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# ENERGY-EFFICIENCY LABELS AND STANDARDS:

A GUIDEBOOK FOR APPLIANCES, EQUIPMENT, AND LIGHTING



LEAD AUTHORS: STEPHEN WIEL AND JAMES E. McMAHON

# ENERGY-EFFICIENCY LABELS AND STANDARDS:

A GUIDEBOOK FOR APPLIANCES, EQUIPMENT, AND LIGHTING

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## PREFACE

Energy-performance improvements in consumer products are an essential element in any government's portfolio of energy-efficiency and climate change mitigation programs. Governments need to develop balanced programs, both voluntary and regulatory, that remove cost-ineffective, energy-wasting products from the marketplace and stimulate the development of cost-effective, energy-efficient technology. Energy-efficiency labels and standards for appliances, equipment, and lighting products deserve to be among the first policy tools considered by a country's energy policy makers. The U.S. Agency for International Development (USAID) and the United Nations Foundation (UNF) recognize the need to support policy makers in their efforts to implement energy-efficiency standards and labeling programs and have developed this guidebook, together with the Collaborative Labeling and Appliance Standards Program (CLASP), as a primary reference.

This guidebook was prepared over the course of the past year with significant contribution from the authors and reviewers mentioned previously. Their diligent participation has made this the international guidance tool it was intended to be. The lead authors would also like to thank the following individuals for their support in the development, production, and distribution of the guidebook: Marcy Beck, Elisa Derby, Diana Dhunke, Ted Gartner, and Julie Osborn of Lawrence Berkeley National Laboratory as well as Anthony Ma of Bevilacqua-Knight, Inc.

This guidebook is designed as a manual for government officials and others around the world responsible for developing, implementing, enforcing, monitoring, and maintaining labeling and standards-setting programs. It discusses the pros and cons of adopting energy-efficiency labels and standards and describes the data, facilities, and institutional and human resources needed for these programs. It provides guidance on the design, development, implementation, maintenance, and evaluation of the programs and on the design of the labels and standards themselves. In addition, it directs the reader to references and other resources likely to be useful in conducting the activities described and includes a chapter on energy policies and programs that complement appliance efficiency labels and standards.

This guidebook attempts to reflect the essential framework of labeling and standards programs. It is the intent of the authors and sponsors to distribute copies of this book worldwide at no charge for the general public benefit. The guidebook is also available on the web at [www.CLASOnline.org](http://www.CLASOnline.org) and can be downloaded to be used intact or piecemeal for whatever beneficial purposes readers may conceive.



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# 1. INTRODUCTION

## 1.1

### Labels and Standards in Context

Nations traditionally classify their energy consumption into three sectors—buildings, industry, and transportation. Energy in residential and commercial buildings is consumed by appliances, equipment, and lighting. In homes around the world, energy is consumed by everything from refrigerators and clothes-washing machines to garbage compactors and desktop computers, all in ever-increasing numbers. In office buildings, energy is consumed by everything from computers and copiers to water coolers and photosensor-controlled lighting, also in ever-increasing numbers. Heating and cooling equipment—often out of sight—is a collection of energy-consuming equipment as well. The energy-efficiency labeling and standards-setting programs described in this guidebook are intended to reduce the energy consumption of all of these products without diminishing the services they provide to consumers.

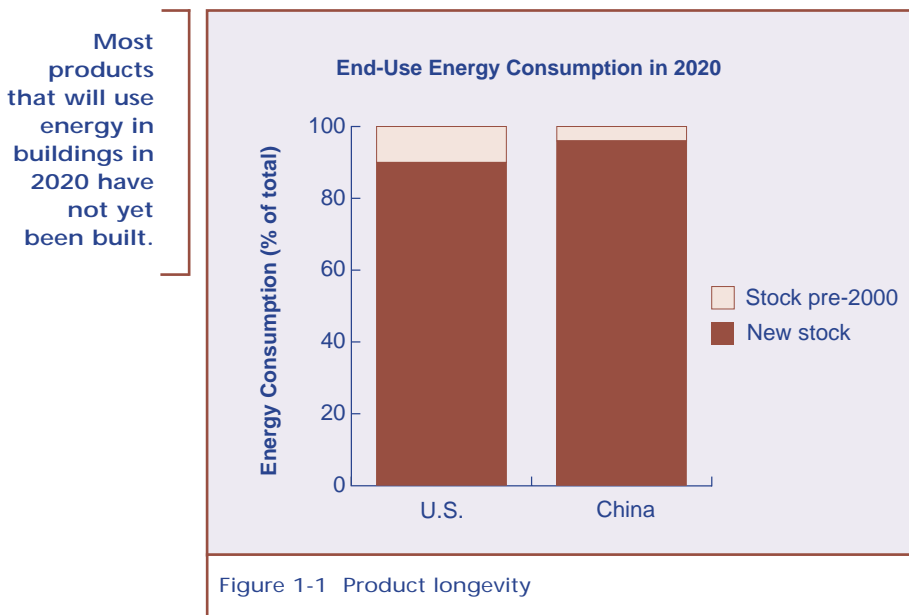
Worldwide, the use of energy in human activities related to buildings, including the use of appliances, equipment, and lighting, accounts for 34% of total energy consumption (Price 1998). Energy consumption also contributes about 25 to 30% of energy-related CO<sub>2</sub> emissions, accounting for 19 to 22% of all anthropogenic CO<sub>2</sub> emissions and 10 to 12% of our net contribution to climate change from all greenhouse gases (Wiel 1998).

The above numbers are a snapshot of today; what's ahead? Recent (1990 to 1995) annual average growth rates for energy use in buildings have ranged from a negative 7.2% in the residential sector of the Eastern European/Western Asian economies in transition to a positive 8.9% in the commercial sector of the Pacific Asian nations. On average, energy use in buildings is growing by 0.8% per year worldwide (Price 1998). This predicted growth in energy use is likely to contribute to overstress in many already stressed economies and environments around the world.

Energy growth rates will vary among nations according to structural differences (demographics, industrial composition, economic growth) and differences in the pattern and amount of energy services that each energy consumer is willing to purchase. In the building sector, these differences stem from different construction methods and uses of energy-consuming products. Each country can accommodate its natural growth in demand for energy services by some combination of supplying more energy and improving the efficiency of energy consumption. In all sectors, improving energy efficiency before increasing energy supply is generally the more economically efficient national strategy. A portfolio of energy policies is

available to governments for this purpose, including strategic energy pricing, financing and incentive programs, regulatory programs, government purchasing directives, and consumer education.

In the year 2020, 31% of energy use in developing countries is expected to occur in residential and commercial buildings. Reducing energy inefficiency in this sector deserves to be as high a priority in any nation's portfolio of energy policies as are parallel policies in the industrial and transportation sectors. Energy-efficiency labels and standards for appliances, equipment, and lighting offer a huge opportunity to improve energy efficiency and are especially effective as an energy policy. Government labeling and standards-setting programs can affect most of the energy that will be used in buildings just two decades from now. As **Figure 1-1** below indicates, most of the energy-consuming products that will account for building energy use 20 years from now have not yet been built.



Well-designed, mandatory energy-efficiency standards remove inefficient products from the marketplace, increasing the overall economic welfare of most consumers without seriously limiting their choice of products. Energy labels empower consumers to make informed choices about the products they buy and to manage their energy bills. Labels and standards are appropriate for most cultures and marketplaces; therefore, the authors believe that energy-efficiency

labels and standards deserve to be the cornerstone of any country's balanced portfolio of energy policies and programs. The specific extent to which labels and standards should be applied and the balance of programs that will most effectively limit energy growth and at the same time stimulate economic growth will depend on individual national circumstances and other considerations discussed in this guidebook.

## 1.2

### Purpose of This Guidebook

The authors have written this guidebook to assist policy makers and the institutions they represent in introducing energy-efficiency labeling and standards-setting programs for appliances, equipment, and lighting products and maintaining these programs effectively over time.

Policy makers will be faced with many difficult questions in the course of developing and maintaining labels and standards-setting programs. The guidebook is designed to assist them in:

- determining whether a labeling or standards-setting program is right for their countries and, if it is, to assist them in determining whether one or both programs are appropriate;
- providing guidance at each design, development, implementation, and maintenance step in the standards-setting process;
- identifying the data, facilities, and cultural, political, and human resources necessary to reach their goals; and
- illustrating, through case examples and references, existing field experience with energy-efficiency labeling and standards.

One goal of this guidebook is to introduce the key steps in the standards-setting process and to give a detailed explanation, based on collective experience, of how to pursue those steps in the most direct and effective manner. Many of the steps discussed can be harmonized with parallel activities of international organizations and other countries in the region and can be undertaken at relatively modest cost, resulting in significant economic and environmental benefits.

Except when discussing, in Chapter 9, government energy policies related to labeling and standards, the guidebook does not address the building codes that are prevalent in most industrialized countries, throughout Southeast Asia, and elsewhere around the world, nor does it address energy-efficiency standards for industrial processes.

## 1.3

### How to Use This Guidebook

This guidebook presents core concepts likely to be useful to people responsible for:

- considering whether or not to initiate an energy-efficiency labeling and/or standards-setting program,
- designing such a program,
- implementing such a program, and/or
- monitoring, enforcing, and maintaining such a program.

The guidebook begins with an overview (Chapter 2) and then addresses the primary steps in the process of creating and conducting energy-efficiency labeling and standards-setting programs. Chapter 3 explores the many factors useful to consider while deciding whether or not to regulate the energy efficiency of any energy-consuming product or to regulate the format and accuracy of information about its energy efficiency. Chapter 3 also discusses political, institutional, cultural, regional, technical, and economic factors that affect how successful or desirable such a program might be in various countries. The next three chapters describe the mechanics of labeling and standards programs: product testing (Chapter 4), label design (Chapter 5), and standards analysis and determination of standards levels (Chapter 6). The following two chapters address operation and maintenance of labeling and standards programs: Chapter 7 focuses on maintaining and enforcing labels and standards and Chapter 8 on evaluating their impacts.

The guidebook concludes with Chapter 9, which recognizes that the most effective national energy strategies are robust aggregations of many energy policies and discusses how energy-efficiency labels and standards fit into a comprehensive national energy strategy.

Each chapter begins with “Prescriptions.” These are the most fundamental lessons the more than 50 contributing authors and reviewers have collectively learned from their many years of experience—the essential features of a successful energy-efficiency labeling and standards-setting program.

Chapters 2 through 9 each contain flow charts showing the basic steps in the relevant aspect of labeling or standards setting that is discussed in that chapter. Together these flow charts make up a checklist of the many actions necessary to undertake a successful program of energy-efficiency labeling or standards.

Throughout the guidebook, we use the phrases “labels and standards” and “labeling and standards setting” to refer broadly to programs that include any combination of mandatory or voluntary energy-efficiency labels, labeling, standards, and standards setting. When our descriptions or prescriptions apply narrowly, we distinguish which particular categories of programs we are addressing.

This guidebook and a comprehensive set of complementary support tools and resources are available on the Collaborative Labeling and Appliance Standards Program (CLASP) website ([www.CLASPOnline.org](http://www.CLASPOnline.org)).











## 2. ENERGY-EFFICIENCY LABELS AND STANDARDS: AN OVERVIEW

### Guidebook Overview Prescriptions

- 1 Verify that efficiency labels and standards are appropriate as a basic element of your country's energy policy portfolio.
- 2 Apply your scarce resources to the products likely to provide the greatest public welfare.
- 3 Select/announce programs for specific products only when you've identified the necessary resources.
- 4 Allocate sufficient time and resources to develop a common product-testing procedure for each major appliance. Focus first on certification of test laboratories and test facilities; if appropriate, leave actual testing to manufacturers and third-party testing organizations. Whenever possible, participate in regional or global harmonization of test procedures, and establish alliances with other nations working toward that end.
- 5 Plan for early involvement of manufacturers and all other interested stakeholders in the label design or standards-setting process.
- 6 Allocate sufficient time and resources to analyze the effects of any potential standards. The more the standards level remains grounded in a thorough, objective technical analysis, the greater the likelihood of political sustainability and subsequent compliance.
- 7 Be open to input from all stakeholders, and proceed in a transparent and responsive manner. Focus on what is best for the country in the long term. Be prepared to withstand strong political pressure.
- 8 Allocate sufficient resources to monitor, evaluate, and report the impacts of programs.

### 2.1

#### Definition of Energy-Efficiency Labels and Standards

Before discussing the many aspects of energy-efficiency labels and standards that follow, we define exactly what is meant by these two terms.

##### 2.1.1 Labels

Energy-efficiency labels are informative labels that are affixed to manufactured products and describe a product's energy performance (usually in the form of energy use, efficiency, or energy cost) to provide

consumers with the data necessary for making informed purchases. We distinguish in this guidebook among three kinds of labels:

- endorsement labels,
- comparative labels, and
- information-only labels.

Endorsement labels are essentially “seals of approval” given according to specified criteria. Comparative labels allow consumers to compare performance among similar products using either discrete categories of performance or a continuous scale. Information-only labels simply provide data on a product’s performance.

Energy labels can stand alone or complement energy standards. They provide information that allows consumers to select efficient models. Labels also provide a common energy-efficiency benchmark that makes it easier for utility companies and government energy-conservation agencies to offer consumers incentives to buy energy-efficient products. The effectiveness of energy labels is highly dependent on how they present information to the consumer.

### 2.1.2 Standards

Energy-efficiency standards are procedures and regulations that prescribe the energy performance of manufactured products, sometimes prohibiting the sale of products that are less energy efficient than the minimum standard. The term “standards” commonly encompasses two possible meanings: 1) well-defined protocols (or laboratory test procedures) by which to obtain a sufficiently accurate estimate of the energy performance of a product in the way it is typically used, or at least a relative ranking of its energy performance compared to other models; and 2) target limits on energy performance (usually maximum use or minimum efficiency) based upon a specified test protocol (McMahon and Turiel 1997). The term “norm” is sometimes used instead of “standard” in Europe and Latin America to refer to the target limit. In this guidebook, we use the term “test protocol” for specifications regarding testing and “standards” for target limits on energy performance that are formally established by a government.

There are three types of energy-efficiency standards:

- prescriptive standards,
- minimum energy performance standards (MEPS), and
- class-average standards.

Prescriptive standards require that a particular feature or device be installed in all new products. Performance standards prescribe minimum efficiencies (or maximum energy consumption) that manufacturers must achieve in each product, specifying the energy performance but not the technology or design details of the product. Class-average standards specify the average efficiency of a manufactured

product, allowing each manufacturer to select the level of efficiency for each model so that the overall average is achieved.

### 2.1.3 Mandatory vs. Voluntary Programs

Is it best to make labels and standards mandatory? What if manufacturers and importers are legally required to meet standards but generally do not adhere to them, as reportedly happened in Europe in the 1960s and 1970s (Waide et al. 1997)? Is the mere threat of mandatory standards enough to make a voluntary program effective? Switzerland has successfully taken this approach (Waide et al. 1997). Japanese manufacturers routinely meet “voluntary targets” even though Japanese regulations make no mention of enforcement or penalties for not meeting these targets. In Japan, the threat of public disclosure of non-compliance is sufficient deterrent to make voluntary targets effectively mandatory (Nakagami and Litt 1997, Murakoshi 1999).

Deciding whether labels or standards should be legally binding is only one aspect of the process of de-signing a compliance mechanism. The goal is to affect the behavior of importers, manufacturers, salespeople, and consumers. Successful programs will be a combination of legal, financial, and social considerations, balanced to meet the structure, economics, and culture of the society.

### 2.1.4 Individual Products vs. Product Class

Is it better to set a standard that restricts the energy consumption of every individual product or to set a standard that controls the average energy efficiency for a class of products?

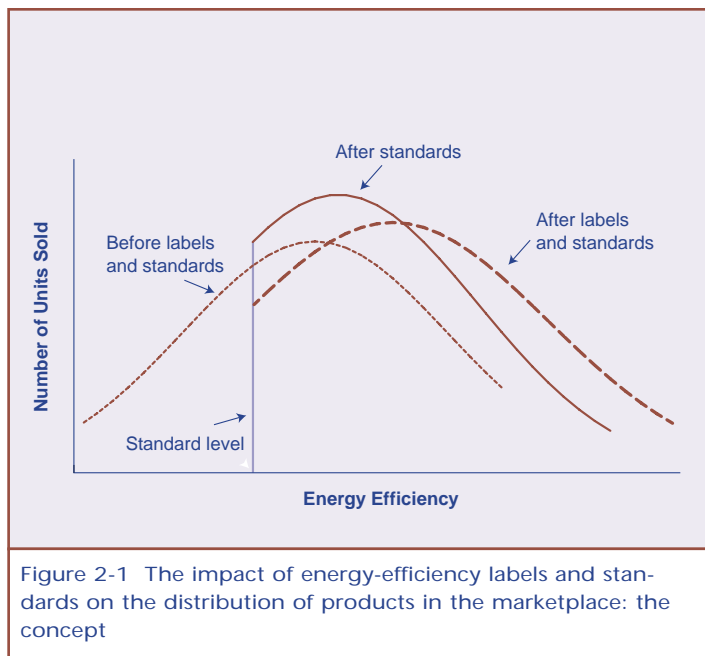
Most standards that have been set for refrigerators, freezers, clothes washers, clothes dryers, dishwashers, air conditioners, lighting products, and other household and office products have so far applied to each unit of every model manufactured. Manufacturers are left the discretion to use any combination of technologies to meet a particular standard. For example, one refrigerator manufacturer may rely on an especially efficient compressor to meet a new standard while another manufacturer may rely on a super-insulating door. Manufacturers test each model they offer and are expected to control the quality of production so that every unit produced meets the standard within a specified tolerance. Compliance can be checked by spot testing the units.

Switzerland and Japan are noted exceptions. These countries give manufacturers the discretion to achieve differing levels of energy efficiency in various models so long as the overall energy-savings target is achieved. This gives manufacturers the opportunity to find creative and economically efficient ways to achieve the desired overall efficiency improvement. However, it requires an elaborate and sophisticated procedure for assessing and enforcing compliance and adds considerable complexity to manufacturer production and shipment schedules. Because the average is an aggregation of different efficiencies of different models, it depends heavily on the relative sales of the different models, which creates uncertainty about whether the class average will actually meet the target on the reporting date for compliance with the standards.

Energy-performance improvements in consumer products are an essential element in any government's portfolio of energy-efficiency policies and climate-change-mitigation programs. Government should develop balanced programs, both voluntary and regulatory, that remove cost-ineffective, energy-wasting products from the marketplace and stimulate the development of cost-effective, energy-efficient technology, as shown in **Figure 2-1**. In some circumstances, mandatory requirements are effective. When designed and implemented well, their advantages are that:

- they can produce very large energy savings;
- they are hugely cost effective and very effective at limiting energy growth without limiting economic growth;

Standards and labels shift the distribution of energy-efficient models sold in the market upward.



- they require change in the behavior of a manageable number of manufacturers rather than the entire consuming public;
- they treat all manufacturers, distributors, and retailers equally; and
- the resulting energy savings are generally assured, comparatively simple to quantify, and readily verified.

Standards shift the distribution of energy-efficient models of products sold in the market upward by eliminating the

least efficient models and establishing a baseline for programs that provide incentives for “beating the standard.”

Labels shift the distribution of energy-efficient models upward by providing information that assists consumers in making rational decisions and stimulating manufacturers to design products that achieve higher ratings than the minimum standard.

The effect of well-designed energy-efficiency labels and standards is to reduce unnecessary electricity and fuel consumption by household and office equipment, e.g., stoves, refrigerators, furnaces, and water heaters. Reducing electricity use reduces fuel combustion in electric power plants. Cost-effective

reduction in overall fuel combustion has several beneficial consequences. The six most significant of these benefits are:

- reducing capital investment in energy supply infrastructure,
- enhancing national economic efficiency by reducing energy bills,
- enhancing consumer welfare,
- strengthening competitive markets,
- meeting climate-change goals, and
- averting urban/regional pollution.

These benefits are described in the following sections.

### **2.2.1 Labels and Standards Reduce Capital Investment in Energy Supply Infrastructure**

In industrialized countries, energy consumption by appliances, equipment, and lighting is already substantial. Energy use per capita has generally stabilized, and total energy use in buildings is growing roughly proportionally to population. In developing countries, by contrast, energy consumption in buildings is generally much lower than in industrialized nations but is growing rapidly as more people use particular types of appliances and per-capita energy consumption increases. For example, Sweden, with a Gross Domestic Product (GDP) per capita of US\$17,500, had total energy use per capita of 170 megajoules in 1996, with a growth rate of 0.8% per year during the previous 10 years. In the same year, China, with a GDP per capita of US\$2,700, had total energy use per capita of 22 megajoules, with growth during the same 10-year period of 8.7% per year (IEA 1999). Most other countries have growth rates that fall between these two examples. Countries that expect rapid energy growth (which is most countries) face the uncomfortable need to invest hard currency in energy-consuming products and the new power plants to supply the resulting energy needs.

Improvement in the energy efficiency of an electricity-, natural-gas-, or other fuel-consuming product reduces the amount of energy that the product uses. If the product consumes electricity and operates at times of peak power demand, the improved efficiency also reduces demand for new power plants. For highly cost-effective energy-efficiency measures such as labels and standards, this reduced investment in power plants is vastly greater than the increased cost of designing and manufacturing energy-efficient components of the energy-consuming products that these power plants service. For example, Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab) analysis shows that if improvements in energy efficiency averted 20% of Pakistan's projected energy demand during the next 25 years, Pakistan would need US\$10 billion less in hard currency for capital investments in power plants, transmission lines, and fuel. These efficiency improvements could cost as little as \$2.5 billion, with a portion of that in local currency. In other words, efficiency labels and standards reduce future investments in costly



power plant construction, freeing capital for more economically advantageous investments in the energy sector, such as compact fluorescent lamp manufacturing facilities or basic health and educational services.

### **2.2.2 Labels and Standards Enhance National Economic Efficiency by Reducing Energy Bills**

The rationale of reduced future investments applies equally to spending on fuel. Efficiency labels and standards reduce future investments in fuel acquisition, delivery, and use. The amount that is spent in the energy sector of any country in any year siphons money away from other sectors. Because much energy-sector spending directly supports production of other goods and services, a more efficient energy sector results in a more efficient economy.

Considering Pakistan as an example again, the 20% reduction in energy consumption discussed earlier would reduce the country's electricity-to-GDP growth-rate ratio from the current range of 1.0 to 1.5, which steadily increases the relative energy cost in the economy, to a more desirable range of 0.8 to 1.2, which would free much hard currency for other important social and economic expenditures.

### **2.2.3 Labels and Standards Enhance Consumer Welfare**

When applied appropriately, labels and standards can boost energy efficiency and enhance consumer welfare. In the U.S., for example, the number of refrigerator models and features available to consumers has increased since standards have been put in place, and purchase prices have been even lower than those expected and justified by regulators (Greening et al. 1996). The average amount of electricity needed to operate a new refrigerator in the U.S. has dropped by 74% since standards were first announced in the state of California a quarter century ago even though new refrigerators have enhanced features and larger capacity. (It is important to note, however, that, if inappropriately and unnecessarily applied, standards can limit choice, add to product cost, and disrupt trade.)

### **2.2.4 Labels and Standards Strengthen Competitive Markets**

If designed effectively, energy-efficiency standards and improved products can make local businesses more profitable in the long run; make local appliance, lighting, and motor manufacturers more competitive in the global marketplace; and make local markets more attractive for multinational commerce. By contrast, unnecessary and inappropriate standards can undermine burgeoning new local industries at a time when access to capital and other resources is limited. In addition, standards can have either a positive or negative effect on trade, by purposefully or inadvertently creating or removing indirect trade barriers.

