them

III. Analyze data

IV. Apply evaluation results

10.2. Establishing Evaluation Objectives

Program evaluations can have multiple purposes, some of which may imply different audiences for the evaluation results. For example, the main objectives of the evaluation may be to:

- Improve the implementation of public sector energy conservation programs.
- Document energy and cost baselines or savings as a basis for energy service company (ESCO) agreements, other performance-based financing, credits for reduced greenhouse gas emissions, or to ensure continued support from program funders.
- Share program experience and results as an example for others to follow.

In the first case, where the aim is mainly to improve program implementation, the primary client would be the program manager(s), a senior administrator, or perhaps a public official (department head, minister, or city council member). In the second example, the main clients for results that document energy or cost savings might be the agency leading the project as well as the ESCO or lender. The principal audience could also be a third-party sponsor who funded the program (e.g., a grantor) and wants to verify that the intended results were obtained, or an oversight agency responsible for reviewing government operations. In the third example, the main client for sharing program experiences may be an outside group: other agencies, other levels of government, international organizations, or governments in other countries.

The purpose and client for the evaluation will affect the methods used, the degree of accuracy and certainty of data required, and the level of resources needed. Some evaluations may be designed to serve multiple objectives or multiple clients. In these cases it is important, at the start, to recognize and resolve any competing demands among the various parties who will receive the evaluation results.

10.3. Identifying Data Needs and Resources, and Collecting Them

The cost of evaluating public sector energy conservation programs will vary depending on a number of factors, such as:

- The size and type of the program. For instance, estimating savings impacts from information dissemination programs will involve certain types of effort (e.g., surveying purchasers, tabulating procurement logs) that will differ for building retrofit programs (e.g., assessing energy bills and counting light bulbs).
- The types of energy-saving measures to be evaluated and the resulting data needs. For example, lighting efficiency improvements are generally easier to measure than changes in more complex building systems such as central air conditioning. Also, some types of data (e.g., on fleet vehicle fuel economy) are easier to obtain than others (e.g., data on transit system energy performance).
- The type of evaluation method. For example, costs may be higher if energy savings are calculated or estimated using a detailed computer simulation (such as an Energy Plus model) than if the evaluation is based on the collection and analysis of electricity or fuel bills.
- The amount and quality of data already available. For example, is there an individual utility meter for each public building? Are utility bills available in an easily accessible electronic format? Are energy data already being collected for other reasons, such as to validate payments to an ESCO? Is there a central fueling station for fleet vehicles, or another system for recording the fuel use and distance driven by each vehicle?
- The desired degree of statistical accuracy. For example, larger sample sizes for surveys, interviews, or spot measurements (in order to obtain greater levels of precision) will incur higher costs.

A comprehensive evaluation of a broad-based energy management program may require several types of data, including survey or interview data, reports on administrative activities (such as purchasing logs), utility billing data for individual facilities, or fuel consumption for government fleet vehicles. To establish a baseline or a benchmark for comparison, historical energy use data may be needed, not only for the public entity's facilities and operations, but also for broader market trends and energy use outside the public sector.

In addition to the data, staff time and expertise are also key resources needed for evaluation. Depending on the resources available, varying proportions of the data collection and evaluation can be done by in-house staff or out-sourced to contractors. Depending on the level of prior staff experience, it may be important to invest resources for training in-house staff in evaluation.

While most of the cost for data collection and analysis occurs once program implementation is underway, it is important to allocate some share of the evaluation budget and staff time to up-front costs for two key tasks:

- Developing the evaluation plan, including designing program data collection.
- Collecting baseline ("before") data and building some kind of model to project future energy use in the absence of the project (i.e., an "adjusted baseline").

Finally, it is important to remember that, no matter how limited the resources or how imperfect the data, it is always possible to conduct useful evaluation, even if only at a minimal level. Evaluators should not be discouraged if they cannot gather data of the highest quality, address every important issue, or take as much time as they might like for an in-depth analysis. However, in such cases the evaluator must clearly explain to decision-makers how the constraints of cost, time, and data may affect the degree of confidence that can be placed in evaluation findings.

Evaluation Data Needs and Sources

There are many types of data useful for evaluating the impact of public sector energy conservation programs, and many potential sources and methods for collecting (or estimating) them. When possible, existing sources of data should be considered first. New primary data collection should be undertaken only as needed to fill in the most important information gaps. As much as possible, the cost of collecting and analyzing each data element should be weighed against its likely value. In some cases, the same information might be of value to more than one program, including programs outside the public sector. Data with multiple uses are especially likely to come from surveys that are carefully planned and interviews that are deliberately designed to make best use of each respondent's limited time and patience. Table 10-1 provides examples of common types of data and potential sources of information for evaluating public sector programs.

Table 10-1. Evaluation Data Types and Data Sources

Data Type	Potential Data Sources
Baseline energy trends for: existing public buildings new public buildings public infrastructure and transit	Utility bills
	Energy audits
	Spot measurements
	Computer simulation
	Data from energy management and control systems
Baseline energy trends – public purchasing	Purchasing records, surveys of vendors and public entity buyers, walk-through audits
Energy efficiency knowledge, awareness, and practices	Pre- and post-program surveys of employees and decision-makers; market research
	Agency reports
Energy cost impacts	Utility bills
Non-energy benefits	Building occupant surveys, employee sickness and absentee records
Technical and institutional capacity-building for energy conservation	Focus groups, pre/post employee surveys, or records of successful completion of training and professional certification
Indirect market impacts (public sector leadership)	Market research on building/equipment efficiency trends in non-government facilities and purchasing
	Changes in products or services offered commercially (product efficiencies, , number/proportion of vendors offering efficient products and services)
	Interviews with manufacturers, retailers, trade associations, and non-government customers
Emissions of greenhouse gases and other air pollutants	National, regional, seasonal, or time-of-use emissions factors or a utility dispatch model

Continuous vs. Short-term Measurements

In many cases, energy savings can be accurately measured only through long-term monitoring (typically one year or more, to account for seasonal changes in weather and occupancy patterns). Where savings are expected to be more than a few percent of a facility's total energy use, long-term monitoring can be based on a whole-building utility meter, although changes in use, occupancy, and weather can reduce the accuracy of these findings. Where several energy-saving measures are implemented at the same time, it may be necessary to use sub-meters for individual circuits such as lighting, or for major pieces of equipment, such as a boiler or chiller. Energy management and control systems, found in larger buildings, can also offer useful data. However, since these systems are generally designed for instantaneous control functions, they may not store data for later analysis unless they are re-programmed to do so. Energy information systems (EISs), discussed in Chapter 3, are better suited to assist evaluation efforts in this way.

For some energy conservation measures, energy savings may be reliably predicted from short-term measurements with no need for long-term monitoring. Energy savings from efficient lighting, for example, can usually be predicted from either a one-time measurement or from manufacturers' product information, especially where lighting system operating hours are automatically controlled or readily observed. (For lighting changes, the level and quality of light delivered within a building may need to be evaluated, in addition to energy use.) Energy savings from efficient office equipment and plumbing fixtures can also be spot-measured, although since use patterns may vary over time, it may be advisable to track consumption on a sample basis (e.g., a series of spot measurements over a period of time), through either direct observation or software-based monitoring tools.

In general, the measurement procedure needs to be carefully tailored to each type of energy-saving measure. The degree of accuracy required and the amount of variance among buildings, users, or pieces of equipment should all be considered in choosing the simplest and least costly method, appropriate sampling strategy, and duration of measurements. As noted earlier, the IPMVP offers guidance in measuring results and evaluating many types of energy-saving projects.