There are many anecdotes and various views on the effects of standards on individual companies, and many manufacturers claim that they have been unsuccessful in maintaining margin on incremental product costs after the implementation of energy performance standards. In sum, the application of

new standards offers governments an opportunity to effect a change in their nation's business environment. The desired outcome is a strengthened competitive market in the long run.

### 2.2.5 Labels and Standards Meet Climate-Change Goals

Energy-efficiency labels and standards can help a country meet climate-change goals. Reducing energy consumption decreases carbon emissions from fossil-fuel power plants. For example, appliance standards currently in effect in the U.S. are projected to result in a reduction in residential-sector carbon emissions of 4 to 5% of 1990 levels by the year 2010 (Kooimey 1998).

### 2.2.6 Labels and Standards Avert Urban/Regional Pollution

Energy-efficiency labels and standards can help a country avert urban/regional pollution. Reducing energy consumption in buildings also decreases fossil-fuel power plant emissions of sulfur dioxide, nitrogen oxides, particulate matter, and other toxic gases and aerosols.

The previous sections describe the benefits of well-designed and effectively implemented labels and standards. It is important, however, to remember that poorly designed or executed programs can actually harm consumers, manufacturers, other stakeholders, the overall economy, and the environment. Inattention to detail in the development and implementation of the program can have especially devastating impacts on poor consumers or small manufacturers. Poorly designed standards can cause overinvestment in energy efficiency, which results in consumers paying, on average, more for a product than they will recover in utility bill savings. This in turn decreases national economic efficiency.

## 2.3

### History and Scope of Energy-Efficiency Labels and Standards

Conceptually, energy-efficiency labels and standards can be applied to any product that consumes energy as it provides its services. The national benefits of labels and standards applied to the most prevalent and energy-intensive appliances, such as home refrigerators and commercial air-conditioning systems, are generally substantially higher than the cost of implementing the labels and standards programs and producing the efficient products. The benefits of labels or standards for less common or less energy-intensive products, such as toasters, are often too small to justify the costs.

The first mandatory minimum energy-efficiency standards in modern times are widely believed to have been introduced as early as 1962 in Poland for a range of industrial appliances. The French government set standards for refrigerators in 1966 and for freezers in 1978. Other European governments, including Russia, introduced legislation mandating efficiency information labels and performance standards throughout the 1960s and 1970s. Much of this early legislation was weak and poorly implemented, had little impact on appliance energy consumption, and was repealed in the late 1970s and early 1980s under pressure to harmonize European trading conditions (Waide et al. 1997). The first energy-efficiency standards that dramatically affected manufacturers and significantly reduced the consumption of energy were mandated in the U.S. by the state of California in 1976. These standards became effective in 1977 and

**Table 2-1 The Status of Energy-Efficiency Labels and Standards**

Fuel Type	Product	1966	1976	1978	1979	1981	1984	1986	1989					
		France	United States	Germany	Russia	Canada	Japan	Taipei, China	Australia	Brazil	New Zealand	Israel	China	Malaysia
E	Refrigerators	M M	M M	V	V	M M	M V	V M	M M	V V	V		M	
	Room AC		M M		M	M M	V	V M	M	V V	V	M M	M	
E	Clothes Washers	M	M M	V		M M		V	M	V V	V		M	
E	Freezers	M	M M		M	M M	M V		M	V V	V			
E	Ballasts		M			V M	V		M	V V			M	M
E	Lamps		M M			M	V			V V				
EN	Clothes Dryers		M	V		M M		M	M		V			
EN	Water Heaters	M	M M		M	M		M	V*		V M			
E	Dishwashers	M	M M	V	M	M M			M		V			
EN	Ranges/Ovens	M	M	V	M	M M				V V				
E	Motors		M			M				V V				M
E	Central AC		M M			V M				V V			M	
E	Televisions	M	V		M		V						M	
EN	Boilers	M	V M							V V				
E	Monitors		V		M									
E	Space Heaters	M	M									M		
E	Computers (PC)		V		M		V							
E	Heat Pumps		M M			V M	V							
E	VCRs		V				V							
E	Printers		V		M									
N	Furnaces		M M			M								
E	Copiers		V				V							
E	Radio Rcvr/Rcdr		V		M								M	
B	Windows		M							V		V		
E	Fax Machines		V											
E	Fans												M	
E	Irons				V								M	
W	Showerheads		M M							V V				
E	Range Hoods													
E	Transformers									V V				
E	Pumps									V V				
W	Faucets		M M											
E	Scanners				M									
E	Rice Cookers												M	
E	Electric Kettles				V									
E	Vacuum Cleaners				V		V							
E	Skylights													
B	Doors													
E	Microwave Ovens			V										
E	Dehumidifiers					M								
	Solar Water Heaters									V V				
EN	Pool Heaters				M									
E	Icemakers					M								

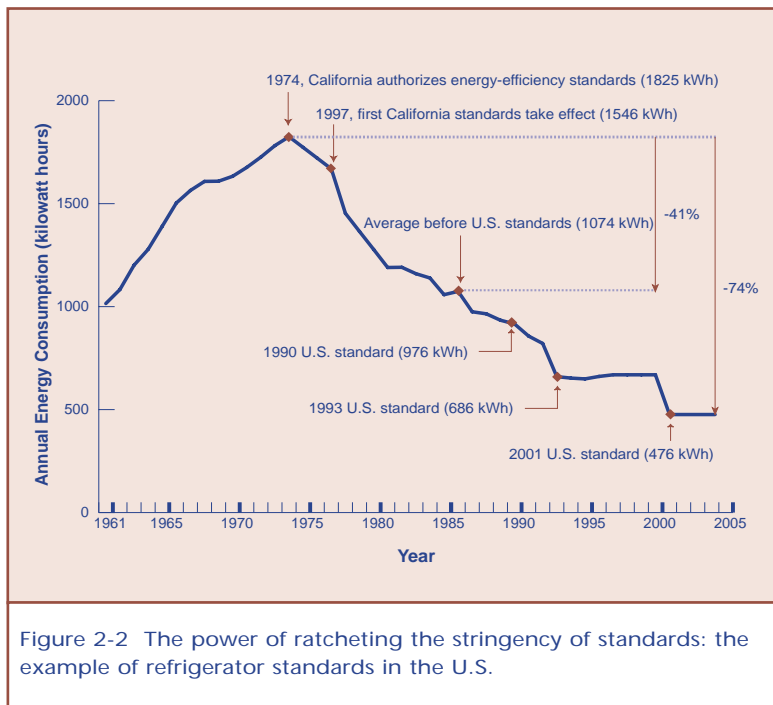
E = electric  
 N = natural gas  
 B = building shell  
 W = water



were followed by national standards that became effective starting in 1988. By 2001, about two dozen governments around the world, including the members of the European Union, have adopted mandatory energy-efficiency standards or labels for at least one product.

Mandatory labeling programs have developed in parallel with standards. In 1976 France introduced mandatory comparison labeling of heating appliances, boilers, water heaters, refrigerators, clothes washers, televisions, ranges, and dishwashers. Japan, Canada, and the U.S. soon followed suit with programs covering these and other products. The U.S. labeling program, enacted by law in 1975, took effect under the name EnergyGuide in 1980 for major household appliances. No new mandatory labeling programs were undertaken until Australia adopted a labeling program in 1987. The Australian program, like the eight more that were created throughout the 1990s around the world, also covers major household appliances (Duffy 1996). A history of the introduction of labels and standards programs during the past three decades is shown in **Table 2-1**.

Energy-efficiency standards are the primary reason that the average new refrigerator sold in the U.S. today uses one-quarter the electricity of the average new refrigerator manufactured 25 years ago.



The beginning standards level set for each product has varied by country. For countries designing standards to have long-term impact, the intent is for standards to become increasingly stringent over time as part of a basic strategy for coaxing newly emerging energy-efficient technology into the marketplace. Refrigerator standards in the U.S. are the most dramatic example of this ratcheting effect, which can be seen vividly in **Figure 2-2**.

## 2.4

### Resources Needed for Developing Energy-Efficiency Labels and Standards Programs

The development and implementation of energy-efficiency labels and standards require legal, financial, human, physical, and institutional resources. Each of these already exists to some degree in every coun-

try, and each is likely to need at least a little, if not major, bolstering to facilitate an effective labeling or standards program. The chapters of this guidebook address the resources required for each step in the process. Here in Chapter 2, we provide one anecdotal experience of the overall magnitude of government spending needed to develop and implement an energy-efficiency standards program.

The U.S. program of national mandatory energy-efficiency standards began in 1978. The program has developed (and, in six cases, updated) 28 residential and commercial product standards. During the first 19 years of the program, the U.S. government spent US\$104 million in developing and implementing these standards. The U.S. government spent an average of US\$5.5 million annually, and never more than US\$11.3 million or less than US\$2.3 million in a single year. Spending per household was in the range of 2¢ to 12¢ per year for a total of \$1.00 (\$2.00 in constant U.S. dollars). The payback on the increased investments in efficient technology by manufacturers and consumers that have resulted from this endeavor has been enormous, as will be demonstrated in the next section.

As labeling and standards-setting programs proliferate, international cooperation will become increasingly advantageous in reducing the resources needed for developing these programs. The International Energy Agency (IEA) identifies several forms of cooperation, including collaboration in the design of tests, labels, and standards; harmonization of the test procedures and the energy set points used in labels and standards; and coordination of program implementation and monitoring efforts. Such cooperation potentially has five benefits (IEA 2000):

- greater market transparency,
- reduced costs for product testing and design,
- enhanced prospects for trade and technology transfer,
- reduced costs for developing government and utility efficiency programs, and
- enhanced international procurement.

## 2.5

### Effectiveness of Energy-Efficiency Labels and Standards

The effectiveness of energy-efficiency labels and standards is generally reported as 1) calculations of impacts prepared prior to implementation, 2) anecdotal testimonials, or 3) calculations of impacts based on monitoring the response to labels and standards that are in place.

Whether the calculations are before implementation or after, they are generally based on solid market data. Such data generally show the potential impact in a dramatic way, as is the case for clothes washer efficiency in the U.S. market seen in **Figure 2-3**. The data show that the 1994 standards shifted the market to provide washers that are dramatically more efficient. The performance differences that exist in an unregulated market typically range over a factor of three (Adnot and Orphelin 1999). The impact of energy-efficiency labels has likewise been shown to be dramatic. The first evaluation of the impact of the recent European Union (EU) labeling scheme showed that the sales-weighted average energy efficiency

An evaluation of the impact of 1994 clothes washer standards in the U.S. shows a dramatic upward shift in the energy efficiency of models offered for sale after the standards were implemented.

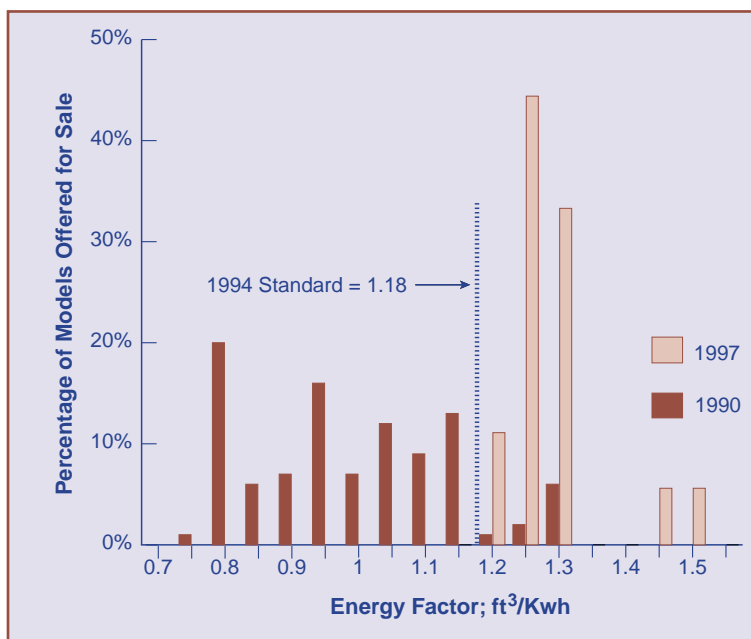


Figure 2-3 Clothes washer energy factors in the U.S.

of refrigeration appliances improved by 29% between 1992 and late 1999, with about one-third of the impact attributable to labeling (Bertoldi 2000). Such assessments clearly imply a huge potential for reducing the energy use of that one product although they fall short of estimating the overall impact (e.g., reduction in total energy use, net economic effect, or environmental contribution).

The best example of pre-implementation calculations of overall impact is the U.S. claim that energy-efficiency standards in place in the residential sector result in cumulative present-valued dollar net savings of about \$33 to \$49 billion from 1990 to 2010, after subtracting the additional cost of the more efficient equipment. Cumulative primary energy savings during this period are estimated to total 10.6 to 12.7 exajoules. The result in 2010 is a 5.1 to 6.1% reduction in residential energy use. Average benefit/cost ratios for these standards are estimated to be about 3.5 to 4.4 for the U.S. as a whole.

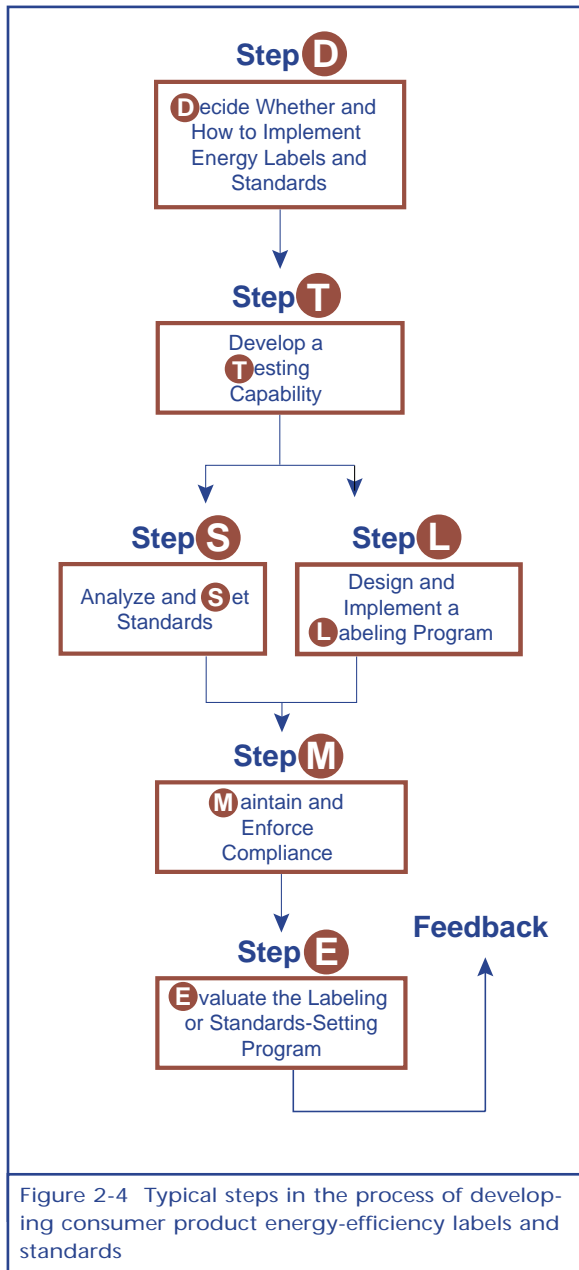
The total \$2 per household federal expenditure for implementing the standards is estimated to induce investment in energy-saving features of \$130 to \$140 per household, to result in \$450 to \$620 gross savings per household in fuel costs, and to contribute \$320 to \$480 of net-present-value savings per household to the U.S. economy during the period 1990 to 2010 (accounting for savings accruing after 2010 would increase the size of the net benefits). Projected annual residential carbon reductions are approximately 9 million metric tons of carbon/year from 2000 through 2010, an amount roughly equal to 4% of 1990 residential carbon emissions (Koomey et al. 1998).

In the way of testimonials, a representative of Bosch-Siemens, a European appliance manufacturer, was quoted in 1995 as saying “This labelling is having a major effect on our sales.... We see market share decline or rise within even as short as three months after labelling commences” (Ginthum 1995). The reader will have no trouble finding such quotes anywhere across the spectrum, from euphoria (from the Chief Executive Officer (CEO) whose company dramatically increased market share after labels and standards went into effect) to neutral observations, like the example provided, to despair (from the plant manager whose facility was shut down because of new efficient technology). In addition to individual anecdotes, policy shifts are sometimes described, as in this excerpt from the United Nations Foundation (UNF)

Within the broad area of the changes required in the energy systems of both developing and developed countries, UNF has chosen two specific programmatic areas which would have a highly leveraged impact on the future development patterns of the developing world: energy-efficiency labeling and standards, and community-based rural electrification using sustainable energy technologies.

Examples of actual monitoring and verification of the impact of standards are harder to find. The most rigorous one that we've found is a retrospective evaluation of the features and energy consumption of refrigerators in the U.S. prior to 1990 standards and after imposition of 1990 and 1993 standards. The

assessment concluded that “consumers appear to have received higher levels of cold food storage service at lower operating costs, without significant increases in purchase, or ‘first,’ costs” (Greening et al. 1996). However, because structural changes in the appliance market accompanied the introduction of U.S. refrigerator labels and standards, we can't conclusively attribute the benefits to the standards. However, we are confident that most such evaluations of the impact of particular standards would show similar benefits accruing after labels and standards are in place. The U.S. government also maintains an appliance standards data book for its own use that relies on actual product shipments, actual product efficiencies, and actual market prices to recalculate the forecast savings from its various standards. The analysis in the data book provides a cursory verification, for the benefit of the implementing agency, that the standards are having the planned effect.



**2.6** Steps in Developing Energy-Efficiency Labels and Standards Programs

Typical steps in the process of developing consumer product energy-efficiency labels and standards are defined. These steps are shown schematically in **Figure 2-4**, described briefly in the following paragraphs, and discussed in depth in subsequent chapters.



## 2.6.1 First Step **D** : Decide Whether and How to Implement Energy Efficient Labels and Standards

A government's decision whether or not to develop an energy-efficiency labeling or standards-setting program is complex and difficult. Many actors and factors determine whether such a program is beneficial in any particular country. Chances for success are best if the process of making the decision and preparing to establish a labeling or standards program includes:

- assessing how local cultural, institutional, and political factors are likely to influence the adoption and effectiveness of such programs;
- establishing strong and clear political legitimacy for standards;
- deciding the extent to which the program should rely on existing test facilities, test procedures, label design, and standards already established by international organizations or neighboring countries;
- assessing the data needs of the program and the capability of the government to acquire and manage those data; and
- screening and selecting which types of products are the highest priorities.

These basic elements in preparing for a labeling or standards-setting program are described in Chapter 3. Some key aspects of the process are described below.

### Assessing the capacity to develop and implement a program

Appropriate constitutional, legislative, and administrative authority must exist or be established for conducting each of the steps of the standards-setting process. Sometimes the decisions to implement energy-efficiency labels and standards and to cover particular products are made by legislation. Otherwise, these decisions must be formally made by the implementing agency. Trained, competent personnel must be available and institutions must exist to institute change. A testing capability must exist or be established. Resources must be allocated. The steps and schedule for establishing energy-efficiency labels and standards must be clearly prescribed in enabling legislation or rule making. The potential impact on local manufacturers must be understood and acceptable. And the appropriate political will must exist or be reasonably achievable.

Once the decision has been made to adopt energy-efficiency labeling requirements and standards, the implementing agency must establish rules for all the subsequent steps in the process, that is, for analysis, public input, compliance testing, certification, enforcement, monitoring, and revision. This is a time-consuming venture that evolves over the years as the initial path chosen is refined.

### Assessing data needs and screening/selecting products

Before deciding to implement energy standards in a country, it is important to estimate the potential impact of the standards by quantifying their environmental and monetary benefits. Much informa-

tion is available from existing labels and standards programs around the world. Some is provided in this guidebook, and much more is available from the referenced resources. Ideally, assessment of the technical potential of labels and standards will be based on data describing:

- current levels and forecasted trends for efficiency of products in the marketplace,
- expected level of efficiency possible,
- existence and characteristics of domestically manufactured products,
- existence and characteristics of imported products, and
- existence and levels of standards in other countries.

Sometimes this assessment will involve collecting and interpreting new local data on consumer products and their use. This process, along with the assessment of how much of the technical potential can be achieved and how much it will cost, is described in Chapter 3.

Deciding which products should be covered by standards depends on a number of factors. Implementing labels or standards for different consumer products, such as refrigerators, freezers, room air conditioners, lamps, and ballasts, will involve different costs and yield different benefits. In addition to analyzing the impact of and resources needed to implement a given standard, choosing a standard also may require assessing the reality and the politics of the manufacturers' market, the government's ability to enforce the standards, and other factors. It is important for program credibility and success that energy-efficiency labeling and standards programs be established and applied to any product only when the necessary resources are likely to be available.

### 2.6.2 Second Step **T** : Develop a Testing Capability

A common product-testing procedure for each major appliance is a vital precursor to the development of a label or standard for that product. Each manufacturer's products must be evaluated in the same way as those of every other manufacturer. For each product, this requires a standard metric (kilowatt-hours per year, coefficient of performance, seasonal energy-efficiency rating, efficacy factor, etc.), a standard test facility, a standard test procedure, and a process for assuring compliance with testing requirements, as described in Chapter 4.

Testing capabilities can be created in a testing center within the country, shared among several countries, or purchased from outside the country. In some countries where most or all of the units of a particular appliance are imported from foreign manufacturers, it may be more cost effective to rely on existing test facilities from the country of origin. Assistance is often available to help plan and design the necessary test facility (see Section 2.8).

Testing by manufacturers and private laboratories needs to be accredited and recognized. Generally, government costs are reduced and product marketing delays are avoided if governments rely mainly on private testing and only conduct audits themselves.

Adoption of existing test protocols for assessing product energy efficiency is strongly preferable to creation of a new protocol. Existing protocols have the benefits of known repeatability and reproducibility along with known facility needs and defined benefits and issues. New protocols risk new, unforeseen issues. There is great benefit to manufacturers and all affected parties if the test protocol is harmonized at the highest possible level—preferably globally, or among regional areas of trade. This allows consistent decision criteria and standardization among all models, which, in turn, allows for economy of scale in manufacturing. Investments in energy testing facilities and test resources are also minimized.

### 2.6.3 Third **L** and Fourth **S** Steps: Design and Implement a Labeling Program and Analyze and Set Standards

#### Label design

Label requirements can be established in a variety of ways, usually involving consumer research (e.g., use of focus groups) as an important part of the process. After a labeling program has been designed and initial decisions have been made, a testing program must be created that will ensure accuracy and confidence in the information presented on the label. Then the label can be designed and the program implemented.

A label can provide a single rating or a large number of data, and an energy-performance measurement can be represented as a particular category, a point on a scale, or a single number. Examples of several types of labels are provided in Chapter 5. The initial effectiveness of the approach selected will likely depend on cultural preferences and many other factors. Label designers typically face the choice of whether to focus on accommodating current consumer response to achieve short-term impact or striving for long-term changes in consumer understanding and behavior. This choice is addressed in more detail in Chapter 5.

Consideration should be given to a regional labeling approach if the marketplace, particularly for imported products, is more regional than national. Even slightly different labeling requirements among nations can be disruptive to trade, can limit choices, and can add to consumer costs. Harmonization of labels needs to be considered in two parts: harmonization of technical foundation (the metrics and any technical categorization) and harmonization of label format and presentation. There are good reasons for harmonizing the former as broadly as possible. In many situations, there are good reasons, which outweigh the advantages of harmonization, for customizing the latter.

#### Standards-setting

A standard can be set to:

- eliminate the less efficient models currently on the market,
- harmonize with another country's standard to prohibit import of inefficient products, and/or
- encourage importers and local manufacturers to develop the most economically efficient products.

Several types of analyses should be conducted to ensure that a standard achieves its purpose. Following is a listing of the types of analyses described in Chapter 6 that have been used and for which methodologies are available for determining the level at which to set a standard. Any country will want to customize existing data and analytical models to fit its own needs, train government staff or others to perform the analysis, and review the analysis to verify results.

**Engineering Analysis**—An Engineering Analysis assesses the energy performance of products currently being purchased in the country and establishes the technical feasibility and cost of each technology option that might improve a product's energy efficiency as well as evaluating its impact on overall product performance.

**National Impact Analysis**—A National Impact Analysis assesses:

- the societal costs and benefits of any proposed standard;
- the impacts on gas and electric utilities that would result from reduced energy consumption; and
- the environmental effects in terms of changes in emissions of pollutants such as carbon dioxide, sulfur oxides, and nitrogen oxides that would occur in residential and commercial buildings and power plants as a result of reduced energy consumption.

**Consumer Analysis**—A Consumer Analysis establishes the economic impacts on individual consumers of any standard being considered, including increased equipment prices and reduced operating expenses.

**Manufacturing Analysis**—A Manufacturing Analysis predicts the impact of any standard being considered on international and domestic manufacturers and their suppliers and importers. It assesses the resulting profitability, growth, and competitiveness of the industry and predicts changes in employment. Depending on the local situation, this analysis may be expanded to include distributors and retailers.

The recommendation to standardize test protocols should not necessarily be extended to energy standards levels. Standards levels should be assessed based on national situations and should integrate factors such as user habits, the use environment (including power distribution characteristics), the technological and financial situations of affected manufacturers, and the estimated impact on the national economy. Motor technology provides an example of why standards differentiation is merited: higher-efficiency motor designs typically applied in developed countries are sometimes not appropriate for the higher-variability power distribution networks typically found in developing countries.

### Stakeholder and consumer involvement

The initial recommendation of a label design or standard for any consumer product should begin a process of public review and revision. The need for standards is based on the premise that manufacturers make and consumers buy products that are detrimental to the economy and the environment and thus the production and use of these products runs counter to the overall public good. Manufac-

turers generally object to being forced to produce more efficient products than they would otherwise produce. Energy-efficiency and environmental advocates generally want manufacturers to produce products that are as efficient as is technically possible. The government's role is to determine the optimum public good using information that is often incomplete and claims that are sometimes contradictory. The more input the government collects from all involved stakeholders, the more informed its decisions will be.

A starting standards level is best set based on a compilation and examination of the results of various analyses, tempered by technical and political judgment, which leads to a recommendation that maximizes the long-term public good. In the early stages of the process, there should be as much reliance on the results of the analysis and as little political judgment as possible (no matter which interested stakeholders apply pressure). The analysis keeps the ultimate political recommendation within realistic bounds. The more the level of a standard remains grounded in a thorough, objective technical and economic analysis, the greater its political sustainability and the degree of compliance with it. Thorough, objective analysis requires an equitable balance of input from the various interest groups.

Legislators or government officials in any country responsible for establishing labels and standards programs must specify what level of public involvement is most appropriate for that country. Experience to date shows that the more manufacturers and other interested stakeholders are involved early in the label-design or standards-setting process, the more effective the resulting labels and standards (greater economic efficiency, more product model options, and more appropriate applications of technology) and the greater the rate of compliance by affected manufacturers. Whether the goal is to refine the design of an energy-efficiency label or the level mandated by an energy-efficiency standard, testing the response of the users of the labels and stakeholders affected by the standards early in the process is extremely useful in enhancing the quality of the outcome. In many developing countries, there is little experience in providing public notice, conducting focus groups or public hearings, interpreting public comments, reviewing public comments and weighing their relevance, and making appropriate changes to balance the expressed interests of many stakeholders. The experience of other countries in collecting, acknowledging, and seriously considering public input is sometimes transferable, depending on the democratic tradition and governance style of each country. Assistance is often available for these efforts.

### **Promulgation**

The steps and schedule for establishing energy-efficiency labels and standards are most often clearly prescribed and legally straightforward in enabling legislation or rule making. Specifying the information requirements and format for labels, the level for standards, and the schedule for both can be politically sensitive, and politically induced delays are common. Often, manufacturers and their suppliers and distributors practically or philosophically oppose such government regulation. Manufacturers must have time to create labels, retool, make and distribute new models, and dispose of old inventory. They will often desire a longer transition period than government regulators want. The interests of other stakeholders may bring pressure for additional analysis and greater efficiency levels.

Government officials responsible for promulgating labeling requirements and standards must find an appropriate balance between consensus building and unilateral government action. They should be open, transparent, and flexible in balancing the variety of considerations entailed in deciding whether and what labeling and standard regime to adopt. No matter how much they rely on consensus building, they must be prepared to withstand strong political pressure and maintain a regulatory posture with focus on what is best for the country in the long term. More information on this subject is provided in Chapter 5 for labeling and Chapter 6 for standards-setting.

#### 2.6.4 Fifth Step **M** : Maintain and Enforce Compliance

After the label design process is mandated or a standard is set, those responsible for the labeling and standards-setting programs must certify, monitor, and enforce compliance. We use the term “certification” in this guidebook to refer to all activities that ensure that a manufacturer’s product initially complies with a labeling requirement or a minimum energy-efficiency standard. “Self-certification,” in which manufacturers formally test their own products and, in practice, also test each other’s products and force compliance, is practiced in the U.S., Japan, and most European countries. The term “monitor compliance” refers to all activities that ensure that a manufacturer’s products remain in compliance with a standard after the products have been certified. The term “enforcement” refers to all activities used to deal with manufacturers, distributors, and retailers that are not in compliance with the regulations. The government officials responsible for labels or standards must be prepared to assess the potential effectiveness of self-certification and other certification processes, establish certification and compliance monitoring procedures, and train personnel in certification procedures, compliance monitoring, and enforcement programs. They must also be ready to defend their actions if challenged in courts, as has happened in some countries.

Aside from legal issues of compliance and enforcement, there is the practical issue of helping people acclimate to a marketplace that requires manufacturers to provide information labels on products and to manufacture and market products that meet or exceed a specified efficiency level. This takes time, but providing information and training at various points in the product chain can significantly shorten the length of time. In fact, the viability of a labels or standards program can be jeopardized without appropriate public education and training. In some countries, the involvement of environmental advocacy organizations is also important. Training programs in product engineering or regulatory compliance for manufacturers, label interpretation for product salespersons and consumers, label and standards design for implementing agency officials, and public involvement for stakeholders are all part of a well-designed labels and standards program. Likewise, a public education campaign to educate consumers about what labels mean and how to use them can be crucial to the success of a program.

All these aspects of maintenance and enforcement of labeling and standards-setting programs are addressed in Chapter 7.

### 2.6.5 Sixth Step **E** : Evaluate the Labeling or Standards-Setting Program

If a government is to maintain an energy-efficiency labels and standards program over the long run, it will have to monitor the program's performance to gather guidance for adapting the program to changing circumstances and to clearly demonstrate to funding agencies and the public that the expected benefits are actually being achieved. Good test procedures, labels, and standards require periodic review and update. Periodic review allows the government to adjust test procedures, redesign labels, and adjust or "ratchet" the stringency of standards upward as new technology emerges and use-patterns change. Review cycles in countries with such programs typically range from three to 12 years, depending on the product and national priorities.

As described in Chapter 8, establishing a monitoring program includes planning the evaluation and setting objectives, collecting data, analyzing the data, and applying the evaluation results, where appropriate, to meet several goals. These goals include refining the design, implementation, and evaluation of the labeling and standards-setting programs; supporting other energy programs and policies; and supporting accurate forecasting of energy demand for strategic planning. The analysis will normally include assessments of the actual energy consumption of the regulated products, the level of consumer satisfaction with new energy-efficient models, and the impact on individual manufacturers and their industry. It is important for the government's energy-efficiency labeling and standards-setting program to allocate resources and perform this task in a systematic and meaningful way.

In addition, labeling and standards-setting agencies are usually obligated to report the results of their activities. Generally, this merely requires a compilation of the results of all the activity described above. Only if the monitoring program is underfunded is there likely to be any difficulty in achieving this task.

## 2.7

### Relationship to Other Energy Programs and Policies

Energy-efficiency labels and standards work best in conjunction with other policy instruments designed to shift the market toward greater energy efficiency. Efficiency standards typically eliminate the least efficient models from the market. Other energy policies and programs, including energy-efficiency labeling, help to further shift the market toward higher energy efficiency. No one government policy makes an energy-efficient economy. Together, an array of policy instruments can influence manufacturing, supply, distribution, product purchases, and the installation, operation, and maintenance of energy-consuming products in our society. When working effectively, these policy instruments accelerate the penetration of energy-efficient technology throughout the market. It will take a rich portfolio of policies to achieve the stated economic and environmental goals of most of the world's nations.

Although energy-efficiency labels and standards are considered by many to be the backbone of a country's energy-efficiency portfolio, the package should also include complementary programs, such as those for:

- energy pricing and metering;
- incentives and financing;
- regulation, in addition to information labels and standards;
- research and development;
- voluntary participation, including quality marks, targets, and promotion campaigns;
- energy-efficient government purchasing;
- energy auditing; and
- consumer education.

An important trend in some countries is to combine policy instruments in ways that selectively support “market transformation”—specific interventions for a limited period leading to a permanent shift in the market toward greater energy efficiency. Chapter 9 discusses how labels and standards fit within a larger portfolio of energy-efficiency policies and programs, and how best to combine and sequence these to create an effective, sustainable market transformation process.

## 2.8

### Availability of Technical Assistance

Need help? Whether it is technical expertise or financial assistance you’re looking for, help is often available through bilateral and multilateral grants and loans to do such things as:

- assess the potential benefits and costs of labels and standards;
- establish appropriate legal frameworks for labels and standards;
- develop test procedures, laboratory services, and labeling schemes;
- set cost-effective standards, making use of various analytical methodologies;
- monitor and report on labels and standards; and
- train government officials, utility company employees, product manufacturers, product distributors, product salespeople, architects/designers, environmental activists, and/or consumers in any aspect of the design, development, implementation, and use of energy-efficiency labels and standards.

Several organizations have grant programs that provide technical expertise to developing countries specifically for creating energy-efficiency labeling and standards programs. The most prominent of these are listed below; there are many more, however, especially in European countries:

- The United States Agency for International Development (USAID), which offers training and technical assistance for energy-efficiency labeling and standards programs for most countries (USAID, for example, funded the preparation of this guidebook).



- The United Nations Department of Economic and Social Affairs (UN/DESA), which has been helping six Arab countries with energy standards, has been implementing a refrigerator efficiency project in China, and is now offering assistance through a grant from the United Nations Foundation assisting all aspects of energy-efficiency labeling and standards programs worldwide.
- The United Nations Economic Commission for Latin America and the Caribbean (UN/ECLAC), which is currently working with several countries in Latin America to enact legal and regulatory reform for energy standards through a parliamentary approach.
- The United Nations Economic and Social Commission for Asia and the Pacific (UN/ESCAP), which has organized workshops in numerous countries in Asia to promote energy standards.
- The United Nations Economic Commission for Europe (UN/ECE), which promotes standards under its Energy Efficiency 2000 program and manages some European Commission programs in Eastern Europe.
- The Global Environmental Facility (GEF), administered through the World Bank, the United Nations Development Program (UNDP), and the United Nations Environmental Program (UNEP), which provides grants for greenhouse gas mitigation. For example, GEF has contributed \$9.8 million to a \$40 million program to improve the efficiency of refrigerators in China, including the development of stringent energy-efficiency standards.
- UNDP—See GEF entry above.
- UNEP—See GEF entry above.
- The European Commission's Directorate General for Transport and Energy (DG TREN), which sponsors projects to promote energy-efficiency programs, including labeling and transformation of the appliance market in European countries outside the EU. It also has programs to foster collaboration with Latin America and Asia on energy efficiency.
- The International Energy Agency (IEA), which conducts regional workshops and prepares publications to promote energy-efficiency standards and labels in non-IEA countries.
- The French Agency for the Environment and Energy Management (ADEME) which collaborates to promote energy-efficient appliances in North Africa, the Middle East, and Asia.

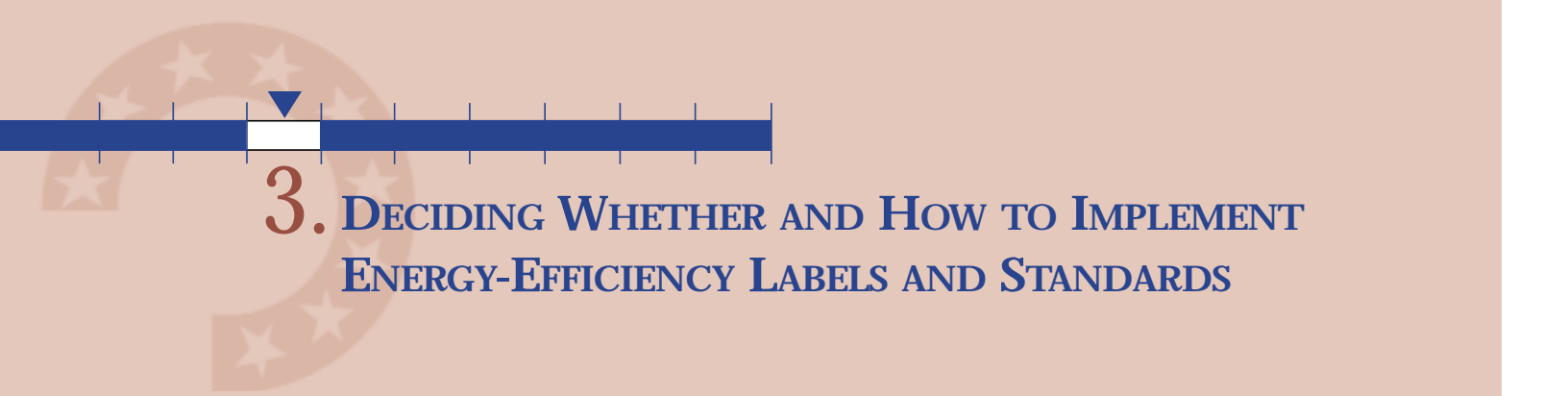
In addition to grant programs, multilateral banks are increasingly recognizing that energy-efficiency labels and standards are cost effective for governments and have been providing loans to fund various aspects of the development of these programs. At this point, we are aware of loans of this type given by the Asian Development Bank (ADB), the Interamerican Development Bank (IDB), and the International Bank for Reconstruction and Development (IBRD, World Bank).

Furthermore, many other organizations worldwide are involved in the various aspects of developing labeling and standards-setting programs. These organizations include manufacturers' associations, standards-setting organizations, testing laboratories, government agencies, lending institutions, consultants,

universities, and public interest advocacy groups. More information is given about these organizations wherever appropriate in the chapters that follow.

The recently formed organization CLASP—composed of the Alliance to Save Energy, the International Institute for Energy Conservation, Lawrence Berkeley National Laboratory, and a variety of affiliates from around the world—provides technical assistance upon request and extensive information about labeling and standards-setting programs, including current information about resources available for supporting such programs, at its website: [www.CLASPOnline.org](http://www.CLASPOnline.org).





## 3. DECIDING WHETHER AND HOW TO IMPLEMENT ENERGY-EFFICIENCY LABELS AND STANDARDS

### Guidebook Prescriptions for Deciding About Labels and Standards

- 1 Review existing legislation and establish framework legislation to develop a legal basis for labels and standards.
- 2 Assess existing institutional capacity for developing, implementing, and maintaining a labeling and standards-setting program.
- 3 Develop an overall labeling and standards-setting plan and assign one government agency primary responsibility for driving the program.
- 4 Harmonize energy-performance test procedures with international protocols to facilitate testing and reduce barriers to trade.
- 5 Establish minimum data needs and develop a plan for collecting the data necessary to conduct analysis to support the program. It is better to rely on simple forecasts based on limited but reliable data than on detailed forecasts from end-use models that are based on unreliable proxy data. If you need more data to decide whether or not to proceed, take the time to collect it.
- 6 Use cost-effectiveness analysis to screen the products to be included in the program, in order of priority.
- 7 Plan to periodically review and update the labels and standards every few years.

### 3.1

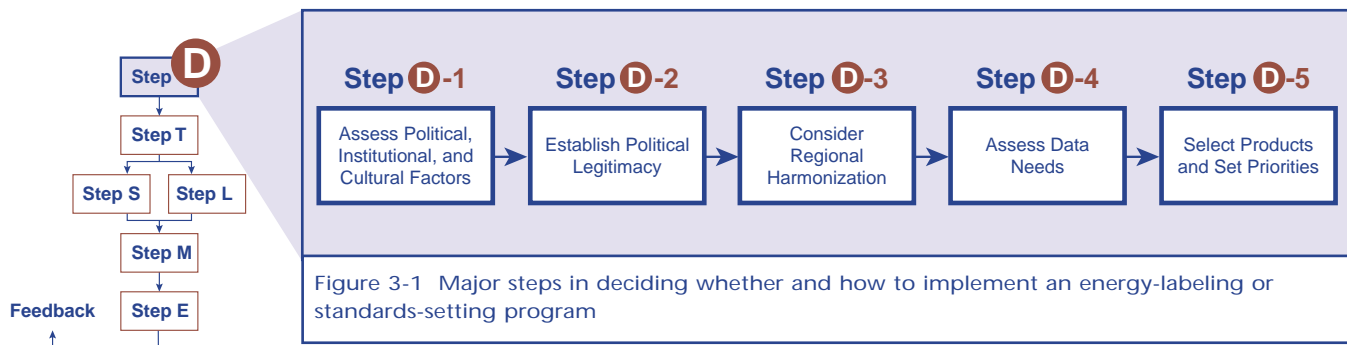
#### Step **D**-1: Assess Political, Institutional, and Cultural Factors

A government's decision whether or not to develop an energy-efficiency labeling or standards-setting program is complex and difficult. Once it has been established that there are significant energy-efficiency differences between existing and potential product models, there are many actors and many factors to consider. The first step is to assess how local cultural, institutional, and political factors are likely to influence the adoption and effectiveness of such programs. This assessment can determine which programs, if any, to pursue and can identify factors likely to facilitate or hinder the effort. For example, in countries with a strong central government tradition, it may be relatively easy to reach political consensus that a sweeping set of minimum energy-efficiency standards will provide consumer benefits that are not being captured by the private market. In other countries, there may be greater resistance from influential stakeholders to mandatory regulations, and time and education may be required for people to accept the

benefits claimed for energy-efficiency standards, as well as to accept that standards are economically beneficial to the consumer and do not decrease consumers' choice of products or reduce the number of consumers who can afford quality-of-life improvements such as air conditioners. In countries where there is strong resistance to mandatory standards, a voluntary or mandatory energy-labeling program and/or voluntary standards program may be more saleable.

International experience to date has shown that, in the case of energy labeling, cultural differences are often not as important as cultural similarities, and much of what works in one region is often transferable to another (as described in Chapter 5). In all cases where the decision is made to proceed with labels or standards, it is important to develop support for labeling and standards-setting programs not only within the government but in the private and non-governmental organization (NGO) sectors as well. In addition, impartial and credible labeling and standards-setting institutions need to be in place to ensure effective results. These institutions need to have a mandate, an adequate budget, and enough staff to effectively oversee the development and implementation of the programs.

Figure 3-1 schematically illustrates a five-step process for deciding to implement a labeling and standards-setting program.



### 3.1.1 Assessing Existing Energy Regulatory Frameworks

It is useful to begin an assessment of local cultural and political factors by examining the existing regulatory framework. Is there legislation affecting the energy performance of products? Is any agency empowered to establish minimum energy-efficiency standards or a mandatory energy-labeling program? These questions must be answered early because legislation forms the basis of an effective mandatory program. Although legislation is not a prerequisite for the development of labeling and standards-setting programs and some voluntary programs have been effective, legislative support will greatly enhance the likelihood that a labeling or standards-setting program will be adopted and will have a significant impact.

For mandatory labels and standards, a legal basis must be established. Even in cases where voluntary agreements are reached with industry, these agreements are often only achieved when industry perceives that government negotiators may enforce a mandatory scheme instead. This has been the case in negotiations to develop voluntary appliance energy-efficiency targets in Switzerland, Japan, and the EU.

Legislation should provide a clear legal mandate for a government agency to require manufacturers (or retailers) to test products in a uniform way and place the labels on all affected products. The passage of legislation also signals strong political support for the program.

Voluntary comparative-labeling schemes have been implemented in countries as diverse as Thailand, Hong Kong, India, and Brazil. The success of these voluntary schemes has varied. In most cases, only appliances in the higher-efficiency classes tend to carry labels because manufacturers and retailers of lower-efficiency products have no incentive to advertise that their products are inefficient (see Insert Box: *Case Study of Thai Labeling Program: A Voluntary Labeling Example*). When only the most efficient products have a label, the comparative label becomes an endorsement label indicating the top-rated models.

The most widely practiced approach for developing legal authority for labels or standards entails two stages. First, general legislation, called “framework” legislation, is introduced. This establishment of legislation is followed by implementation of regulations that are tailored to specific product types (e.g., lamps, refrigerators, etc.). (See discussion of framework legislation in Section 3.2.2).

### 3.1.2 Assessing Existing Institutional Capacity

Early in the process of assessing local cultural and political factors, it is important to assess the existing institutional capacity to develop, implement, and maintain labeling and standards-setting programs. Such programs require a variety of institutional skills to carry out the following activities:

- test energy consumption, performance, and energy-efficiency levels;
- develop, issue, and maintain labels and standards regulations;
- monitor compliance;

### Case Study of Thai Labeling Program: A Voluntary Labeling Example

The Thai voluntary labeling program has worked well for refrigerators but has been less effective for air conditioners. After two years of the program, 85% of single-door refrigerators in the market had achieved an energy label ranking of “4” or “5” (5 is the highest ranking), while after four years, 92% had achieved label rankings of “4” or “5,” with more than 95% of these labels being the top-rated “5” ranking. Because the label levels were initially set with “4” being 10% more efficient than the market average and “5” being 25% more efficient than the market average, this indicates that the labeling program has resulted in a roughly 25% increase in the average efficiency of single-door refrigerators.

The voluntary labeling program for air conditioners has been less effective than the refrigerator-labeling program because of the uneven distribution of air conditioner efficiencies. In the air conditioner market, high-end domestic and imported units have higher energy efficiencies but cost twice as much as the lower-priced domestic units that dominate the market. As a result, only manufacturers or importers of the most efficient models attain a “4” or “5” label ranking on their products. After three years of the program, less than 40% of models in the market were labeled. These have only the “4” or “5” ranking. The remaining models—almost all with much lower efficiencies—were unlabeled.

*Source: AMI (Agra-Monenco International) 1999.*

- enforce regulatory requirements; and
- evaluate program implementation and impacts.