10.4. Analyzing the Data

The core problem in assessing energy savings from a given initiative or project is that the savings, by definition, cannot be directly measured--because they represent the *absence* of something (energy consumption), they leave no direct trace. Moreover, in parallel with changes resulting from energy-saving programs, other factors that affect consumption (such as weather or hours of operation) also may change—making it difficult to attribute changes in energy use to the program. Consequently, the analysis of data from initiatives designed to save energy poses some difficult problems. However, there are a number of well-established methods for handling these difficulties.

Establishing a Baseline

Program evaluation requires a credible baseline. Determining the baseline is inherently difficult because it requires answering a hypothetical question: "What would have happened in the absence of the program or project?"

Pre-program energy consumption is often used as a base case, with any subsequent changes in energy use interpreted as savings (or losses) due to the program. However, as mentioned above, it is often the case that energy use would have changed even without the program—sometimes even by amounts as large or larger than the expected program savings—as a result of other influences such as:

- Changes in facility use (since some activities are substantially more energy-intensive than others).
- Increased or decreased occupant densities or hours of operation.
- Changes in weather.
- Changes in energy prices.
- Normal (end-of-life) equipment replacement, combined with more efficient equipment offerings due to higher required standards, technological advances, or other market forces.
- "Load creep," (a slow but steady increase in overall energy use by a facility) due to new equipment (particularly "plug load"), as well as the tendency of buildings to deviate from their commissioned state over time.
- Impact of other public policies (e.g., energy requirements in building codes, administrative reforms, green purchasing, or "government sustainability" campaigns).

In these cases, the evaluator may decide to use a trend projection or modeled scenario as the projected baseline. Adjustments can sometimes be made to prevent important variables from distorting the evaluation. For example, heating and/or cooling degree days can be used to adjust for weather (bumping up or down the expected fuel or electricity use), although it is most accurate to do this by creating a slope-intercept regression model to ensure the adjustment of only the weather-sensitive portion of the load.

Alternatively, both pre- and post-program energy use might be compared with conditions in other departments or facilities (non-participants), energy use in non-public sector buildings, or public sector baseline data from other countries. For a more thorough discussion of this type of comparative "benchmarking," consult Chapter 3.

Attribution of Savings

Related to the question of defining a baseline is how much of the observed change in energy use should be attributed to the program being evaluated, rather than other energy efficiency programs or non-program factors. Often, these other factors cannot be completely eliminated even with the careful choice of a base case or comparison group.

For example, a government policy on energy-efficient purchasing may be implemented in conjunction with a national program for energy efficiency labeling of appliances and equipment. Since product labeling programs influence both government and non-government purchasing, one solution may be to estimate the incremental effect of the government procurement policy simply based on the difference in purchasing practices (or changes in these practices) between the government and non-government sectors. However, the purchasing decision processes may be different enough between government and non-government buyers that this simple method may not be telling.

At the same time, the government purchasing policy clearly would not be as effective without the energy labeling program in place to help government buyers identify the most efficient products. Finally, for some products it may be the combined effect of energy labels and government policy to buy efficient products that encourages manufacturers and suppliers to introduce more energy-efficient products—or to price them more competitively, since their competitors are also offering more of these higher-efficiency models. In this example, the combined effect of two programs, energy labeling and government purchasing, may turn out to be much greater than the impact of either program by itself (see Figure 10-1). The evaluation framework may need to be flexible enough to

consider not just individual program impacts but also their interaction with other programs, policies, or market/technology shifts. In these cases, evaluators can employ comparison groups, surveys, and even econometrics and other advanced statistical techniques to try to tease apart influences.

Figure 10-1. Programs with Interactive Impacts

Performance Indicators

In many cases, performance indicators can be a useful way to organize primary data and help determine which data are the most important to collect in order to evaluate program effectiveness. "Indicators" are often partial, approximate, and indirect clues about important aspects of program performance and results. Thus, it may be important to consider multiple indicators, each of which provides added insight into the overall goal or desired outcome. It is equally important to keep in mind the limitations of any single indicator.