The review of institutional capacity should specify roles for appropriate institutions, identify areas that need strengthening, and evaluate the tasks needed to build to the necessary level the capacity in all the key institutions. The review will help to establish the existence of any major practical constraints that might limit program development. It should also give an early indication of the program's viability, taking into account the likely resources and depth of political support.

It may be an inefficient use of limited financial, technical, and human resources for each nation to develop separate institutional capacity for labeling and standards programs. Consideration should be given to regional approaches or to relying on programs in other geographical areas that affect the local appliance market. Unless there is evidence of importation of highly inefficient products into a country, it may be able to rely on a neighbor's program.

### Testing

In time sequence, energy-performance testing is the first capability that must be in place. Until there is reliable testing of energy performance, it will not be possible to start a labeling program or even to assess the benefit/cost implications of a national minimum energy-efficiency standards program.

The establishment of fully equipped, staffed, and accredited test laboratories, the subject of Chapter 4, can be the most resource-intensive and time-consuming aspect of developing a labeling and standards-setting program. Test laboratories are expensive to create and operate, and it is not generally practical for them to be sustained solely for the purpose of an energy-labeling and standards-setting program. If no suitable test laboratories are in place within a country, it may be necessary to consider their establishment as part of wider government programs covering product safety, quality, and environmental acceptability. Alternatively, policy makers may consider pooling resources with neighboring countries to establish a regionally funded and managed test laboratory.

Another option may be to rely on existing private-sector test laboratories. Care must be taken, however, to avoid potential conflicts of interest. For example, it is not appropriate for laboratories that are doing research testing for regulated companies on a contract basis to also act as program-designated test centers.

### Administration

Ideally, one governmental agency should have overall responsibility for developing, issuing, and maintaining both labels and standards, to ensure that the labels and standards are enacted and upgraded in a consistent manner. Frequently, however, there are conflicting institutional claims for control of the programs. These claims must be addressed and resolved to avoid a damaging division of resources that will reduce program impacts. In some countries, a division of resources has occurred when different agencies or institutions issued separate energy/environment endorsement labels, comparative ener-

gy labels, or “eco labels.” It is unusual for a single agency to have all the necessary skills to develop the labels and standards in-house. External experts are often hired to assist in the process, especially to provide information on specific products.

### Monitoring

The agency responsible for monitoring compliance should be clearly designated and adequately funded. Compliance monitoring of labels and standards usually operates on two levels: first, through product testing to ensure that the labeled energy performance is correct; and second, through retail inspections to ensure that labels are correctly displayed at the point of sale. A variety of strategies can be used to check products on the market. These include random-check testing, manufacturer self-regulation, and establishment of an independent certification body, which could combine elements of the preceding two strategies. For a compliance program to be effective, there must be a clear system of procedures and penalties.

### Enforcement

The enforcing institution must have an adequate budget and staff to carry out its task. One possible problem in developing countries is that civil service regulations and pay scales may make it difficult for government testing and enforcement agencies to attract and maintain high-quality staff. The institutional review that precedes the process of establishing a program should determine whether the agency responsible for enforcement has the personnel and resources to operate effectively.

### Evaluation

The institution responsible for evaluating the impact of a labeling or standards-setting program must employ or have access to trained researchers capable of objective review. Ideally, the agency charged with the responsibility for evaluation should be independent of the administering agency, although this is rarely the case.

## 3.2

### Step D-2: Establish Political Legitimacy

Mandatory labels and standards can have an inherent adversarial aspect because they force manufacturers to take action that they might not otherwise take. Minimum energy-efficiency standards, for example, compel the appliance and equipment industry to design, manufacture, and market more efficient products than they might otherwise. If such potential conflicts are not dealt with early in a program’s design, they may prove detrimental to its operation. It is, therefore, important to establish strong and clear political legitimacy for standards as early and as thoroughly as possible. This is the second step in deciding whether or not to develop labeling and standards-setting programs.

Political legitimacy can take various forms depending on the nature of the government or other agencies involved. Legitimacy is strongest when a program is widely recognized as reflecting a social consensus



that is supported by top political leaders and articulated in binding legislation or decrees. Whatever the form of expression, political authorities should establish a clear sense of the:

- strength of their political resolve,
- objectives of the program,
- lines of program authority,
- boundaries for program intervention,
- need for an open and transparent process for program design, and
- relationships with other relevant energy and non-energy policies.

### **3.2.1 Determining Boundaries of Authority and Responsibility**

For the sake of program effectiveness and economies of scale, governments may prefer to enact labels or standards in as large a market as possible. However, product markets often do not match political boundaries. The issues can be especially complex in federated states. The federal government may or may not have sufficient authority to regulate all types of commerce within its states or provinces. Below we provide three examples of the process of legislating labeling and standards setting in countries that each comprise a federation of states or provinces: Canada, Australia, and the U.S.

In Canada, federal jurisdiction over energy is limited to international and inter-provincial commerce. Thus, federal standards apply only to products imported into Canada and/or shipped between provinces and not to products manufactured and sold within a single province. Given the nature of the Canadian appliance and equipment market, federal jurisdiction is sufficient for an effective program. Standards apply to the vast majority of products sold in Canada.

In Australia, individual states and territories are responsible for legislation, regulation, and the associated administration. State-based legislation is necessary because the Australian constitution gives Australian states clear responsibility for management of resources, including energy. Thus, the role of the federal government has become to coordinate. Federal authorities assist in writing “model” legislation that the states and territories then “mirror.”

In the U.S., regulations enacted by individual states have been superseded by national regulations for most products. Manufacturers in the U.S. actually pushed for uniform regulation throughout the country so they would not be forced to offer different product lines in different states. Some economists have suggested that federal regulations are more economically efficient.

### **3.2.2 Enacting Framework Legislation or Decrees**

Political authority for standards should be grounded in a strong but flexible foundation. In most countries, this means enacting a framework law or issuing a decree that mandates standards for certain products, with provisions for expanding and revising the program later (European Community 1992). Framework legislation should be generic and comprehensive rather than piecemeal in nature. It is best

if it creates a legal basis and authority for developing labels and/or standards without specifying technical details related to specific products. In occasional cases—for example, where there exists a solid but possibly fleeting political consensus in support of standards—it may be advisable to act quickly and outline only the very basic framework of the program in the law itself, leaving all the technical details to a capable regulatory body. In other cases, such as where the political consensus is weak, it may be advisable to write technical details into the law to make them more enduring. Generally, the preferable strategy is to develop a generic framework that empowers a capable agency to develop the technical details.

By empowering an implementing agency to develop product-specific regulations at a later date, framework legislation avoids the necessity of a return to the legislative assembly to seek approval for each new regulation. This approach has two benefits: it passes responsibility for developing product-specific legislation to a body with technical competence, and it removes a potentially serious cause of delays that could greatly reduce program effectiveness. Framework legislation should identify the main stakeholders and define their roles, responsibilities, and obligations with respect to the law. It should also designate a government agency as the “implementing agency” and give this agency the authority to issue product-specific minimum efficiency standards (see Insert Box: *Framework Legislation*).

At the very least, framework legislation or decrees should provide:

- defined program objectives,
- authorized types of intervention (mandatory standards and/or voluntary targets),
- criteria for determining which products are covered,
- criteria for the level of technical intervention (based on consumer payback time, life-cycle costing criteria, or harmonization with trading partners),
- an envisioned implementation time frame,
- process rules and deadlines, and
- a requirement for an evaluation report on the program’s impact, including effects on manufacturers, consumers, and the nation.

In practice, the amount of technical detail (e.g., product categories, standards levels, implementation dates, revision schedules, etc.) specified in a law or decree is likely a matter of political strategy. Provisions such as the U.S. prohibition on standards that significantly impair product selection, product function, or national commerce can reassure concerned stakeholders.

### Framework Legislation

Two good examples of framework legislation are the European Union Directive establishing a framework on energy labeling (92/75/EC) and the U.S. National Appliance Energy Conservation Act (NAECA) of 1987, updated in 1988. The EU Directive gives authority to the European Commission to issue product-specific energy labels following approval from a national panel of appointed specialists. The NAECA legislation empowers and obligates the U.S. Department of Energy (DOE) to issue minimum energy-efficiency standards for energy-intensive tradable equipment when a specific set of criteria are met. For a fuller discussion of framework legislation see Waide 1998.

### 3.2.3 Maintaining Political Support for Program Development and Operation

Standards must evolve with products and their markets, and a coalition of manufacturers and other interested parties must be maintained to support effective implementation and operation of a program over time. Without such political support, opportunities could be missed for substantial energy savings and carbon-emission reductions. In addition, a standard that is too stringent or overly prescriptive can result in a manufacturer backlash and create an unintended obstruction to development of efficient products.

Standards should be revised and updated regularly. In many cases, this requires a great deal of analysis concerning the viability and cost effectiveness of standards. The revision process can itself be a source of controversy. For example, in the U.S., standards development was delayed for more than a year during 1995-96 because of stakeholder discontent with the process of standards revisions. It is necessary to establish a revision process that minimizes nonsubstantive issues of disagreement and allows full consideration of substantive issues. In the U.S. case, the program got back on track only after an extensive reform of the process gave stakeholders a say in each step of the revision process—from priority setting to final rule making (Turiel et al. 1996).

It is also important for policy makers to keep in mind the resources needed over many years for the development, maintenance, operation, and evaluation of a labeling or standards-setting program. Substantive negotiations on the technical details of standards cannot take place without quality technical data and analysis and periodic program evaluation. Well-designed framework laws or decrees and procedural rules cannot be followed if they are not accompanied by adequate funding.

## 3.3

### Step D-3: Consider Regional Harmonization

The third step in deciding whether or not to develop a labeling or standards-setting program is for policy makers to determine the extent to which they can rely on test facilities, test procedures, label designs, and standards that are already established by international organizations or in neighboring countries.

#### 3.3.1 Rationale for Harmonization

Most electrical products and appliances are subject to national standards that specify minimum safety and performance requirements. Because countries have different industrial or product standards, it is difficult and time consuming for a manufacturer or exporter to carry out the necessary tests and get customs approval to import a product into many different countries. Costly and time-consuming customs procedures amount to a non-tariff trade barrier.

“Harmonization” is commonly used in international trade negotiations—and in particular in the World Trade Organization (WTO)—to refer to the use of common standards, test procedures, import

tariffs, etc., designed to liberalize or facilitate international trade. In some regional organizations, such as the Asia-Pacific Economic Cooperation forum (APEC), the preferred term is “alignment.”

The goal of harmonization is to reduce non-tariff trade barriers by (IIEC 1999):

- simplifying and harmonizing customs procedures between countries;
- harmonizing test procedures, labels, and standards; and
- implementing mutual recognition agreements.

Below, we discuss the pros and cons of harmonization of test procedures, labels, and standards.

### **3.3.2 Harmonizing Test Procedures**

Many countries already have a government-backed institution to oversee the development of testing and certification procedures for industrial and consumer products. Typically, the mandate of these standards agencies is to certify the safety and performance of designated products. Safety and performance standards are usually adopted by a local technical committee and are aligned with international standards such as those developed by the International Standards Organization (ISO) or the International Electrotechnical Commission (IEC). For most products, safety and performance standards specify protocols for testing performance and mandate some minimum levels of safety and quality. Only occasionally do national standards include energy efficiency as a criterion. Each country must decide how to design a minimum energy standards program drawing on the resources and expertise of the existing standards agency, the national energy agency, and other qualified bodies.

It is beneficial for national test procedures to be harmonized as closely as possible with international test procedures. This means that international procedures should be adopted with few changes or exceptions to the original. The best international testing protocols cover many climate conditions and a broad range of operating conditions. Test results under harmonized protocols provide benchmarks for product comparisons. However, in some cases a country may adopt modified test conditions to better reflect the local operating environment for a product. In addition, some countries may require testing of product characteristics that are unrelated to energy use (e.g., noise level) to ensure that energy-efficiency gains are not achieved at the expense of poor product performance. Appliance energy testing is discussed in more detail in Chapter 4.

### **3.3.3 Harmonizing Labels**

Should policy makers harmonize their energy labels with those of other countries? The successful “harmonization” of the energy label among 15 countries and 10 languages of the EU shows that it is possible to devise a functional unified label that works across borders. Even slightly different labeling requirements among nations can be disruptive to trade and can ultimately limit choices and add to consumer costs. A regional labeling approach is appropriate if the marketplace, particularly for imported products, is more regional than national.

However, harmonizing labels may not be an important policy goal for every country. There is little reason for harmonizing labels unless a label used in one country or region would also be effective in other countries or regions (Harrington 1997). In fact, an effort to harmonize all information on energy labels among several countries could reduce the impact of the label in each country because the optimal design elements of an effective label may be different in different cultures; symbols or graphic elements that work in one country may not necessarily transfer to another. The best way for policy makers to design an effective label is to carry out consumer research in their country to determine which label design can be most readily understood and is most likely to influence consumers to purchase an energy-efficient product.

For smaller, developing countries with little or no manufacturing capacity for a particular product, harmonization could strengthen the national economy by fostering trade in a common regional market.

Table 3-1 below shows the advantages and disadvantages of harmonizing a label across countries.

<b>Advantages and Disadvantages of Harmonizing Energy Labels</b>	
<b>Advantages</b>	<b>Disadvantages</b>
International or regional market signals are clear, especially when discrete category labels are used.	Language differences require reprinting label text for many different countries.
Design costs among countries are reduced.	A single label may not be effective across political and cultural boundaries.
Printing costs are slightly reduced.	A “learning” curve among countries is unlikely because consumers only purchase in one country.
For small, culturally similar countries within a region, there may be economies of scale.	It is practical for manufacturers to apply a uniform energy label at the point of production if the destination markets all use the same language and the same label.

*Generally the advantages of harmonization outweigh the disadvantages.*

### 3.3.4 Harmonizing Energy-Efficiency Standards

If standards are to be adopted, careful consideration should be given to whether to harmonize the standards on a regional or international basis. A series of different standards applied in the same trading region can have a significantly disruptive effect on commerce for both native and importing industries. The benefits from harmonizing minimum energy-efficiency standards are important but may be secondary to the primary benefits of the standards themselves. Harmonization should not become the excuse for avoiding or delaying implementation of a labeling or standards-setting program.

Harmonization of mandatory rules limiting the sale of inefficient products requires expenditure of political capital. A developing country that is struggling economically may not find it practical to establish minimum energy-efficiency standards (MEES) that are aligned with the energy-efficiency standards of large developed nations such as Japan or the U.S. There are a number of reasons for this, including the following:

- there is likely to be a lack of energy-efficient products available in the developing country;
- the incremental cost of energy-efficient products is likely to be high relative to average income in the developing country; and
- tough energy-efficiency standards may hurt local industry and benefit importers of foreign products.

Still, harmonization of standards has often been found to be useful. The EU is harmonizing standards among its member countries. In connection with joining the EU, several central European countries (Hungary, Slovenia, the Czech Republic, and others) have adopted EU standards and directives concerning appliances. Small groups of neighboring countries of comparable economic status in Central or South America, Southeast Asia (the Association of Southeast Asian Nations, ASEAN), Africa, or the Middle East could benefit from a similar step. The economies of smaller developing countries with little or no manufacturing capacity for a particular product could be strengthened through harmonized standards that could foster trade in a common regional market.

### 3.3.5 Role of Mutual Recognition Agreements

Mutual recognition agreements (MRAs) simplify cross-border trade in products that must be tested and inspected. MRAs are:

multilateral arrangements between two or more economies to mutually recognize or accept some or all aspects of another's conformity test procedures such as test results and certification (IIEC 1999, Motoomull 1999, Rath 1999).

The APEC Electrical Mutual Recognition Agreement (MRA) is an example of an intergovernmental MRA that was established to facilitate trade in electrical products within the APEC region, which includes 22 countries in the Asia-Pacific basin. The MRA has three main components:

Part 1: information exchange agreement

Part 2: mutual recognition of test results

Part 3: mutual recognition of certification.

These are separate parts of the MRA, and a country can choose to sign onto just one part (e.g., information exchange) or all three. The MRA covers most electrical products but not telecommunications equipment, which will be covered under a separate APEC MRA. The Electrical MRA was completed in 1999. The current draft of the Electrical MRA covers safety and performance requirements but not energy-efficiency requirements.

The MRA will reduce the barriers to trade in energy-using products by reducing the need to test a product several times in order to import it into multiple countries. This MRA will facilitate trade in electrical products with other signatory countries because test results certified by an accredited laboratory in that country will be recognized by other signatory countries.

Broadly speaking, there are two types of MRAs:

### Intergovernmental MRAs

Intergovernmental MRAs are established between governments and cover products that are regulated by the government sector, such as electric appliances or telecommunications or food products. These agreements can be bilateral or multilateral. The recent trend has been toward multilateral MRAs, such as the APEC Electrical MRA, because forging agreements of this kind is much less time consuming than establishing separate, bilateral MRAs with a number of countries (see Insert Box: *APEC Electrical Mutual Recognition Agreement*, previous page).

### Technical MRAs

Technical MRAs establish technical equivalency between bodies in different countries. These types of agreements can cover laboratory accreditation agencies, inspection accreditation, and testing certification organizations. The key usefulness of technical MRAs for electrical products is that they facilitate testing by manufacturers because they can eliminate the need for retesting a product in a foreign country. For example, technical MRAs between European and U.S. laboratories allow the results from a European laboratory that tests a product according to a U.S. test procedure to be accepted in the U.S. without requiring retesting.

## 3.4

### Step D-4: Assess Data Needs

To optimize the design of a labeling and standards-setting program, it is necessary to gather, organize, and analyze a large number of diverse data. The fourth step in deciding whether or not to develop labeling and standards-setting programs is to assess the program's data needs and the capability of the government to acquire and manage that data.

The data needs are significant to support a sound, mandatory energy-performance standard that is economically and technically justified. This is one reason why consideration should be given to other types of standards and voluntary programs or to reliance on other standards programs in the region that have the effect of stimulating the manufacture and use of energy-efficient products. Even if a country is determined to proceed with mandatory standards, far fewer data are required to justify, for example, a simple standard that eliminates the 10 or 20% or even half of the products that are least energy efficient. Many more data are necessary to support the much more stringent energy standards regimes such as those in the U.S. or Europe, which are based on technological feasibility.

#### 3.4.1 Assessing Types of Data Needed for Analysis

The data needed for labels and standards development can be put into the broad categories of market, engineering, usage, behavioral, and ancillary data.

## Market data

General and specific market data are needed to assess potential program impacts and to optimize program design. These data should include the following:

- equipment annual sales volumes,
- sales prices,
- production volumes,
- import and export volumes,
- equipment distribution channels (including how the equipment is distributed from manufacturers and importers to retail outlets),
- retail-sector characteristics (including market shares by retail type and sector—e.g., electrical specialists/retailers, furniture or kitchen specialists, department stores, etc.; retail marketing strategies and niches; geographical spread; and typical profit margins), and
- manufacturing-sector characteristics (including information on competition; market shares; brands; parent groups and trade alliances; type of production—e.g., full production, final assembly only, etc.; type and quality of products produced; production capacities; component suppliers; distribution of production; costs of marketing, transportation, and vending; costs driven by regulatory policy; typical profit margins; research and development (R&D) levels; technical capabilities; access to high technology; and flexibility of the production process).

Most of the types of market data listed above would, ideally, be disaggregated into sales by equipment subcategories and efficiency levels. For example, for air conditioners, major subcategories of window-versus wall-type units might be further divided into split, multi-split, and cooling only, depending on the volumes of each type that are sold. The subcategories should also be grouped by size (e.g., cooling capacity), if possible. The most useful type of data would be historical time series and would continue to be gathered after a program is under way, for use in program evaluation.

## Engineering data

The goal of gathering engineering data should be to assemble a comprehensive database of summary technical and energy characteristics for individual product models available on the market. These data include:

- comprehensive technical descriptions of typical (baseline) products to conduct energy-engineering simulations for standards development (e.g., for some preselected, average-efficiency room air conditioners, this might include data on the compressor, accumulator geometry, evaporator coil, evaporator blower, refrigerant line, flow-control device, condenser coil, condenser fan, and operating temperatures and pressures), and
- component and material cost data to estimate life-cycle product costs associated with incremental design improvements to increase efficiency.



## Usage data

These data include:

- historical, annual time series of equipment ownership levels and energy use or energy efficiency, ideally broken down by equipment subcategories;
- demographic statistics such as the number of households, number and size of office buildings, distribution of occupants per building, socioeconomic characteristics of occupants, data about occupants by income level and region, typical occupancy patterns, etc.;
- existing equipment stock, including the rate of replacement and rate of acquisition (needed for forecasts of the equipment market and of energy consumption); and
- end-use measurements of how the equipment is used in practice, both nationally and in different climate regions (for climate-sensitive appliances), including energy consumption, power demand, and time and frequency of use (Sidler 1997).

## Behavioral data

These data include:

- attitudes of consumers and equipment users toward energy savings, purchasing decisions, label designs, environmental concerns, and product service;
- retailer attitudes toward and knowledge of energy efficiency in general, labeling, selling priorities, and consumer preferences;
- manufacturer attitudes concerning energy efficiency in general, energy labeling, specific label designs, product energy performance, and marketing priorities; and
- socioeconomic segmentation of equipment purchasers and users.

## Ancillary data

These data include:

- known and forecasted energy prices and tariffs;
- information on utility generation, transmission, and distribution, including capacities, demand, costs (peak and off peak), and the fuel mix;
- national energy statistics;
- national trade, economic, and employment statistics;
- direct and indirect environmental emissions;
- any additional environmental impacts of equipment production and usage; and
- comparative data on the effectiveness of alternative and complementary energy-efficiency programs.

It is not always possible to gather all of the data just listed. Prior to designing a program, officials should establish minimum data needs and prioritize the need for the remaining data. The intended use of the data needs to be clearly defined, and proxy data or reasonable assumptions should be used whenever specific data are not available.

### 3.4.2 Specifying the Data-Gathering Process

It can be very difficult to gather detailed, product-specific engineering and cost data from manufacturers and suppliers unless a high level of trust has been established between manufacturers and government. Manufacturers should be brought into the process from the outset through the formation of a stakeholder committee. The committee structure allows manufacturers to present their views and concerns and to “buy in” to the standards-setting process. In addition, the committee can facilitate the process of collecting data to analyze the impact of the labeling and standards-setting program.

There are a number of sources for the data needed:

- Stakeholders (parties who may have an interest in the required data, and should be the first point of contact), can be helpful in identifying a range of data sources including existing literature, reports, or market surveys when available.
- Industry organizations, such as trade, manufacturer, or retailer associations, will often have valuable market and product data that they may be prepared to share.
- Market research companies may be prepared to sell market data.
- Manufacturer catalogs can be good sources of model-specific technical data for statistical analyses.
- Long-established test laboratories often have model-specific data on product performance.
- Direct contact with manufacturers is the best way to gather detailed engineering data and data on production processes and manufacturing costs.
- Surveys and questionnaires can be used to gather behavioral data. Such data may already be available from local market research firms.
- Government ministries and information agencies and their publications are the best source of ancillary and demographic data. These agencies include census bureaus, national statistics bureaus, ministries of industry or energy information centers, customs departments, housing authorities, and electric or gas utilities.

### 3.4.3 Finding a Home for the Data

Policy makers should designate an institutional home for the data generated throughout the course of the program. In both industrialized and developing countries, an outside consultant is often contracted to collect and analyze the data. Both governments and funding agencies must recognize the need for skill transfer so that, when consultants complete their task, the local institution can maintain the database.

The local institution should not only store the data but also be capable of updating the database, providing useful and consistent analysis based on it, and making it available to third parties, such as academics who wish to use it for research and analysis.