Box 10-1 lists some examples of performance indicators for a program on energy-efficient government purchasing. In most cases, an agency would choose a subset from this list, selecting indicators based on their:

- Relevance to project objectives.
- Usefulness as feedback to policymakers and agency program managers.
- Practicality, in terms of the availability and cost of data.
- Value to the implementing agency, policy-makers, and others in documenting program effectiveness and progress toward defined goals.

Box 10-1. Performance Indicators for an Energy-Efficient Government Purchasing Program

1) Policy Awareness:

- Attendance at training workshops or conference presentations
- Visits to websites or requests for publications (by government employees, suppliers, and other, non-government purchasers)
- Survey responses from target audiences (e.g., public officials, managers, technical staff, agency employees, vendors, contractors)

2) Policy Adoption:

- Laws or statutes adopted
- Policy or administrative guidelines issued
- Regular updates and additions to program guidance (indicating an active implementation effort)

3) Program Implementation:

- Technical specifications for energy efficiency
- Changes in the "boilerplate" language (e.g., for public tenders, contracts, or building design specifications) to incorporate energy efficiency criteria
- Training materials developed and delivered
- Funding leveraged

4) Results:

- Shifts in the average levels (and distribution) of energy efficiency for products purchased by government
- Reduced purchase prices for efficient products bought by government

5) Public Sector Impacts:

- Reduced energy consumption and costs for government agencies
- Associated reductions in energy-related pollution and greenhouse gas emissions

6) Market Impacts:

- Adoption of government energy efficiency criteria by other buyers (private firms, consumers, or other governments)
- Introduction of new, energy-efficient models that meet government purchasing criteria
- Reduction in the number/proportion of models offered that do *not* meet government efficiency criteria
- Increased marketing of energy-efficient products (to government and others) by suppliers, manufacturers, or importers
- Changes in the market-mix of efficiency for all products sold
- Reduction in the relative cost of efficient (versus baseline) models, due to increased competition and production/distribution volume.

Valuing Energy Savings

It may seem to be a simple task to translate energy savings into cost savings to the public entity, but there are different approaches to consider. Multiplying the total number of kWh (or liters of gasoline or cubic meters of natural gas, etc.) by the average price paid per unit is the simplest method, and often satisfactory. However, it is customary that the actual price paid for fuel or electricity will vary from one location to another; it may be important to take these differences into account. Also, electricity rate structures in some countries may provide a *marginal* rate for the last units (kWh or kW) consumed (or saved) that is significantly different from the average kWh or kW cost. Where possible, electricity savings should be valued based on this marginal rate. Some rate structures also include demand ratchet charges, seasonal or time-of-day adjustments, and other complexities that can affect the actual savings in a customer's electricity bill.

Where energy and cost savings from an energy conservation measure or program are realized over a period of several years, it is also important to properly account for the lower present value of future savings, using an appropriate discount rate. "Life-cycle cost" or net present value analysis is discussed in Chapter 4.

Another issue arises in the case where public sector entities are already paying significantly less for the fuel and power used in their own operations than the average costs of energy to private companies or individual citizens. This may be due to government's ability to negotiate for bulk purchases of energy, or to other factors (such as historically subsidized energy provided to the government). In these cases, should the public entity "value" the energy saved in its own operations at its actual billed cost, as if it were a private firm? Or instead, should it value these savings at the somewhat higher average (or marginal) price actually paid by other consumers, who are also taxpayers? The higher "societal price" is, arguably, a better reflection of the value to the society as a whole of the energy savings achieved by the public entity.

Finally, there is the question of whether to add a "public benefit" value to energy savings, to account for factors such as environmental benefits from avoiding energy-related pollution. Deciding on a monetary value for environmental benefits is a complex and often controversial topic, beyond the scope of this book. However, the next section briefly discusses how to quantify energy-related reductions in air pollution and greenhouse gas emissions.