## 3.5

### Step **D**-5: Select Products and Set Priorities

The fifth step in the process of deciding whether or not to develop labeling or standards-setting programs is to screen and select which types of products are the highest priorities for these programs. Every energy-consuming product—and some non-energy-using ones, such as windows and doors—is a candidate for labels and standards. In theory, there are no limitations on which products can be addressed by energy-efficiency regulations. However, energy-efficiency regulations require considerable financial and managerial resources, so it is only possible and practical to develop labels and standards for a limited number of products at a time. It is therefore necessary to establish priorities among a government's market transformation policy options and, within the labels and standards option, among products, based on which product regulations are likely to have the most impact. In practice, for reasons that will be explored here, both regulatory and non-regulatory energy-efficiency policies have focused on only a few products.

#### 3.5.1 Setting Screening Criteria

What are the main criteria for selecting products? The arguments for establishing product priorities are numerous; among the most well known are:

##### **Impact on total energy demand**

For each product considered, the total energy demand of the stock must be significant compared to the energy demand of the sector. Assessing the energy demand of a given end use may require a combination of market analysis, specific surveys, end-use metering, laboratory testing, and educated guesses. The problem may be to decide when the energy demand is significant for a given end use. To start with, any product whose stock represents more than 1% of total energy demand should be considered. In the context of mitigating greenhouse gas emissions, the amount of CO<sub>2</sub> emissions that result from the energy demand for a given stock of products is also a consideration.

##### **Level of ownership and turnover**

Energy-efficiency policy should focus on products that have a high level of market penetration and for which market penetration is rapidly increasing. The penetration of a given appliance is measured by the level of ownership, that is, the percentage of households that own and use the equipment in question. The rate of increase in ownership is also important.

In the current global market, the penetration of many new types of energy-consuming equipment, especially electronic or information technology products, is growing much faster than the penetration of traditional major appliances. Even though these electronic devices use less energy per unit than a

traditional household appliance, their proliferation has a significant impact on energy demand. However, for the new generation of electronic equipment, such as personal computers, the short useful life of the products makes it difficult for regulators to introduce minimum performance standards in a timely and meaningful way. Using personal computers as an example, we can see that it is difficult to assess the energy consumption of the next generation of processors when the technology is likely to change drastically within only one or two years. For these types of products, regulators may choose to establish minimum performance standards for some key components, such as the power supply, energy management of the display, or standby losses.

### **Potential for energy-efficiency improvement**

A specific research study may be required to determine the potential for energy-efficiency improvements in a product. In particular, it is necessary to understand the importance of both the design of the technology itself and the impact of user behavior on final energy consumption of an appliance. For instance, refrigeration appliances are excellent candidates for an energy-efficiency standard because they run constantly, there are numerous technical options to improve their efficiency, and the impact of user behavior on final energy consumption is smaller than for many other products. At the opposite extreme, the energy consumed by an electric iron is primarily dependent on individual user behavior, and the technology is simple, so irons are less promising candidates for energy-efficiency regulation.

### **Assessment of winners and losers**

The adoption of mandatory energy-efficiency labels and standards creates winners and losers. Some manufacturers will benefit, and some will be worse off. Some consumers will profit, and some will never recover added investments in energy-efficiency features. For both manufacturers and consumers, there will be a range of profitability and loss. (An example of the magnitude and extent of benefits and losses can be seen in Chapter 6.)

If especially stringent standards levels are anticipated, consideration should be given to the possibility that some manufacturers or consumers will be discontent. In general, the range of gain or loss for consumers is relative to normal purchase and operating costs. Regulators need to consider whether the regulations might cause any manufacturer to close a production plant, resulting in the loss of local jobs.

In some situations, it may be appropriate to consider measures to mitigate negative impacts of standards. For example, in extreme cases, increased welfare assistance might be appropriate in conjunction with a mandatory energy-efficiency standard for a basic appliance like refrigerators in order to ensure that those appliances are affordable in most households. Tax relief might be in order for manufacturers that are seriously adversely impacted by a particular standard.

### **Whether a product is covered by a test procedure**

The existence of a test procedure that establishes the performance, including energy consumption, of a given product greatly facilitates implementation of minimum performance standards. International

norms and test protocols are always preferable for developing minimum energy-performance standards. International test protocols, in both their form and application for safety, can be used as models for developing minimum energy-performance standards. Analysis of international norms for the safety of energy-consuming equipment can provide valuable insights into strategies for future energy-efficiency regulation.

For some products—new products and those that are used only in some regions—international test protocols may not exist. This is the case for rice cookers, for example, which have a high market penetration in some cultures where rice is a staple food. In cases like these, a test protocol must be designed with the goal of sound energy performance, not only when the product is in use but also when it is not performing its primary function—for example, while in standby mode.

### Existence of energy-efficiency regulations in other parts of the world

Many energy-consuming products are traded internationally. It is a good idea when proposing a new standard to at least consider adopting (or adapting) the applicable regulations from the exporting country. For example, minimum energy-efficiency standards for household refrigerators are in place in several parts of the world, including North America, Europe, Japan, and Australia. As a result, refrigerators are a priority candidate for an energy-efficiency regulation elsewhere. Policy makers can save time and resources and avoid having inefficient products dumped in their countries by examining existing regulations in other markets and adapting them to their own national markets. However, caution must be exercised in adapting existing regulations from other markets; consideration should be given to local user habits, power distribution infrastructure, and other influential factors.

### Existence of an energy-labeling scheme

Energy labeling may be the best precursor to the introduction of minimum performance standards. Manufacturers of appliances covered by an existing energy-labeling program are aware of the need to conserve energy and are in a better position than most manufacturers to recognize the impact of marketing products that consume less energy. They may also be better prepared to participate in negotiations to set minimum performance standards.

In Europe, voluntary energy performance targets have been established for both domestic clothes washers and dishwashers. These targets were based directly on the energy-efficiency rankings in the energy-labeling scheme and may eventually become mandatory minimum performance standards in Europe.

**Table 3-2** characterizes appliances into two tiers based on the priority for establishing minimum energy-performance standards for these products. The characterization is based on the international experience of the authors and reviewers. Actual priorities in any country will depend on local conditions (e.g., dishwashers may not be a priority in some developing countries because of very low market penetration). Specific results in any one country will also vary according to the prevalence and use of each appliance or product.

*Because most countries have the capacity to implement labels or standards for only a few products at a time, it is important to pick those that will have the highest impact first.*

**Table 3-2** A Sample Priority List of Appliances to be Covered by Minimum Energy-Efficiency Standards

**Top Candidates for Minimum Energy-Efficiency Standards**

- Domestic refrigerators, freezers, and combined refrigerator-freezer units
- Air conditioners
- Fluorescent lamp ballasts
- Fluorescent tube lamps
- Electric motors
- Washing machines, tumble dryers, and combined washer-dryer units
- Boilers
- Furnaces
- Storage water heaters
- Heat pumps
- Pumps
- Fans
- Television sets

**Second-Tier Candidates for Minimum Energy-Efficiency Standards**

- Cooking products (including stoves, rice cookers, and hot plates)
- Dishwashers
- Chillers
- Commercial refrigeration appliances
- Electricity distribution transformers
- Photocopiers
- Other lamps (compact fluorescent, incandescent, high-intensity discharge) and illumination and lighting systems for buildings
- Office equipment and new information technologies
- Standby power
- Peripheral equipment for television sets (videocassette recorders [VCRs], satellite antennae, decoders, set-top boxes)
- Personal computers
- Peripheral equipment for personal computers (printers, modems) (standby power)
- Radio sets, stereo equipment (standby power)
- Telephone apparatus, fax machines (standby power)
- Public illumination and lighting systems
- Lifts/elevators

### 3.5.2 Assessing Potential Costs and Impacts

During the screening process, analysts evaluate the likely energy savings, cost savings, and associated environmental benefits from developing standards and/or labeling. Products to be included in the program are screened and ranked in terms of cost effectiveness and potential for savings. The existence of national goals for total energy savings helps in this screening.

The basic steps in assessing the potential cost and impact of a standards or labeling program are:

- Develop a baseline model. The baseline represents the energy performance of a typical model for a given product (e.g., refrigerators) and is the starting point for the engineering analysis. Baseline characteristics determine what type of design modifications can be made to the product to improve its energy efficiency.
- Identify potential energy-efficiency improvements. This involves assessing the technical options available for improving the energy efficiency of each product.
- Estimate the cost of energy-efficiency improvements. Based on market research, the energy-efficiency improvements and extra manufacturing costs associated with each of the options can be calculated as in **Table 3-3**, and analysts can evaluate any associated increased manufacturing costs likely to be passed on to the customer through the supply chain (see Insert Box: *Cost Efficiency*). Alternatively, analysts can collect data on the cost and performance of existing units on the market, to determine a cost-efficiency relationship.
- Calculate the potential savings from energy-efficiency improvements. This involves estimating the energy savings from the energy-efficient design options for each product.
- Calculate cost effectiveness. This involves estimating the life-cycle costs and payback periods for different levels of minimum energy-efficiency standards or from a labeling program.

A baseline representing the amount of energy used by a product in the absence of labels and standards must be developed.

It is much easier to measure the savings potential for minimum energy-efficiency standards than for labeling. This is because minimum energy-efficiency standards remove all products with a lower-than-mandated energy-efficiency level from the market, which makes the savings calculation comparatively straightforward. Comparative labeling, however, affects all models on the market, so any net energy-efficiency changes associated with it are difficult to separate from ongoing market trends.

Once cost and energy-efficiency data have been collected, baseline energy-efficiency information is used to estimate how much energy will be saved if the average energy efficiency of all models is increased by a certain amount. Energy end-use forecasting models that accurately predict energy demand can be used for projecting policy impacts. In reality, however, detailed end-use data may not be readily available. In the absence of these data, simplified methods can be used to forecast the energy savings achievable through energy-efficiency standards. It is better to rely on simple forecasts based on limited but reliable

## Cost Efficiency

A cost-efficiency table is a method for deciding how to establish a level for minimum energy-efficiency standards. Table 3-3 is a real example from a recent analysis that was performed to establish minimum energy-performance standards for Thailand. The table begins with a row showing the annual electricity use of a baseline (“base case”) Thai refrigerator—255 kWh/year. It then shows the cost and energy-efficiency improvements associated with additional technical measures that can be taken to improve the refrigerator energy efficiency. Note that the first few measures are the most cost effective, with the highest benefit/cost ratios. Subsequent steps are still cost effective but have slightly lower benefit/cost ratios. Also, be aware that methodologies for more sophisticated analyses that account for variability among consumers and uncertainty in the data are available.

*A cost-efficiency table is a useful tool for establishing the appropriate level for a minimum energy-efficiency standard.*

**Table 3-3** Cost Efficiency of a Thai Refrigerator

Description	Annual kWh	Energy Saving (%)	Manufacturer Cost (Baht)	Retail Cost (%)	Benefit/Cost Ratio (see notes)	
					This Step	All Steps
Base case	255	N/A	N/A	N/A	N/A	N/A
1 Add 1 cm insulation to side walls	234	8.4	47	1.5	2.9	2.9
2 Add 1 additional cm to side walls (add 2 cm total, including Step 1)	227	11.1	94	3.0	1.1	2.3
3 Add 2 cm insulation to back walls (2 cm were added to side walls in Step 2)	216	15.3	137	4.4	1.9	2.1
4 Small “good” compressor: 52.9 kCal/hr, 0.92 COP* (replacing 58 kCal/hr, 0.89 COP compressor)	201	21.1	237	7.6	1.1	1.7
5 Add run capacitor to small compressor: COP=1.01	183	28.5	362	11.6	1.1	1.5
6 Improve door gasket design (reduce gasket heat loss by 25%)	171	32.9	442	14.2	1.1	1.4

Notes: • Baseline model is a 176-liter, 1-door, manual defrost refrigerator freezer.  
 • Each of the steps listed in this table is incremental to the previous step.  
 • The benefit/cost ratio is the ratio of the discounted net present values of the societal benefits to the societal costs.  
 \* COP = Coefficient of Performance

Source: ERM-Siam 1999, p. 2-19



data than on detailed forecasts from end-use models that are based on unreliable proxy data. An equipment stock model can organize product ownership and retirement data and use key demand drivers such as forecasts of the number of households and of household income. Such a model or spreadsheet can generate forecasts of equipment sales. In practice, crude sales forecasts are often made during the screening stage using simple spreadsheets.

The next steps in a thorough assessment are to:

- identify technical potential: the maximum technically achievable energy savings,
- estimate economic potential: the economically optimum energy savings from a product-user's (consumer's) perspective, and
- evaluate achievable potential: the practical, sustainable energy-savings potential, given market barriers and competing policies.

### Technical potential

An assessment of the technical potential for energy savings can be focused on the best theoretically conceivable design, the best design using conventional technologies, or the best design currently on the market (either national or international). These three reference points for focusing the measurement of technical potential offer different levels of possibility for the “maximum” technical savings potential and the time horizon in which this potential could be achieved. Typically a national and/or international statistical analysis can be used to compare the difference in energy-efficiency levels between currently available products and the reference energy-efficiency level. The magnitude of that difference can be translated into savings potentials by assuming that all new equipment sales are at the higher energy-efficiency level in the energy-forecast model or spreadsheet.

### Economic potential

The economic potential can be estimated in one of two ways. One method is to assume that labels and/or standards will achieve the greatest economic efficiency from the consumer perspective. This entails calculating the estimated incremental increase in product price against the expected reduction in the cost of operating the product for any given increase in the energy-efficiency level. In the absence of a thorough analysis, this estimation can be made in a rough way using market data on the correlation (if any) between product price and energy efficiency. Another method is to assume that the labels and/or standards will achieve the greatest economic efficiency from a societal perspective. This will be the case when the initial costs of the energy-efficiency improvements are less than the utility's cost of supplying energy over the life of a product.

### Achievable potential

Achievable potential is the analyst's best estimate of how much of the economic potential can be achieved in practice for a given product or program, based on experience with a similar program or product in another location or country. Achievable potential is less than economic potential because

Table 3-4

**Barriers to the Purchase of Efficient Products**

*What appear to be cost-effective investments in energy efficiency are often not made because of the presence of market and non-market barriers.*

**Market and Non-Market Barriers**

Higher first cost  
 Low energy price  
 Lack of awareness of energy efficiency  
 Lack of information about efficient products  
 Low priority for consumers  
 Low priority for manufacturers/retailers  
 Equipment purchased by third party  
 Lack of technology availability  
 Lack of government programs/support

of the presence of market and non-market barriers that will reduce the actual savings achieved. The most commonly cited barriers are listed in **Table 3-4**. The shortfall is generally less for mandatory programs than for voluntary ones.

**3.5.3 Planning for Phase-In, Evaluation, and Update**

Minimum energy-efficiency standards need to be periodically reviewed and raised as the overall energy efficiency of products on the market improves and new technical options become available. The method and amount by which any minimum energy-efficiency standard is increased will vary depending on the product.

Establishing a procedure for revisions will require input from the various stakeholder committees. It will require a discussion of methods for setting and adjusting minimum energy-efficiency standards levels as well as for accommodating industry feedback on time frames that can be reasonably met given other external pressures on manufacturers.

International experience has shown that the most effective minimum energy-efficiency standards regimes involve industry input in the establishment and periodic review/raising of minimum levels.

This chapter of the guidebook has discussed considerations that are useful in deciding whether or not to develop an energy-efficiency labeling or standards-setting program. Once the decision has been made, the next step is to establish test procedures and facilities. This subject is addressed in Chapter 4.



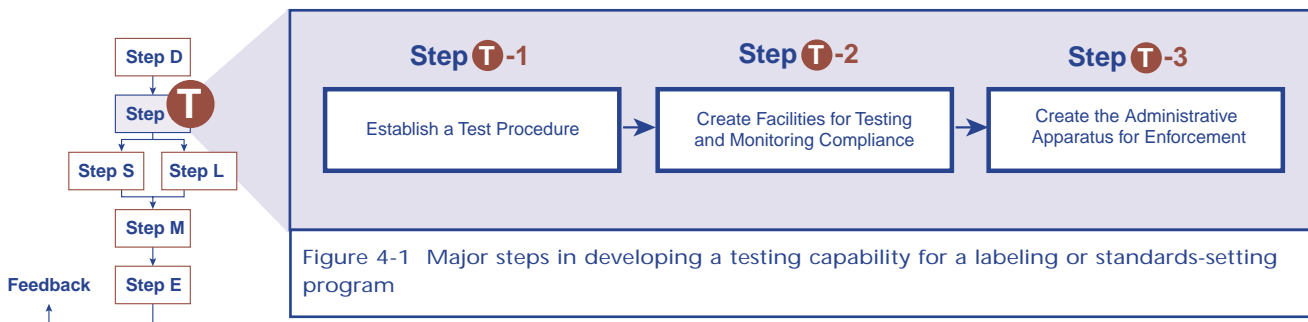
## 4. ENERGY TESTING FOR APPLIANCES

### Guidebook Prescriptions for Energy Testing

- 1 Begin adopting or establishing test procedures and facilities before standards and label regulations are enacted. Include a significant budget for meetings, testing, and foreign travel.
- 2 Don't even think about developing a labels or standards program without an independent test facility for ensuring compliance.
- 3 Ensure that test facilities are certified and will provide credible results.
- 4 Adopt internationally recognized test and capacity-measurement procedures whenever possible. If this is not possible, consider simplified versions of internationally recognized tests to lower the costs and technological obstacles to testing.
- 5 Make the procedures for reporting test results, preparing forms, and establishing a database of compliant units as simple and easy to access as possible.
- 6 Make the mechanism to request waivers, exceptions, or deviations from the test procedure when the test is not appropriate as simple and easy to access as possible.
- 7 Implement self-certification by manufacturers, if possible, to minimize the cost of a compliance program.

### 4.1 Energy Testing Infrastructure

The process of creating an energy testing capability must begin long before a labeling or standards-setting program is launched. The major steps in this process are shown in **Figure 4-1**.



This chapter explains what energy testing is and then describes the infrastructure needed to establish test procedures, test facilities, and testing compliance to support an energy-efficiency labeling or standards-setting program.

#### **4.1.1 Definition of an Energy Test Procedure**

An energy test procedure is an agreed-upon method of measuring the energy performance of an appliance. The results of an energy test procedure may be expressed as an efficiency, efficacy (for lighting products), annual energy use, or energy consumption for a specified cycle, depending on the appliance being tested. Worldwide, there are energy test procedures for all major energy-consuming household appliances.

The test procedure and the regulatory standard for an appliance are often lumped together, but they are very different. A regulatory standard establishes a level of minimum energy efficiency, while the test procedure describes the method used to measure the energy performance of the product. A regulatory standard typically references the appropriate test procedures.

#### **4.1.2 Importance of Test Procedures**

The primary purpose of an energy test procedure is to rank similar products by their energy performance. The same procedure is also used to evaluate new technologies and forecast their energy performance. When efficiency is the prime concern, there is often more to measuring energy performance than simply measuring energy use. This difference is important to keep in mind because the specification of performance constitutes one of the major philosophical differences in the various approaches to labels and standards around the world.

The test procedure (sometimes referred to as “test standard”) is the foundation for energy-efficiency standards, energy labels, and other related programs (Meier and Hill 1997). It provides manufacturers, regulatory authorities, and consumers a way of consistently comparing energy use and savings among different appliance models. A well-designed test procedure meets the needs of its users economically and with an acceptable level of accuracy and correspondence to actual conditions. By contrast, a poorly designed energy test procedure can undermine the effectiveness of everything built upon it. The adoption of established test procedures, especially those of internationally recognized testing organizations, makes it easy to compare the efficiency of different models.

#### **4.1.3 Elements of a Good Test Procedure**

In all cases, an ideal energy test procedure should:

- reflect actual usage conditions;
- yield repeatable, accurate results;
- reflect the relative performance of different design options for a given appliance;

- cover a wide range of models within a category;
- produce results that can be easily compared with results from other test procedures; and
- be inexpensive to perform.

Unfortunately, these goals usually conflict with each other. A test that tries to accurately duplicate actual usage will probably be expensive and not easily replicated. For example, most energy test procedures for room air conditioners measure efficiency while a unit is operating at steady-state at a specified outdoor temperature. This is a relatively easy mode to test after the test chamber has been created; efficiencies can be measured quickly and reliably. In practice, however, air conditioners operate mostly at part load or at a higher outdoor temperature, where the efficiency will typically be lower. Part-load performance is much more complicated to measure, and results are more difficult to duplicate reliably. Likewise, most energy test procedures measure energy efficiency at a single specified ambient air temperature. Testing at different ambient temperatures requires costly retesting and still fails to capture all the differences in ambient conditions. Testing to country-specific ambient temperatures makes it difficult to compare product performance across borders.

As a result, an energy test procedure is a compromise: it does not fully achieve any of the criteria for an ideal test, but it satisfies enough of them to discourage excessive complaints. At a minimum, a ranking of different models by their tested energy performance should correspond reasonably closely to a ranking by the models' field energy performance. This correspondence has been verified in only a few cases (Meier 1995).

Tested energy performance reflects an appliance's performance only as it leaves the factory. The tested energy performance therefore cannot account for what may occur during transport, installation, or operation. Central air conditioners, for example, require matching and connection of internal and external components. Mismatched components can seriously reduce efficiency. Less durable appliances may suffer more rapid degradation in performance. Policies, such as training for installers, must be used to address these issues.

## 4.2

### Step **T**-1: Establish a Test Procedure

The first step in developing an energy-efficiency standard or label is to establish energy test procedures for the products that are to have labels or be covered by standards. This step can and should begin even before the standards legislation has been approved. It will require a significant investment in technical analysis, including participation in meetings and foreign travel to observe test facilities and international standards committees in action. In most cases, test procedures already exist although they may not be formally recognized as established. Manufacturers frequently test their units for quality control and comparison with the competition. The fundamental choice for a government that is building an energy-efficiency labeling or standards program is whether to develop and achieve consensus on a unique domestic procedure or adopt an established international procedure. In considering this choice, governments will

want to review international test procedures, decide which existing test procedures to modify/use for measuring product energy efficiency or which new procedures to develop, assess the capacity for in-country and neighboring-country laboratories to test energy performance of priority products, and decide whether to expand existing test laboratories, construct new test laboratories, rely on laboratories in neighboring countries, or rely on private-sector laboratories.

#### 4.2.1 Key Institutions Responsible for Making Test Procedures

Test procedures are typically created by manufacturers' associations, government agencies, non-government organizations (NGOs), and professional societies. A partial list of the major institutions responsible for energy test procedures covering appliances is presented in **Table 4-1**. The two international entities responsible for appliance energy test procedures are the International Standards Organization (ISO) and its sister organization, the International Electrotechnical Commission (IEC). ISO mainly focuses on mechanical performance, and IEC mainly focuses on electrical performance. They rely on an interna-

**Table 4-1**

**Key Institutions Involved in Creating Energy Test Procedures for Appliances**

*A variety of institutions around the world are engaged in creating and harmonizing energy-efficiency test procedures.*

Institution	Acronym	URL
International Standards Organization	ISO	<a href="http://www.iso.ch">www.iso.ch</a>
International Electrotechnical Commission	IEC	<a href="http://www.iec.ch">www.iec.ch</a>
European Committee for Electrotechnical Standardization	CENELEC	<a href="http://www.cenelec.be">www.cenelec.be</a>
European Committee for Standardization	CEN	<a href="http://www.cenorm.be">www.cenorm.be</a>
Japan Industrial Standards Committee	JIS	<a href="http://www.jisc.org">www.jisc.org</a>
American National Standards Institute	ANSI	<a href="http://www.ansi.org">www.ansi.org</a>
Air-Conditioning and Refrigeration Institute	ARI	<a href="http://www.ari.org">www.ari.org</a>
American Society of Heating, Refrigerating, and Air-Conditioning Engineers	ASHRAE	<a href="http://www.ashrae.org">www.ashrae.org</a>
United States Department of Energy	U.S. DOE	<a href="http://www.eren.doe.gov/buildings/codes_standards">www.eren.doe.gov/buildings/codes_standards</a> <a href="http://www.access.gpo.gov/nara/cfr/index.html">www.access.gpo.gov/nara/cfr/index.html</a>
World Standards Services Network	WSSN	<a href="http://www.wssn.net">www.wssn.net</a>

tional network of regional and national standards organizations. In Europe, the European Committee for Standardization (CEN) and its sister organization, the European Committee for Electro-technical Standardization (CENELEC), are the regional equivalents of ISO and IEC, respectively. They have assumed responsibility for European Union-wide test procedures. In Japan, the Japan Industrial Standards Committee (JIS) is responsible for all appliance test procedures. In the U.S., the responsibility is spread among several organizations.

#### 4.2.2 Existing Test Procedures

All major appliances have at least one established energy test procedure, and most appliances have several. Refrigerators alone have at least five international or national energy test procedures (although this number is slowly declining as a result of harmonization). The general approach for each appliance is described in **Table 4-2** on the next page.

**Table 4-3** on page 61 is a partial list of test procedures that have international significance or recognition for major appliances. The same test procedure often has several different names because it is often adopted by several different standards organizations. For example, an IEC test standard may reference an identical CENELEC test standard. In addition, many test procedures refer to other test procedures for certain details of the testing process; thus, it is often necessary to obtain several documents to understand the full scope of a test. The exact citation often changes when a test procedure is updated or harmonized, so it is important to first determine the most current document before proceeding. A detailed and comprehensive description of current energy test procedures for appliances in the Asia-Pacific region is available in a recent Asia-Pacific Economic Cooperation (APEC) report (*Energy Efficient Strategies 1999*).

Energy test procedures for consumer home electronics, such as televisions, VCRs, and audio equipment, have only recently been developed. These are summarized in **Table 4-4** on page 61. A large portion of the total electricity consumed by these appliances is used in standby mode, so the focus of energy test procedures has largely been on standby electricity consumption rather than consumption in the “on” mode.

#### 4.2.3 The Difficulty of Modifying Existing Test Procedures

The steps to modify an energy test procedure are typically cumbersome and time-consuming. Most standards organizations are inherently conservative, so there must be strong pressure before a modification is considered and approved. Thus, standards-setting organizations are typically slow to modify test procedures in response to new technologies in appliances. Manufacturers (who play a major role in establishing international test procedures) also want to defend any technical advantage that a current test may afford them. When regulatory labeling and standards-setting programs are linked to test procedures, modifications become even more difficult to implement. Nevertheless, in cases where there is a consensus that rapid change is needed, such change is possible. For example, the Japanese government was able to significantly modify the test procedures for refrigerators in approximately one year so that these pro-



Table 4-2

**General Approach for Testing Energy Performance in Major Appliances**

*Each product requires its own test facility and general approach to testing.*

Appliance	Description of Energy Test Procedure
<b>Annual Energy Use</b>	
Domestic Refrigerator	Refrigerator is placed in environmental chamber with doors closed. Ambient temperature is slightly higher than room temperature to account for door openings and food loading (IEC and U.S.). In Japan, doors are opened at specified intervals.
Domestic Water Heater	Storage losses are measured under specified conditions. The energy required to service specified hot water draw cycle is sometimes added to this (U.S.).
<b>Efficiency or Efficacy</b>	
Room Air Conditioner	Air conditioner is placed in calorimeter chamber. Heat removal rate is measured under steady-state conditions and at only one level of humidity.
Central Air Conditioner	Heat removal rate is measured using a combined air enthalpy approach at one or more load conditions.
Heat Pump	Heat removal rate is measured using a combined air enthalpy approach at one or more load conditions.
Motor	Motor is placed on a dynamometer test stand and operated at full load and normal temperatures (U.S.). Alternatively, input power and losses are measured, and the difference is assumed to be the output (Japan and IEC).
Furnace/Boiler	Furnace or boiler is operated under steady-state conditions. Heat output is determined indirectly by measuring temperature and concentrations of combustion products. Fan and pump energy is sometimes added to input energy.
Light	Light output is measured in an integrating sphere. Light input is measured differently for each component, depending on type of light, ballast, and other features. Combination yields an efficacy.
<b>Energy Use per Cycle</b>	
Dishwasher	Energy consumption is measured for a standard cleaning cycle. Cleaning performance may also be included (IEC).
Clothes Washer	Energy consumption is measured for a standard cleaning cycle. Cleaning performance may also be included (IEC).

Table 4-3

Energy Test Procedures for Common Appliances

*Each product requires its own test procedures.*

Appliance	International	Japan	United States
Refrigerator/Freezer	Freezer ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers), and ISO 8561	JIS C 9607	Code of Federal Regulations (10 CFR Part 430 Subpart B Appendices A1 and B1)
Room Air Conditioner	ISO 5151-94( E)	JIS C9612-94	Code of Federal Regulations (10 CFR Part 430 Subpart B Appendix F)
Central Air Conditioner	ISO 13253	JIS B 8616-93	Code of Federal Regulations (10 CFR Part 430 Subpart B Appendix M)
Heat Pump	Treated as an air conditioner	Treated as an air conditioner	Treated as an air conditioner
Motor	IEC60034-2A	JIS C4210	National Electrical Manufacturers' Association (NEMA), MG 1-1987 (equivalent to Institute of Electrical and Electronics Engineers, (IEEE) 112)
Furnace/Boiler	Depends on fuel used	Depends on fuel used	Code of Federal Regulations (10 CFR Part 430 Subpart B Appendix N )
Water Heater	IEC60379	There is no explicit energy-efficiency test procedure.	Code of Federal Regulations (10 CFR Part 430 Subpart B Appendix E)
Light	There is no explicit energy-efficiency test procedure.		NEMA LE-5
Dishwasher	IEC60436-81	JIS C9606-93	Code of Federal Regulations (10 CFR Part 430 Subpart B Appendix C)
Clothes Washer	IEC60456-98		Code of Federal Regulations (10 CFR Part 430 Subpart B Appendix J)

Table 4-4

URLs for Energy Test Procedures for Consumer Home Appliances: Europe, Japan, U.S.

*Information is available in the EU, the U.S., and Japan regarding newly emerging test procedures for consumer home electronics.*

Appliance	Europe	Japan	United States
Television, Videocassette Recorder, Audio Equipment, Standby Power	<a href="http://www.gealabel.org">www.gealabel.org</a>	<a href="http://www.eccj.or.jp/index_e.html">www.eccj.or.jp/index_e.html</a>	<a href="http://www.epa.gov/energystar">www.epa.gov/energystar</a>

cedures would be in force in time for a new Japanese efficiency standard. This unusually rapid change was accomplished only because of close cooperation among the Japanese government, the manufacturers, and the standards association.

#### 4.2.4 The Difficulty of Translating Results from One Test to Another

Energy tests, whether for labels or standards, are expensive. The efficiency test for a gas-fired water heater costs about US\$1,000 per unit. One internationally recognized testing laboratory charges roughly US\$2,000 to perform the U.S. DOE test procedure on a single refrigerator and US\$6,000 for a central air-conditioning unit. The laboratory tests and administrative work needed to create an EU energy label for a clothes-washing machine cost about US\$3,800 (Sommer 1996). Because of the cost of testing, it is tempting to try to compare results from one test to those from another. This should generally be avoided, however, because test procedures often differ in important aspects, which leads to widely different energy values. For example, furnace and boiler efficiency tests in the EU are based on the fuel's "low heating value," that is, excluding the latent heat of condensation of the combustion gases. Tests in the U.S. typically use the "high heating value." This difference alone will cause at least a 5% difference in reported efficiency. Formulas for converting values from one test to another have been attempted but with little success (Meier 1987, Bansal and Krüger 1995). One exception may be motors. An algorithm has been prepared for translating motor test results from one protocol to another within specified margins of error (de Almeida 2000).

Tests sometimes differ in underlying philosophy as well as in method. European tests for washing machines seek to measure the energy required to achieve a standard level of cleaning performance. U.S. test procedures simply measure energy consumption for a standard cycle and let the manufacturer determine the level of cleaning performance. Performance tests, like those in Europe, are generally more complicated and expensive. These differences lead to significantly different test procedures.

#### 4.2.5 Selecting a Test Procedure

Creating an energy test procedure requires investments in a physical setup, including test facilities and trained technicians, as well as the resulting institutional investments in the administrative apparatus and in representation at technical meetings. A range of stakeholders, such as manufacturers, trade organizations, and government agencies, are involved in supporting these investments. The infrastructure will be different for each appliance depending on the level of sophistication and advancement of the industry, the extent of imports, and the choice of test procedure. Small or poor countries may be unable to support these costs and therefore may be obliged to accept internationally sanctioned test procedures from ISO and IEC. Countries with close economic ties to Japan, the EU, or the U.S. may find it convenient to harmonize with their strongest trade partner. If the U.S. is the strongest partner, it may be simpler to harmonize with the Canadian Standards Association (CSA) test procedures because CSA tests, although nearly identical to U.S. tests, are specified in *Système Internationale* (SI), or International System units. Harmonization has the advantage that a country can draw upon an existing test and an international network of testing facilities to reduce barriers against import and export of appliances. Local manufac-

turers planning for eventual foreign trade or multinational firms seeking to harmonize production facilities will support this approach.

By contrast, a country may be saddled with a test procedure that is unnecessarily complex or simply inappropriate for local conditions. Japan recently decided that the ISO test for refrigerators was not appropriate because the test ignores the impact of humidity and door openings; Japan replaced the ISO test with its own procedure. Particular costs imposed by certain tests also need to be considered. For example, some clothes washer and dishwasher tests require a standardized detergent. Special test materials are typically available from only one or two suppliers, at an inflated price. For example, the ISO refrigerator test requires the use of thermal mass with specific properties (to simulate food), which is available from only one supplier in Germany.

Modification of recognized international test protocols should be approached with caution. In addition to eliminating the potential for harmonizing test protocols with other regions, alterations introduce the need to statistically validate test repeatability and reproducibility. These changes increase the cost of developing the test protocol.

In making the decision whether to develop a unique domestic test procedure, adopt an established international procedure, or adopt a simplified version of an international test procedure, the criteria discussed in Section 4.1.3 must be considered. There must be strong reasons for not selecting an international test procedure, because a domestic procedure will take more time to develop and maintain than an international test procedure. Small countries, or those with a very small local appliance manufacturing base, should have extraordinary reasons not to adopt an internationally recognized standard before proceeding to develop their own. Countries with a large appliance manufacturing industry have more flexibility regarding local test procedures. One example is the case of Japan and washing machines. The ISO test procedure is strongly oriented toward hot-water washing. Japanese clothes-washing practices rely almost exclusively on ambient water temperatures (thanks to the presence of soft water throughout Japan). Because the efficiency of hot-water use is not relevant to Japan, Japan's tests emphasize motor efficiency over hot-water use. It is possible to harmonize some appliances' test procedures with international procedures while establishing local procedures for others. As conditions in the country change, the mix of local and international test procedures can also change.

Choosing a test procedure for a product being regulated may be especially difficult if several different tests are used by manufacturers in a country (perhaps because the manufacturers are local subsidiaries of companies from different countries that use different procedures). A trade association of manufacturers and the domestic standards association (the local counterpart to ISO) typically work together to establish a test procedure, but the government can also assemble its own advisory group and decide on a test procedure on its own. In the long run, however, some sort of technical review group will be required to enhance and/or legitimize in-house government expertise.

The process will generally be faster if an international test procedure is simply adopted than if a unique domestic procedure is established. The speed of adoption will also depend on the extent to which the

government decides to involve local manufacturers; the greater the involvement, the slower but more effective the process. The speed will also depend on the government's approach to certification and enforcement (discussed in Chapter 7). If a completely new test procedure is created, then it must be publicly announced and field tested, and staff must be trained to perform it. This process can easily take longer than one year. Staff training is particularly important because most of the tests will be conducted by manufacturers in their own facilities.

#### **4.2.6 Announcing the Test Procedure**

The final test procedure needs to be decided on and announced well in advance of the start date for efficiency labels or standards. Manufacturers need time to determine which models comply and then to retool as needed. In addition, manufacturers need time to equip and certify their own test facilities.

#### **4.2.7 Normalizing Energy Values for Volume, Capacity, and Performance**

Most energy measurements are normalized by volume or capacity or categorized by some other feature. These numbers typically become the “denominators” used in stating energy performance test results. Usually, separate test prescriptions define the way volume, capacity, illumination, performance, or other characteristics are to be uniformly measured. The details of these tests are as important as the test procedures themselves. For example, if manufacturers routinely overstate an appliance's capacity, they will misstate its apparent efficiency. Therefore, along with establishing the test procedure, it is beneficial to establish a procedure for measuring capacity.

#### **4.2.8 Reconciling Test Values and Declared Energy Consumption**

There is a natural variation in the energy efficiency of appliances as they come off the assembly line. For example, two air conditioners leaving the assembly line one week apart may differ in efficiency by as much as 5% depending on the degree of quality control in the manufacturing facility. This variation arises from minute differences in components, materials, and assembly. There must, therefore, be a procedure for converting measurements of individual appliances' energy performance into a value representing the entire production run (the “declared” energy consumption). The choice of procedure is important because it has a major impact on the cost of testing (that is, the number of units that need to be tested), the ability of the manufacturers to provide misleading (though technically legal) declared values, and the ease of enforcing energy standards.

Most testing includes a procedure to establish a declared energy consumption for an appliance. This typically involves randomly selecting two or more appliances after they leave the assembly line. The declared value is usually the mean of the measurements of these two units. However, if their test values differ by more than a certain amount (determined by a statistical formula), then additional units must be tested. Here is the current ISO procedure for refrigerators (ISO 1999):

If the energy consumption is stated by the manufacturer, the value measured in the energy-consumption test shall not be greater by more than 15% than the stated energy consumption.

If the result of the test carried out on the first appliance is greater than the declared value plus 15%, the test shall be carried out on a further three appliances.

If the three additional tests are required, the arithmetical mean of the energy-consumption values of these three appliances shall be equal to or less than the declared value plus 10%.

In practice, some manufacturers measure the energy performance of one unit and then declare the energy consumption to be 15% less than the measured value. This yields a declared energy consumption that, while clearly avoiding the intent of the procedure, remains legitimate. For this reason, the U.S. has narrowed the tolerance to 5% for many products.

#### 4.2.9 Emerging Issues in Energy Testing

Assuming that as new countries develop standards and/or labeling programs, at least a few of them will adopt international test procedures, it is important to recognize some of the emerging issues that will affect all energy test procedures, especially issues related to regulatory standards and energy labels.

Appliances are increasingly controlled by microprocessors linked to an array of sensors and controls. Microprocessor control offers many opportunities for energy savings, such as variable-speed drives in air conditioners, the ability to adjust a wash cycle based on a sensing of the extent of soiling in a clothes washer, or the ability to vary combustion conditions in a boiler based on demand. Savings of more than 30% are often easy to achieve with microprocessor controls, and test procedures should be changed to credit these savings.

However, the same technology also can be used to circumvent or defeat a test procedure. In some products, the microprocessor has been designed to sense when the appliance is being tested and, in response, switch to a special low-energy mode (Meier 1998). Several U.S. manufacturers of automobiles and diesel engines were caught using this strategy and were fined nearly \$1 billion. Eventually, all appliance energy test procedures will need to be revised to reflect the increasing use of microprocessor controls because the tests will need to assess both the mechanical components (the “hardware”) and the programming (the “software”) installed to operate the device. No standards-setting organization is currently preparing for this transformation. During the next decade each current test procedure is likely to enter a period of transition as this problem is confronted.

Also, the separation of energy test procedures and mandatory regulations is becoming less clear. One example of this situation arises in testing tolerances and energy labels. The European A-G energy-efficiency labeling scheme establishes separate tolerance categories that are less than 10% of total energy use. Because the ISO test procedure for refrigerators establishes a 15% tolerance in measurements, manufacturers have exploited the tolerance limit and claimed a “C” refrigerator to be an “A.” The existence of the European labeling system is putting pressure on ISO and IEC to require narrower tolerances (see Insert Box: *Compliance Monitoring in the EU*, Chapter 7, pages 140-141).

This example raises an intriguing question: can there be true internationally harmonized energy test procedures when there are local labels or standards? If the experience in the U.S.—a country with one of the longest histories of labels and standards—is any indication, then the answer is probably “no” for most products. The original test procedures developed by U.S. trade associations and professional societies could not be changed rapidly enough to accommodate new technologies. The U.S. DOE was forced to issue many alternative tests, waivers, and default values to accommodate those technological innovations. Over time, this set of waivers, alternative tests, and default values grew sufficiently broad to deserve being called the “DOE test.” A similar situation appears to be developing in the EU even though regulatory labels and standards are only a few years old.

4.3

Step **T**-2: Create Facilities for Testing and Monitoring Compliance

Test facilities are needed to perform energy tests. Almost every appliance requires a unique setup for an energy test. For example, a refrigerator requires an environmental chamber, and an air conditioner requires a calorimeter chamber. A list of some firms capable of performing internationally recognized energy tests along with an accompanying certification of results is presented in **Table 4-5**. The websites listed in the table describe the kinds of facilities and special features available. Most modern facilities can test several units at one time and collect all data on a data logger system. A country may decide to avoid developing its own test facility and use these kinds of facilities for occasional compliance testing (such as random tests) because such facilities are expensive to construct and maintain. A fully operational

Table 4-5

**Some Firms that Can Perform Internationally Recognized Energy Tests along with Accompanying Certification of Results**

*Many firms around the world are available to perform internationally recognized energy tests and certify the results.*

Name	Country	URL
Intertek Testing Service	U.S.	<a href="http://www.itsglobal.com">www.itsglobal.com</a>
Underwriters Laboratories, Inc.	U.S.	<a href="http://www.ul.com">www.ul.com</a>
CSA	Canada	<a href="http://www.csa.ca/english/product_services/ps_cert_energy.html">www.csa.ca/english/product_services/ps_cert_energy.html</a>
Korea Testing Laboratory	Korea	<a href="http://www.ktl.re.kr">www.ktl.re.kr</a>
Le Laboratoire Central des Industries Electriques (LCIE)	France	<a href="http://www.lcie.fr">www.lcie.fr</a>
Laboratoire National d'Essais (LNE)	France	<a href="http://www.lne.fr">www.lne.fr</a>

(i.e., turnkey) motor testing facility, for example, costs up to US\$100,000. A turnkey room air-conditioning test facility (a balanced calorimeter room) costs about US\$500,000 and requires at least two staff members to operate efficiently. A new turnkey facility capable of testing all major appliances (including motors and lights) costs many millions of dollars and requires at least 15 full-time staff members.

Most large, international appliance manufacturers maintain their own in-house test facilities to ensure that their units comply with energy regulations. They use energy tests not only to verify compliance but also as an element of quality control, prototype testing, and checking competitors' models. For these reasons, appliance testing most often occurs on these manufacturers' premises. Smaller manufacturers may rely on cruder test facilities with less precise results and contract with private, independent test laboratories when more precise measurements are needed.

A government that operates a labeling or standards-setting program must also have a facility that can perform reliable, unbiased energy tests. This independent facility can be either operated by the government or operated by a private firm. Few, if any, countries maintain government laboratories for large-scale appliance testing. Even the U.S. lacks a full-fledged, government-operated appliance test facility. Other national testing facilities, such as those in France, Australia, and Canada, perform private testing to defray the cost of maintaining the facilities. By contrast, in the Philippines, testing fees go back into the federal treasury instead of being reinvested in the facility, so it is difficult to maintain the facility's performance and capabilities (Egan et al. 1997). A preferred course of action is to reinvest the fees in the facility to help guarantee its long-term existence and value.

If energy testing is not widely practiced in a country, a government testing facility may be needed to stimulate improvements in the quality of private test facilities. One procedure is the "round-robin test," where several facilities test the same appliance and compare results to those obtained in the government facility. This process identifies incorrect procedures or equipment. Round-robin measurements have been conducted occasionally in Europe and the U.S. and have often revealed surprisingly large variations in measurement results. The Philippines has also used this strategy.

Energy tests, including setup and breakdown, take considerable time to perform. Room air conditioners require four to six hours. Refrigerators must be tested for a minimum of 24 hours, but most protocols require at least two tests to bracket the desired temperatures. Many tests, such as those for refrigerators and air conditioners, require time for the test facility and the appliance to reach steady-state conditions for at least an hour before the test may begin. These requirements severely restrict the ability of a test facility to rapidly test many units.

Regardless of who actually performs energy tests, the government must establish a procedure for monitoring compliance with labels or standards. The process must specify how test appliances are to be selected from the factory inventory or off the floor at appliance stores, the number of units to be tested, and who pays for the tests. This procedure can be aggressive, with a schedule of random testing, or activated only in response to complaints from consumer associations or from manufacturers. An aggressive policy



is advisable in the beginning so that manufacturers take seriously a standard or label procedure. Later, a complaint-triggered compliance check can be substituted. In the U.S., the standards program appears to have operated reasonably honestly with almost no government-initiated compliance monitoring. In Europe, the agreement between declared energy consumption values and test results improved after a compliance monitoring scheme was initiated (see Insert Box: *Compliance Monitoring in the EU*, Chapter 7, pages 140-141).

## 4.4

### Step **T** - 3: Create the Administrative Apparatus for Enforcement

Many of the administrative aspects of establishing and administering appliance efficiency labels and standards are discussed elsewhere in this guidebook. However, the administrative details specifically related to test procedures are discussed below.

#### 4.4.1 Establishing Administrative Mechanisms for Certification, Data Collection, and Appeal

The government must prepare forms, organize procedures for reporting test results, and establish a database of compliant units. These mechanisms must be in place before labels or standards become mandatory.

First, the government must select a procedure to certify test results. There are two options:

- the government tests the units and certifies the energy performance, or
- the government allows self-certification by manufacturers.

A self-certification procedure is generally superior because it is cheaper, faster, and relies on manufacturers' existing test facilities. For short periods, while the industry is in its infancy, it may make sense to have a higher-precision central test facility administer tests and charge manufacturers for this service. Manufacturers are often uncomfortable with government certification because they would rather keep the results secret until it is necessary to submit them. Over the long run, manufacturers will likely try to replace government certification with self-certification. A compliance monitoring procedure must accompany any self-certification to ensure that manufacturers submit accurate results to the government. This procedure should include a process for considering complaints from one manufacturer about another or from consumer associations. Japanese consumer organizations, for example, were instrumental in causing Japanese energy test procedures to be modified, and various European consumer organizations have exerted considerable pressure on European manufacturers to honestly report energy efficiency.

No test procedure can cover 100% of the products that must conform to a label or standard requirement because new technologies or special features appear faster than tests can be modified to accommodate them. It is therefore essential to develop a flexible, intelligent, and rapid mechanism for administering

enforcement and waivers. A process must be available to address the small percentage of the products that cannot be tested with the recognized test. A manufacturer may be prevented from offering an inefficient product but should not be prevented from offering a product because the product cannot be tested.