Reduced Greenhouse Gas and other Pollutant Emissions

Once the net energy savings have been determined for a public sector program or project, the associated reduction in air pollutant or greenhouse gas (GHG) emissions can be calculated in one of two ways:

- Using average nationwide emissions factors for each type of fuel (including the average mix of fuels and power plants that generate electricity).
- Using more specific emissions factors calculated by region or time of use (for electricity), ideally based on a dispatch model that identifies the marginal source of fuel or power production avoided through energy savings.

Using either method, an emissions factor translates reduced energy consumption into avoided emissions of GHGs or other air pollutants. Normally, the use of average emission factors is accurate enough for evaluating the impact of most public sector energy efficiency programs, given the degree of uncertainty in estimating net energy savings themselves, and projecting these savings in future years. In a few cases—for example, detailed analysis of the energy performance of a large public building or comparisons of program impacts in different regions with differing local sources of power generation—the more detailed analysis of avoided pollution and GHGs may be warranted.

Accuracy and Uncertainty

Because of the data limitations and uncertainties in all aspects of measuring or estimating energy savings, the evaluation should be explicit about both the level of precision and the statistical confidence associated with a savings estimate. Evaluators can indicate the uncertainty of their results either:

- Qualitatively, by indicating the general level of accuracy using range estimates or descriptors such as low, medium, and high; or
- Quantitatively, for instance, by providing confidence intervals around estimated means and medians.

10.5. Applying Evaluation Results

The final, critical step in the overall evaluation process is ensuring that the results are effectively communicated to, and used by, decision-makers. Significant and technically sound evaluation results should be useful in:

- *Refining* the design, implementation, and evaluation of the studied program, as well as future programs for public sector energy conservation.
- *Documenting* energy and cost savings as a basis for performance-based financing, continued program funding, or claiming credits for reduced pollutant (including greenhouse gas) emissions.
- *Forecasting* the effects of existing and prospective energy-saving programs on future energy demand.
- *Sharing* program experience and results as an example for others to follow.

Refining the Program

Evaluation results can be used to improve the design and implementation (and future evaluations) of public sector energy conservation programs. For example, evaluation results can identify specific ways to improve program targeting, delivery, or cost-effectiveness. Evaluation findings can also identify additional opportunities to save energy or alternative program approaches that may be more effective. They can also signal when it is time to end a program—either because its objectives have been accomplished or because it is not working well and future progress is unlikely.

Documenting Energy and Cost Savings

For some programs, clear and well-documented measurements of energy and cost savings, especially from an independent (third party) evaluation, can be important as a basis for allocating shared savings between the government customer and an ESCO or other contractor operating on the basis of energy performance. Similarly, evaluation results can provide essential proof to a project sponsor that the funds provided were invested well. Last, properly documented energy savings and associated reductions in air pollutants emissions can be used as a basis for establishing a marketable value for these reductions under systems for trading of emissions credits.

Forecasting Energy Demand and Strategic Planning

Program evaluation results can be used to support energy demand forecasting and resource planning. At the same time, it must be recognized that:

- The direct effects of government sector energy efficiency programs affect only a modest share of energy use in the total economy (generally 10–20 percent, for all levels of government combined).
- Continuation of current levels of programs (and their continued impact) may be uncertain.
- The indirect effects on the total economy due to public sector leadership are among the most difficult to estimate.

Nonetheless, if the public sector is achieving measurable success in improving the energy efficiency of its own buildings and operations, this suggests potential to extend similar measures throughout the economy. The role of energy conservation as a resource for meeting future needs can be incorporated in the process of energy demand forecasting, planning, and policy development.

Sharing Experience and Results

The results from evaluating public sector energy conservation programs should be made available to others, both to take advantage of the lessons learned—successful and unsuccessful—and as a means of encouraging other public and private organizations to take similar action.

References

Efficiency Valuation Organization. 2012. International Performance Measurement and Verification Protocol (IPMVP): Concepts and Options for Determining Energy and Water Savings (Vol. 1). Washington, DC: Efficiency Valuation Organization. www.evo-world.org.