#### **4.4.2 Establishing Procedures to Certify Independent and Manufacturer Test Facilities**

The government must also create a procedure to ensure that testing facilities correctly perform tests with properly calibrated equipment. The procedures for conformity certification, often called accreditation, are well documented by international standards organizations (Breitenberg 1997). As mentioned earlier, an important aspect in less developed countries will be staff training, including regular testing using round-robin measurements.

No matter which aspect of energy testing is being addressed—establishing a test procedure, creating a test facility, or creating the administrative apparatus for enforcement—it is important to remember that all of these elements should be addressed as early as possible in the process of developing labeling and standards-setting programs. An early start ensures time for proper technical analysis, observation of international test facilities, and review of existing international test procedures. After a testing capability is developed, the next step is to design and implement a labeling program, to analyze and set standards, or both, depending on the overall program. The development of a labeling program is described in Chapter 5; standards-setting is described in Chapter 6.





## 5. DESIGNING AND IMPLEMENTING A LABELING PROGRAM

### Guidebook Prescriptions for Designing Labels

- 1 Decide early which products warrant labeling and whether the program will be mandatory or voluntary.
- 2 Work closely with stakeholders. Elicit broad support from manufacturers and retailers during design of the program.
- 3 Develop a program for testing appliances using either accredited domestic, regional, or international test laboratories. Specify energy- and non-energy-performance tests as well as rules to establish label categories and define tolerances. Consider using international or regional test procedures.
- 4 Develop a system for certifying label testing and registration for each product.
- 5 Conduct some consumer research prior to implementing a labeling program. Use this research as the basis for designing an effective label.
- 6 Use a consistent label format for all product types to make it easier for consumers to understand the label, which will increase its overall effectiveness as a policy measure.
- 7 Budget resources for ongoing program promotion and marketing, policing and enforcement, and updates of test procedures and new technologies on the market.
- 8 Develop an evaluation plan at the beginning of the program. Collect both process and impact data. Use the results to improve the program.

### 5.1

#### The Basics of Energy Labeling

This chapter addresses a range of issues that should be considered when designing an energy-labeling program for appliances, equipment, or lighting products. It also describes the steps to be taken in implementing such programs. Although we do not address building products that do not directly consume energy, such as windows, much of the material in this chapter could apply to the development of labeling programs for these types of products as well. Labels that go beyond individual products and describe the energy consumption of whole buildings and industrial systems are beyond the scope of this guidebook.

### 5.1.1 Why Energy Labeling?

The goal of an energy-labeling program should be to encourage consumers to purchase the appliance that provides the services they need, using the least possible energy.

Helping consumers use less energy is the most obvious goal of an energy-labeling program. However, it is important that the service provided by the appliance that consumes the energy also be a focus of the program. Energy service is the benefit that a consumer or user receives as the output from an appliance or piece of equipment—for example, comfort, food preservation, clean and dry clothes, cooked food, or light for working. Together, energy use and energy service define the energy efficiency of a product—that is, energy service output per unit of energy input.

The energy efficiency of an appliance is an invisible attribute. Without a credible energy label, a consumer looking at an appliance can tell little or nothing about its energy efficiency. Yet energy consumption determines the operating cost of most appliances and is therefore of concern to the consumer. Consumers are sometimes aware of basic details about a product, such as wattage, and act on that information—for example, by buying 18W compact fluorescent light bulbs instead of 60W incandescent ones. But wattage is no substitute for the information an energy-labeling program provides—information that would not otherwise be available to consumers.

Energy labeling of appliances, equipment, and lighting products helps improve overall energy efficiency. The first evaluation of the impact of the recent EU labeling scheme for refrigeration appliances, washing machines, and lamps, for example, shows a measurable shift toward sales of the more efficient appliances. The sales-weighted average energy efficiency of refrigeration appliances improved by 29% between 1992 and late 1999. It is estimated that 16% of the impact is due to minimum efficiency standards and 10% is due to the impact of labeling (Bertoldi 2000).

### 5.1.2 How Energy Labels Affect Both Consumers and Manufacturers

An energy label works in three main ways. The label:

- provides consumers with data on which to base informed choices (to select the most efficient and suitable product available),
- encourages manufacturers to improve the energy performance of their models, and
- encourages distributors and retailers to stock and display efficient products.

On the consumer side, energy labels promote the purchase of efficient models. Energy labels provide consumers with information that would otherwise be unavailable and allows them to factor operating costs and energy use into the decision-making process. Even policy makers who oppose government regulation tend to support energy-labeling programs because such programs provide a public good, namely information for consumers, so markets can operate more efficiently.

On the manufacturing and distribution side, labels may have even more impact than on the consumer side. Once a label is seen as having an actual or potential consumer impact, manufacturers tend to (though don't always) respond by removing their worst models from the market and improving the efficiency of their current models. The authors have observed, for example, that many new products being produced in the EU are being designed to barely meet the threshold for one of the higher-efficiency categories. Distributors and retailers also tend to change what products they stock and display in response to labels. These changes result in an improved average efficiency of all products available on the market—not just those sought by energy-aware consumers. The regulatory aspects of an energy-labeling program are relatively non-intrusive, usually requiring that information be presented in a standardized format and that manufacturer claims be accurate.

Energy labels serve an additional purpose: they can provide information and a target that many other energy-efficiency programs will seek to meet or beat. These other programs include utility incentive programs, government procurement efficiency specifications, and building energy codes. These effects of energy-efficiency labels are discussed in Chapter 9.

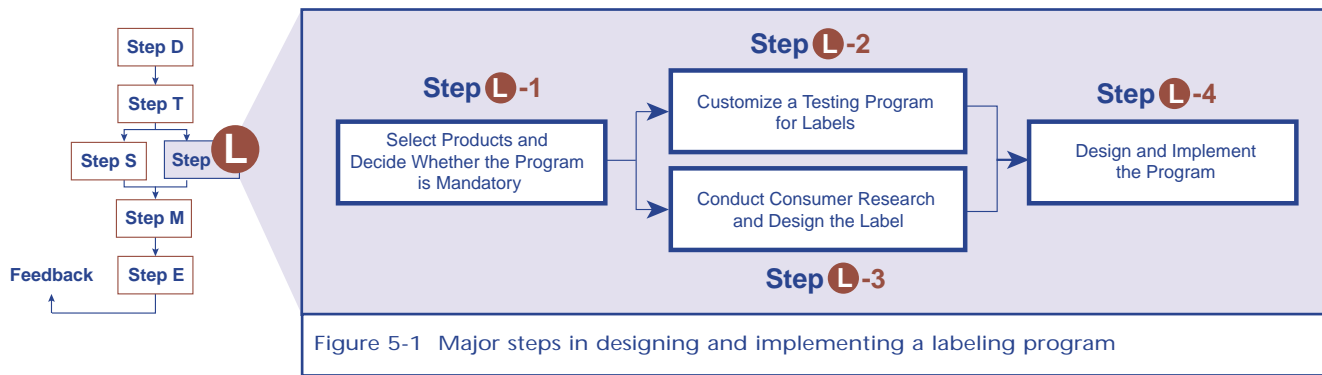
### 5.1.3 Elements of a Labeling Program

From a consumer's perspective, the energy label itself is the most important and most obvious element of an energy-labeling program. The label design is critical because it must convey information in a way that is easy to understand and assists the consumer with purchase decisions.

However, the energy label that appears on a product is only the first part of a more elaborate infrastructure of elements and activities that form the foundation of an energy-labeling program. Although consumers may not be aware of many of these elements, the infrastructure is critical to the program's success and must be carefully planned, implemented, and maintained to ensure that the program is effective. Elements required to develop an energy-labeling program include:

- Initial program decisions. Decide which products should be labeled and whether the labeling program should be voluntary or mandatory.
- Product testing. Establish test laboratories; agree on test protocols, reporting, and registration procedures.
- Label and program design. Conduct consumer research, design label format, agree on technical issues such as establishing category boundaries and tolerance limits.
- Implementation. Market and promote the program, monitor and enforce compliance, update test procedures, evaluate regularly to improve program design.

These steps in developing a labeling program are shown in **Figure 5-1** and described in the sections that follow.



## 5.2

### Step L-1: Select Products and Decide Whether the Program is Mandatory

#### 5.2.1 Which Products Should Be Labeled?

Before a labeling program can be designed, policy makers need to decide which products should be included in the program.

As a general rule, energy labeling will work best for products:

- that use a significant amount of energy,
- that are present in most households (or where rapid growth is predicted),
- for which energy-efficient technology exists that is not being used in most products on the market,
- for which the purchaser pays the energy bills,
- that are purchased by the owner at a retail business (i.e., where the owner inspects items prior to purchase), and
- for which there is (or could easily be) significant variation in the energy efficiency of different units.

If one or more of these conditions are not met, then the effectiveness of energy labeling may be diminished. For products that do not meet these conditions, policy makers should explore alternative program measures.

For some product types, energy-efficiency standards, rather than labeling, may be the best alternative. This is especially true for products like water heaters and central air conditioners that are generally purchased by a third party (i.e., the purchaser does not pay the energy bills). For other products, such as refrigerators, energy-efficiency standards and labels work best together.

There will always be an element of the market that is “energy label resistant.” Many consumers are uninterested in energy use and will ignore the message provided by labels. Still, an energy-labeling

program can achieve significant energy savings even when a large number of consumers ignore the information on the labels.

### 5.2.2 Mandatory or Voluntary?

Once the products for the labeling program have been chosen, policy makers must decide whether the program should be mandatory or voluntary. Although several countries have implemented voluntary energy-labeling programs, experience suggests that, as a rule, mandatory programs work best. The reason is that manufacturers with poor energy ratings tend not to declare the energy consumption of their products under a voluntary program. If products with a poor energy rating have no labels, some consumers who might avoid these products if they had all the information will end up buying them. Ultimately, labeling programs work best if all products are labeled and if consumers can easily distinguish between poor-, average-, higher-, and highest-efficiency products.

## 5.3

### Step L-2: Customize a Testing Program for Labels

A labeling program is unlikely to be effective unless a testing program is in place. Initiating a testing program requires access to competent testing laboratories, either government-owned or in the private sector. Testing laboratories should be accredited and/or certified to ensure accuracy and confidence in the test results. The results of initial testing of a sample of products can be used to:

- characterize the efficiency of the market,
- estimate the potential savings from the labeling program,
- serve as the basis for developing the label categories, and
- provide the energy-performance results used to label each product.

#### 5.3.1 Design of the Testing Program

The design of the testing program for any given product should include the following three essential elements:

- **Energy consumption.** A description of the test that must be performed on the product to yield a valid energy consumption value that will be shown on the energy label. For example, the test might specify energy use per day, per hour, per month, or per cycle.
- **Performance.** A description of other measurements or separate tests that must be performed to establish the product's capacity (e.g., kW cooling capacity for air conditioners, liters internal volume for refrigerators) or function/performance (e.g., a washing and drying index for dishwashers).
- **Tolerance.** Rules specified by regulators to ensure that values reported by tests are within acceptable error bands and to provide for retesting and resolving any apparent differences in results.



The label design and layout described in Section 5.4 significantly affect the tests that can be usefully performed. The tests must verify all the important information on the label. In parallel with the testing program, specifications should be developed for the energy label (size, color, typefaces etc.), how the energy consumption information for a specific model will be presented on the label (e.g., how to calculate and indicate the category or relative energy use), and how the label will be placed on products.

Energy-test procedures are a critical underpinning for all energy programs that seek to measure and improve the energy efficiency of appliances and equipment (Meier 1997, Meier 1998). Test facilities, test procedures, and the basic elements of a testing program are discussed in Chapter 4.

There is a range of approaches to publishing the rules mentioned above. Some tests and rules may be published as formal standards by a country's standards-setting agency or by an international agency such as the International Standards Organization (ISO) or International Electrotechnical Commission (IEC). Alternatively, lawmakers in any country may publish all energy-related requirements—from the test procedure to the requirements for energy labeling—in an official government regulation. Or they may include little technical information in regulations and instead publish the technical requirements for testing and the regulatory requirements for labeling in local technical standards (which can be issued by the government's standards body).

In practice, there is a continuum between these approaches, and the approach differs in every country. Experience suggests that if large volumes of technical requirements are embedded within regulations, then these requirements can be difficult to change and keep up to date. The other problem with the extensive reliance on regulations is that often the people responsible for writing regulations, usually lawyers, are not experts in energy efficiency, so drafting errors can be common unless the text is verified carefully.

There are also cases in which a number of states, provinces, or countries have separate laws and regulations but are implementing a common labeling program (e.g., the Australian states, Canadian provinces, and European countries). In cases like these, it is preferable to have technical requirements referenced to a single source (e.g., a national or international standard) rather than replicating copies of the requirements in numerous separate acts or in local legislation.

### 5.3.2 Registration and Test Reports

There is a range of varying requirements for the certification of test results. Often, but not always, certification involves some form of registration or filing of test reports. Many countries, including Europe, the U.S., and Australia, allow manufacturers to self-certify their products. The cost of the testing and certification program depends directly on how stringent the process is. Self-certification only works, however, if the regulatory agency can effectively police compliance. In any case, the total costs associated with product testing for an energy-labeling program are relatively small in comparison to the total costs of product production, although the cost of testing for products exported to multiple countries with differing test requirements can significantly reduce manufacturers' profit margins.

In some countries (e.g., in Australia and the U.S.), manufacturers have to submit test reports for approval of an energy label. These reports are usually submitted as part of the process of product registration. An alternative approach, used by the EU, is to require manufacturers to retain copies of the formal test reports until manufacturing of the model has ceased (or, more commonly, for a period of some years after manufacturing has ceased). The manufacturer is usually required to produce these test reports only if there is a question regarding the validity of the label claims. Although this approach reduces the governmental administrative costs associated with the program, it makes verifying declared performance difficult. It also may make it difficult to track products on the market and to monitor the compliance and accuracy of the information on labeled products.

### 5.3.3 Harmonizing Labels among Neighboring Countries

Energy labels should be designed to provide consumers with a comparative measure of energy efficiency. Where products are compared using a category-type rating scale, such as stars, numbers or letters, algorithms for energy efficiency need to be tailored to regional or national markets based on currently available products and the local test procedure used to determine energy consumption. Although in many ways it is difficult, if not impossible, to translate current energy rating systems from one country to another, the benefits can be large. Often, mutual recognition agreements (MRAs, see Section 3.3) are useful. A common harmonized test procedure and a universal efficiency categorization scheme are worth pursuing to facilitate trade and reduce the cost of regulation.

The design of the energy label does not need to be harmonized. In fact, customization that accounts for local cultural differences is generally believed to be beneficial for facilitating communication and maximizing consumer understanding. For example, reversing the image of the European-style label for use in countries where language is read from right to left, as was done in Iran, is important. It is also likely that maintaining some common design themes within trading regions is worthwhile to facilitate general association and recognition among labels in neighboring countries.

One scheme for harmonizing the energy label internationally is a system where manufacturers would provide a data label with each unit that gives the product's trademark and basic energy-efficiency numbers. Retailers could apply country-specific energy labels to showroom units, and the data label from the manufacturer could be added to the energy label. The energy label would interpret the data on the data label in the language of the country where the product was being sold. This way, individual manufacturers would not have to print an energy label for each unit sent to each country. This system is used in the EU. For this system to work efficiently, test procedures and the data label must be harmonized internationally.

## 5.4

### Step **L**-3: Conduct Consumer Research and Design the Label

The label design is what consumers actually see when they go to purchase an appliance. Although the details of energy labels for different products may differ slightly, it is important to keep a consistent label

style and format across product types. This makes it easy for consumers, who can learn to understand one type of label to evaluate different products. The sections that follow show how policy makers can draw on consumer research and international experience with labeling programs to design as effective a label as possible.

### 5.4.1 Deciding on the Type of Label

One of the first steps in label design is to decide what type of energy label to use. Broadly speaking, there are three kinds of energy labels in use around the world (Egan 1999, Harris and McCabe 1996):

- endorsement labels,
- comparison labels, and
- information-only labels.

#### Endorsement labels

Endorsement labels essentially offer a “seal of approval” that a product meets certain pre-specified criteria. They generally are based on a “yes-no” cutoff and offer little additional information. One example of an endorsement label for energy efficiency is the ENERGY STAR® label in the U.S. The first national energy-efficiency endorsement label was the U.S. Environmental Protection Agency (EPA) Green Lights label. Subsequently, the ENERGY STAR® label was applied to computers that have energy-saving features. The EPA/DOE ENERGY STAR® label’s use in the U.S. has now expanded to cover heating, ventilation, and air-conditioning equipment; office equipment; consumer electronics; transformers; lighting and windows; insulation; and some home appliances. The Power Smart label was developed similarly by a Canadian utility to apply to a range of electrical products. Typically, endorsement labels are applied to the top tier of efficient products in a market. Another type of endorsement label is the “eco label.” Eco labels indicate that a product or process has superior environmental performance or a minimal environmental impact. Eco-labeling programs are being implemented by a number of governments and NGOs in countries around the world. Some eco-labeling programs include energy efficiency as one component in the label rating scheme, but it is rarely the primary factor in the rating (see Insert Box: *The ENERGY STAR® Program*).

#### Comparative labels

Comparative labels allow consumers to compare energy use among all available models in order to make an informed choice. Two subcategories of comparative labels have been developed around the world: one uses a categorical ranking system; the other uses a continuous scale or bar graph to show relative energy use.

**Categorical**—Categorical labels use a ranking system that allows consumers to tell how energy efficient a model is compared to other models on the market. The label may or may not also contain detailed information on the operating characteristics, costs, and energy use of the models. The main

ENERGY STAR® is a voluntary partnership among the U.S. DOE, the U.S. EPA, product manufacturers, local utilities, and retailers to promote energy-efficient products that qualify for the ENERGY STAR® label. The program was created to educate consumers about energy-efficient products and help them save money and energy while improving the environment through reducing the air pollution and CO<sub>2</sub> emissions associated with energy production.

Since its launch in 1992, the ENERGY STAR® label has become a national, consumer-oriented symbol for energy efficiency. The power of the ENERGY STAR® labeling model results from the fact that it provides a flexible foundation on which many key partners can develop their own individual initiatives. Manufacturers, utilities, retailers, and other organizations that promote energy efficiency have developed efforts around the ENERGY STAR® brand. The impact of each of these individual efforts is magnified by each one's association with the national ENERGY STAR® brand effort. Partners' efforts, along with those of EPA and DOE, related to program development, consumer education, and public recognition of partners' accomplishments blend together to advance a national strategy.

To date, the program has labeled more than 31 product types, including household appliances, compact fluorescent light bulbs, exit signs, consumer electronics (televisions, audio systems, etc.), computers and other office equipment, residential heating and cooling equipment, windows, residential lighting fixtures, utility and customer-owned distribution transformers, roof products, and insulation. Other product labels are still under development. Twenty-five retail partners with more than 4,600 storefronts participate, as do utilities and state administrators that service 60% of American households. For more information, visit [www.energystar.gov](http://www.energystar.gov).

International agreements with Europe, Japan, and other countries promote use of the ENERGY STAR® label in the increasingly global market for office equipment. Although the labeling program initially targeted individual consumers, EPA and DOE have also begun to work with government, corporate, and institutional buyers through the ENERGY STAR® Purchasing Program. A free Purchasing Toolkit as well as on-line information ([www.epa.gov/appdstar/purchasing/](http://www.epa.gov/appdstar/purchasing/)) provide purchasing specifications and software to help buyers estimate their energy and cost savings. See the end of this chapter for a sample ENERGY STAR® label.

emphasis is on establishing clear categories, so a consumer can easily tell, by looking at a single label, how energy efficient a product is relative to others on the market.

**Continuous Scale**—Continuous scale labels provide comparative information that allows consumers to see where the labeled unit fits into the full range of similar models without sorting performance into specific categories.

### Information-only

Information-only labels provide data on the technical performance of the labeled product but offer no simple way (such as a ranking system) to compare energy performance among products. These types of labels contain purely technical information and are generally not considered to be very consumer friendly.

The choice of which label type to use is not always easy. It certainly depends on local consumer knowledge and attitudes. Endorsement labels require the least thinking by the consumer but also provide the least information. If they are well publicized, they may resonate with environmental sympathies and be quite effective, at least with a segment of consumers. Categorical comparison labels provide more information about energy use and, if well designed and implemented, can provide a consistent basis for buyers to focus on energy efficiency from one purchase to another, across or within equipment categories. Furthermore, they can provide a clear basis for other market-transforming programs such as the utility demand-side management incentives discussed in Chapter 9. Continuous comparison labels can transmit more detailed information on relative energy use, but research has shown that this label format may be difficult for consumers to understand (du Pont 1998, Egan 2000). Information-only labels are generally effective only for the most educated and economically and/or environmentally concerned consumers. They do not allow easy comparison with other models in the marketplace.

#### 5.4.2 Conducting Consumer Research for Label Design

One of the best ways to make sure that an appliance efficiency label will communicate effectively with consumers and will be embraced by policy makers and manufacturers is to incorporate market research into its development. Consumer research can determine how understandable the label is and point out what appeals to and persuades consumers. In addition, sharing research with government and industry officials will acquaint them with consumer preferences and foster buy-in of a label design that is effective for consumers.

Market research can take a number of forms and can be extensive or modest. However, the important idea behind this research is that it encourages a wide set of views to be included in the label development process. It also assures that some level of agreement about the “best” label design will be forged. Given that a good deal of money will likely be spent to develop, implement, and evaluate a labeling program, market research is a small investment to help ensure the program’s success.

The best market research approaches are likely to vary somewhat from country to country, and it would be good for those developing efficiency labels to consult with local market research experts to understand the methods available. In general, however, two major types of market research are available:

- Secondary research analyzes and applies the results of past market research to the current situation. Insights from secondary research can be a substitute for gathering new information and can help inform primary research efforts. However, given that label preferences may be quite subjective and may change across cultures, it is important to make sure that the secondary research is valid for the current context.

## Research in India

To understand India's diverse consumers and to develop an appliance efficiency label that would attract, persuade, and communicate clearly to consumers, USAID/India sponsored a three-phase, two-year consumer research project. Phase I, a baseline survey, set the stage for many decisions that followed, including whether or not label development should proceed. In-home interviews with 1,833 urban consumers in six major cities revealed that:

- because of their penetration and brand homogeneity, refrigerators would be the best appliance for initial standards and labeling;
- consumers could be reached through a labeling regime and would respond very positively to such a regime;
- the label design needed to appeal to both men and women because both were involved in buying decisions;
- consumers did not connect energy efficiency to appliance purchases even though energy issues (e.g., shortages, quality) were of high concern to many consumers;
- for the labeling program to be effective, a strong marketing/information campaign would need to be coupled to it; and
- program planning should address consumers' distrust of appliance salespeople and resulting heavy reliance on manufacturers and word of mouth in appliance purchase decisions.

Phase 2 convened 10 qualitative consumer focus groups to test 17 label designs constructed from existing successful label formats elsewhere, using design elements meant to appeal to Indian consumers. Consumers reviewed the options and selected the ones they found most understandable, appealing, and persuasive. The groups also "constructed their own favorite label" from the individual label elements. Despite the many label formats and elements, much consensus emerged. Consumers favored and best understood two label types, one using stars as the rating scale and one using a single-bar, sliding scale. Participants also identified many specific likes and dislikes.

Phase 3 consisted of a focus group to factor the opinions of key government and appliance industry experts into the label development process and a quantitative survey of 673 consumers who were placed in a buying context. Consumers rated four "final" labels for their appeal, comprehensibility, and persuasiveness. Although all four labels scored high, some differences in these three areas resulted in the recommendation of the Indian Power Savings Guide label shown at the end of this chapter.

*Source: IRG 1999*

- Primary research collects new quantitative or qualitative information. Quantitative research uses survey approaches with randomly selected samples of a particular population. Surveys can be done in person, by telephone, or by mail. The results of quantitative surveys can be projected to the whole population from which the sample is drawn. The most common form of qualitative research is called a focus group, in which a small number of people with certain characteristics (e.g., recent buyers of refrigerators) are recruited to participate in a facilitated discussion about a particular topic. Qualitative research provides valuable insights about the in-depth and subjective views of key audiences, and it is particularly useful for gathering responses to visual information such as labels. However, the results of qualitative research cannot be statistically generalized to the greater population.

One good example of using consumer research to develop an effective label design comes from India (see Insert Box: *Research in India*, previous page). Researchers there used a phased approach that included both quantitative and qualitative research methods and involved not only consumers but also other key audiences (IRG 1999). The final label design was therefore based on broad consensus among these various audiences.

*The most common type of energy labels shows five, six, or seven categories of efficiency.*

**Table 5-1** Comparison of Selected Label Types from Around the World

Country	Type of Label	Comments
Australia	Comparative with categories	Six categories range from 1 to 6 stars; 6 stars is most efficient.
Brazil	Comparative with categories	Seven categories range from G to A; A is most efficient.
Canada	Comparative with continuous scale	Scale shows range of models in size class; energy use is the scale metric.
European Union	Comparative with categories	Seven categories range from G to A; A is most efficient.
Iran	Comparative with categories	Seven categories.
Philippines	Information-only label	Labels for air conditioner only; show energy-efficiency ratio (EER) of air conditioner.
South Korea	Comparative with categories	Five categories range from 1 to 5; 5 is most efficient.
Thailand	Comparative with categories	Five categories range from 1 to 5; 5 is most efficient.
United States	Comparative with continuous scale	Scale shows range of models in size class; energy use is the scale metric.

### 5.4.3 Deciding on a Label Format

The end result of the consumer research should be a label design that is effective and easily understood by consumers. If a comparative label is chosen, it is useful to review the format of similar energy labels that are currently being used in most countries around the world that have undertaken labeling programs (see **Table 5-1**).

The basic formats in use around the world for comparative labels can be grouped into three basic styles, as follows:

#### Australian-style label

The Australian style label tends to have a square/rectangular base with a semi-circle or “dial” across the top. The “dial” resembles a speedometer or gauge; the further advanced the gauge is in the clockwise direction, the better the product. This type of label is used in Australia, Thailand, and South Korea and is proposed for India. The number of stars or the “grading” numeral on the scale depends on the highest preset threshold for energy performance that the model is able to meet (there are five, six, or seven rankings in these cases; Australia is moving to half stars). See the end of this chapter for samples of the Australian (old and new), Thai and Indian labels.

#### European-style label

The European style label is a vertical rectangle with letters ranging from A (best) near the top of the label to G (worst) at the bottom. There is a bar next to each letter: e.g., short and green for A and long and red for G. All seven grade bars are visible on every label. The grade of the product is indicated by a black arrow marker located next to the appropriate bar (e.g., for a C-grade product the marker carries the letter C and is positioned against the C bar). Because of EU language requirements, the label is in two parts. The right-hand part, which shows the data, is not language specific and tends to be affixed or supplied with the appliance at the point of manufacture; the left-hand part, which gives the explanatory text, is language specific and tends to be supplied and affixed in the country of sale. This label is used throughout Western Europe and in parts of Eastern Europe. Iran uses a variant of the European-style label that is a mirror image because of the direction of Persian script and uses numerals rather than Roman script letters for rankings: i.e., 1 (best) to 7 (worst). Brazil also uses a European-style label. See the end of this chapter for samples of the European and Iranian labels.

#### U.S.-style label

The rectangular U.S.-style label shows energy cost (based on the national average energy tariff). It also has a linear scale indicating the highest and lowest energy use of models on the market and locates the specific model on that scale. This type of label is used in the U.S. and Canada, where labels are now technically but not visually harmonized (e.g., U.S. labels show energy costs, and Canadian labels do not). In both cases, use of monetary units (dollars) was abandoned in favor of physical units (i.e., kilowatt-hours or efficiency) because variability in energy prices causes labels based on outdated prices to be misleading. See the end of this chapter for samples of the U.S. and Canadian labels.



## Variants

There are a number of variants or hybrids of the three types just discussed.

It is important to remember that an energy label is primarily effective at the point of sale and is not designed to affect ongoing consumer behavior and energy use. The label should therefore be designed to influence consumer decisions at the time of purchase. After a product is purchased, the energy label is normally removed. It therefore makes little sense to design an energy label that aims to influence consumer behavior or use of the product during normal operation. Generally, other types of programs can be designed to influence consumer operation of appliances. One caveat to this last point is that a very effective labeling program can help to create an identity or culture for energy efficiency and thus can provide a springboard for broader awareness campaigns aimed at affecting behavior. This is one of the advantages of a program like Thailand's labeling program where, the top-ranking symbol, "# 5," has become synonymous with saving energy.

## 5.5

### Step **L**-4: Design and Implement the Program

#### 5.5.1 Stakeholder Involvement

One of the first steps in designing a labeling program should be to convene representatives of all interested parties and get input regarding how the program should be designed and marketed. This process of stakeholder involvement can run parallel to the development of the testing program and label design. Stakeholder interviews and meetings should be used to formulate and test the mechanics of how the program will operate. Some program design questions that need to be addressed include:

- Will the labeling program be voluntary or mandatory?
- Which agency will lead the overall program?
- Which agency will manage product testing?
- Will private-sector laboratories be certified for testing?
- Who will issue the labels?
- How will the labels be displayed on the product?
- How will monitoring and enforcement work?
- Who will evaluate the program, and how often?
- How can consumers be convinced that the label is credible?
- How can salespeople be recruited to promote the program?
- Will the labeling program pave the way for minimum efficiency standards?

Most of these questions can be answered through a process of group and individual meetings with key stakeholders. Eventually, if the stakeholder process is well managed, the private sector will buy into and support the program.

Below, we briefly describe the main groups of stakeholders who are typically affected by an energy-labeling program and can be approached to help design and promote the program.

### Manufacturers

Manufacturers are key stakeholders. They are the source of the products to be labeled and are generally responsible for testing products and placing energy labels on products they sell. Because they have designed their products and have, in most cases, tested them extensively according to local and international test procedures, it is critical that any labeling program include a full and ongoing dialogue between the manufacturers and the implementing agency.

The primary goal for most manufacturers is to make products that consumers will want to purchase. Manufacturers have to balance a wide range of elements of product design, including quality, reliability, performance, and price. The introduction of energy labeling makes the product's energy efficiency an important design parameter, at least in cases where the label is effective and is used as a decision tool by a significant percentage of consumers. Manufacturers of the most efficient products tend to be more supportive of energy labeling, while those that have large sales of low-efficiency products tend to be opposed to or less supportive of labeling.

### The implementing agency

The implementing agency is often a government body, although this need not be the case. Its role in an energy-labeling program includes:

- defining the detailed technical requirements in consultation with other stakeholders;
- developing and maintaining the legal and/or administrative framework for the program;
- registering, policing, and enforcing compliance, if applicable, to ensure that the program remains credible;
- providing information to consumers, including ensuring press and TV involvement in the promotional campaign; and
- evaluating the program.

### Retailers

Retailers are often considered to be minor stakeholders in an energy-labeling program. However, salespeople influence the appliance purchase decision in a large percentage of cases. One study found that U.S. salespeople have a significant influence in approximately 30-50% of sales of "white goods" (refrigerators, freezers, dishwashers, clothes washers, dryers, and stoves) (du Pont 1998). Salespeople's

attitudes can range from highly supportive of paying the extra cost for energy-efficiency features to neutral or negative regarding energy efficiency.

Retailers can play a very supportive and positive role in energy-labeling programs if they are actively engaged by the implementing agency to assist in marketing of the programs, if retailer training is provided. On the other hand, retailer impact can be negative if increased energy efficiency reduces profit margins or if there is low regard for energy-saving features. It may be in the interest of retailers to denigrate the credibility of the label or to discount its importance if they believe that this will improve their chances of a sale or increase their profit. Unfortunately, many salespeople work on a commission basis, which may provide them with an incentive to sell models with extra features that use additional energy rather than promoting energy-efficient models.

### Consumers and consumer groups

Consumers are a diverse and diffuse group. It takes significant work to obtain reliable information about consumer use and understanding of energy labels. It takes even more effort to determine the changes in consumer purchasing patterns that are likely to result from the presence of an energy label. Nonetheless, consumer involvement is critical in all phases of the program, from market testing of label designs with focus groups to consumer surveys to marketing the program and disseminating information. Consumers cannot be expected to change their purchasing patterns if information is poor or unavailable or if the label is unclear and difficult to use.

Consumer groups can be critical stakeholders. In many countries, consumer organizations have their own internal, independent test laboratories and are able to provide well-balanced input to technical discussions. There is growing awareness among some consumer groups

### Asian Consumer Declaration

Worldwide, mainstream consumer groups are taking an active role in campaigning on environmental and energy-related issues. At a recent Asia-wide forum on sustainable energy use and consumer information, the NGO delegates listed appliance labeling as one of their primary policy recommendations. The declaration is excerpted below:

“The Forum gave unanimous support to the establishment of appliance labeling schemes for the widest possible variety of electrical products. While a voluntary system may be adopted initially, it is believed that a compulsory system, based on legislation, is preferable and more effective in the medium to long term. The Forum participants noted the variety of different forms of labels currently in use in different countries, and expressed the strong view that labels should be kept as simple as possible and may include a simple categorical rating scheme (e.g., 1-5 stars, A-G categories). Labels should indicate estimated annual energy use in monetary terms rather than kilowatt-hours. Any categorical system of labeling may need to adjust or recalibrate its rating system periodically so as to distinguish adequately between the efficient and non-efficient products. While consumer organizations need not be directly involved in the implementation of labeling schemes, they should have a role in monitoring compliance by appliance manufacturers.”

*Source: UNESCAP 1999*

that energy use is a central element in the environmental problems that many countries face. These groups can provide important input on a range of issues including testing, labeling, program marketing, and public awareness (see Insert Box: *Asian Consumer Declaration*).

### Environmental groups and NGOs

In cases where non-government bodies are large and sufficiently well funded to actively participate in the process of developing and maintaining energy labels, they can provide valuable input. Environmental NGOs are taking an especially keen interest in energy efficiency as concern over climate change spreads. Increasingly, NGOs are developing the skills to analyze and advocate energy-efficiency policies. In cases where NGOs have relevant expertise, they can play an important role in advocating an aggressive and effective labeling program. In this sense, NGOs can help keep implementation agencies focused on broad goals and program outcomes.

#### 5.5.2 Program Marketing and Promotion

Placement of an energy label on a product is only the first step in attempting to influence consumers' purchase decisions. Research has shown that education and promotion are valuable aids in making the label effective. There are a number of related program measures that increase the effectiveness of an energy label. These include:

- retailer support for the program (hostile retailers can neutralize the impact of labels),
- government promotion of the program (e.g., frequent public service announcements and annual efficiency awards),
- publication of lists of current models on the market (e.g., a brochure and an Internet site that are easily accessible), and
- point-of-sale information and support.

Promotional marketing is most effective when consumers are subject to numerous, consistent messages regarding energy efficiency, not just as part of the energy-labeling program but also in other, related energy programs that may be running in parallel. These repeated messages reinforce a culture of energy efficiency among consumers and industry and help to create an energy-efficiency ethic within the country.

#### 5.5.3 Policing and Enforcement

For a mandatory labeling program to be truly effective, there needs to be some mechanism to ensure that manufacturers, distributors, and retailers comply. For a mandatory labeling program, it is usually necessary to have some sort of a policing and enforcement scheme to assess the extent to which labels are not displayed on products. Violation of the labeling requirement must be penalized to discourage continued noncompliance.

If an energy-labeling program is to be credible to the public, it is necessary to ensure that claims made on any energy label are reasonable and accurate. This requires verification of the claims made on labels (capacity, performance, and energy consumption, as applicable) through independent testing. In a competitive market, much of the policing of this nature can be undertaken by competing manufacturers. More discussion of policing and enforcement can be found in Chapter 7 (Sections 7.4 and 7.5).

#### 5.5.4 Program Evaluation

To assess whether energy labels are effective, a policy maker can ask three basic questions:

- Are consumers aware of the label?
- Do they understand it?
- Do they change their behavior because of it?

#### Measuring awareness, understanding, and impact

Awareness is fairly easy to measure through consumer surveys, which are a commonly used proxy measure of the effectiveness of labels. Unfortunately, surveys do not provide useful information about consumer understanding or decision making.

Consumer understanding is more difficult to measure than awareness and requires a mixture of research techniques, including in-person interviews and surveys. Wherever possible, this critical research should be conducted in a field environment under actual purchase conditions rather than in a laboratory removed from the retail environment. The important variables to measure are the relative importance of the label (compared to other features of the appliance) in the purchase decision, how well consumers understand the label's central message as well as its individual elements, the amount of time required to respond to and understand the label, and the degree to which consumers recall the label's elements.

Policy makers often fail to measure the most important label impact: whether the label can be linked to consumer decisions to purchase more efficient appliances. This effect can be assessed by surveying consumers to see whether those who are aware of the label rely on it to select efficient products. The effect on purchase decisions can also be assessed broadly by tracing shipment-weighted average efficiencies in the market and attempting to correlate them over time with the introduction of a labeling program.

#### How effective are energy labels?

Most prior evaluations of energy-labeling programs have shown a high level of consumer awareness of labels. Generally, awareness tends to increase during the life of the labeling program, and the vast majority of shoppers are aware of labels after they have visited stores to make purchases.

Evaluations have found that simple, uncluttered label designs are the most effective for conveying information about energy efficiency. These evaluations have used focus groups and interviews with consumers and salespeople and laboratory tests designed to measure consumers' understanding of different label designs. Recent studies suggest that categorical comparison labels tend to be more readily understood by consumers than continuous comparison labels (du Pont 1998).

### How important is energy in the purchase decision?

Past research in the U.S. has shown that, despite years of campaigns and nearly two decades during which energy labels have been prominently displayed on U.S. appliances, energy use is typically not a high priority during the consumers' decision making. For example, a 1983 survey of U.S. homes showed that energy use and yearly energy costs ranked fifth on a list of important attributes in the purchase of a refrigerator or washer. In a more recent U.S. survey, "low operating cost" ranked seventh on a list of factors that would influence consumers' decisions to buy a new appliance. Consumers considered other factors, such as brand, price, features, and size, to be more important (Brown and Whiting 1996). Some U.S. studies and a study in Denmark have found that training salespeople and providing point-of-purchase information on energy efficiency can increase the priority that consumers place on energy efficiency as a purchase criterion.

Other international studies have shown energy efficiency to be a higher priority. For example, when 1,500 consumers in five Chinese cities were surveyed in 1997, energy efficiency was third on the list of desired features. Another survey in 1999 of 1,500 customers on the topic of air conditioners showed the same result. A recent study compared the effectiveness of appliance energy labels in the U.S. and Thailand. This study found that, among U.S. consumers, energy efficiency ranked ninth in order of priority, with only 11% of respondents ranking efficiency as one of their top three priorities. Among Thai consumers, efficiency ranked fifth, and 28% of consumers ranked efficiency as one of their top three priorities (du Pont 1998).

However, there is a strong potential for bias in this type of research. If the consumers being tested know that the survey is being done by an organization that promotes energy efficiency, they may bias their responses to please the interviewer. For example, a 1991 Australian study showed that energy efficiency and operating costs ranked second in importance after unit capacity and that running costs and efficiency were reported as the most important attributes in the choice of a dishwasher. Because the researchers introduced themselves as energy researchers conducting a study for the local utility on energy efficiency, the results must be viewed with skepticism; a response bias in favor of energy efficiency may well have been generated by the interviewers' introduction (SEC Victoria 1991).

### Types of evaluation

There are two main types of evaluation of labeling programs: process evaluation and impact evaluation. These are covered in detail in Chapter 8. In addition, we see growing interest in some countries

in theory evaluation, a variant of process evaluation. Below, we briefly examine the main elements of each type of evaluation.

**Process Evaluation**—Process evaluation is often qualitative in nature and measures how well the program is functioning. Unfortunately, process elements are sometimes seen as relatively less important by policy makers. In reality, however, process elements are critical to the implementation and success of a program. Process elements include:

- assessing consumer priorities in purchasing an appliance,
- tracking consumer awareness levels,
- monitoring correct display of labels in retail outlets,
- evaluating administrative efficiency (e.g., registration times), and
- checking and verifying manufacturer claims (maintaining program credibility).

**Impact Evaluation**—Impact evaluation is used to determine the energy and environmental effects of a labeling program. Impact data can be used to determine cost effectiveness as well. Impact evaluations can also assist in stock modeling and end-use (bottom-up) forecasting of future trends. Impact elements include:

- influence of the label on purchase decisions,
- tracking of sales-weighted efficiency trends, and
- determination of energy and demand savings.

Impacts can be very difficult to determine accurately, especially for a labeling program. One of the fundamental problems is that, once an energy-labeling program has been in place for a period of time, it becomes increasingly difficult to determine a “base case” against which to compare the program impact.

**Theory Evaluation.** Program designers are increasingly using theories with hypotheses about how a program might affect market players. These designers benefit from evaluations that test their hypotheses both through interviews and by tracking market indicators, which can then be translated to impacts. In addition, there are short-term theories of how a market will evolve so that private actors might shift toward promoting more efficient products in the absence of a program. A theory-based approach, similar to a process evaluation, would test many of the hypotheses presented in this chapter, such as “most/some/all consumers will use labels as part of their purchase decisions” or “labels will encourage manufacturers to improve the energy performance of their products” (Blumstein et al. 2000).

### Evaluation timing

It is important to plan the evaluation before an energy-labeling program is implemented. Data collection strategies can then be built into the program design and operation. It is simpler, more reliable,

and less expensive to plan and collect data during a program's implementation; retrospective data collection is more difficult, more expensive, and sometimes impossible.

### 5.5.5 Updating Test Procedures

Once an energy test procedure is selected, there is an ongoing need to keep it up to date. Elements of this process include keeping up with changes in any related international test procedures and addressing new products and technologies that come onto the market and that may not be adequately addressed by the published testing methods. For example, it may be necessary to make special provisions for new

## Redesign of the Australian Label

The Australian government is finalizing the first update of its 14-year-old appliance energy-labeling scheme, partly in response to the introduction of mandatory minimum energy performance standards for certain appliances that will render the current efficiency rating system obsolete. This is the first time that a categorical energy label (one that ranks an appliance's efficiency into one of a number of graded categories) has been revised and the efficiency categories "ratcheted" upward. The experience may provide insight for other countries facing the same issue. In addition, model regulations have been formulated to promote harmonized implementation of the program, and Australian national test standards (known as "Australian Standards") have been modified to conform to labels and efficiency-standards requirements. These actions are part of a broader set of measures aimed at reducing greenhouse gas emissions and energy use.

As part of the labeling review, market researchers were commissioned to benchmark consumer understanding and acceptance of the current energy label. The response was clear and strong: the label in its current form was well liked and had a high degree of credibility. It quickly became clear that there was a substantial amount of investment in the current label in terms of consumer understanding and image recognition, so the label redesign transformed into an attempt to improve how the label communicates to consumers. A number of new designs were tested with a series of focus groups. It was found that the basic design was well recognized, but there were areas where information could be more clearly presented. There were also calls for limited amounts of additional information, such as a website to find further information and the inclusion of water consumption data for products that use water. The new label is similar to the old label in color and appearance, but the design is simplified, and the font size and text positions are clearer to facilitate consumer understanding. There was also a conscious decision to visually separate the star rating at the top of the label (the part most commonly used by consumers) from the more technical data at the bottom of the label (energy, capacity, and so on) to make the label as friendly as possible. See the end of this chapter for samples of old and new Australian Energy Rating labels.

*Source: Appliance Efficiency 1999, Artcraft Research 1998*



technologies, such as smart refrigerator defrost cycles, that save energy in actual use but not when tested using the selected test procedure. However, before such provisions or credits are made, there needs to be a high degree of certainty that any such “in-use” savings are, in fact, real.

### 5.5.6 Updating Label Design

It is important to periodically evaluate the label design to determine whether it is well understood by consumers and is having an impact on consumer decision making. Australia and the U.S. have recently decided to consider redesigning their appliance energy labels although neither has completed its redesign (Appliance Efficiency 1999, Artcraft Research 1998, Egan 2000b). The experiences of these two efforts to date suggest that an opportunity for significant improvement in program effectiveness is likely from label redesign after a label has been in use for several years (see Insert Box: *Redesign of the Australian Label*, previous page, and Insert Box: *Redesign of the United States Label*).

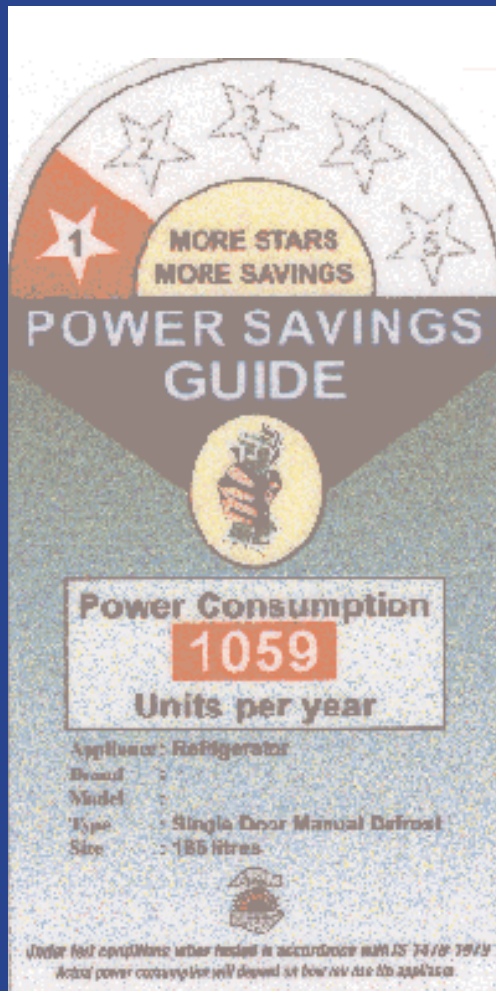
Label redesign is an involved process and takes time, but it does not require nearly the same number of steps as creating a labeling program from the very beginning. Making initial program decisions (what products to label? mandatory or voluntary?), customizing the testing program, conducting the research and deciding on a label design, and, finally, implementing the program have all been described in this chapter. Chapter 6 looks at similar steps for setting the standards, while Chapter 7 addresses the maintenance and enforcement of both labeling and standards programs.

#### Redesign of the United States Label

In the U.S., recent research has shown that the EnergyGuide label is not well understood by a majority of consumers (BPA 1987, Carswell et al. 1989, du Pont 1998). In response, the American Council for an Energy-Efficient Economy (ACEEE) is leading a multi-tasked, interdisciplinary research effort to document how U.S. consumers perceive and use the current EnergyGuide label and to explore options for improving the label design by building on successful label designs elsewhere in the world. The project focuses on products currently covered by the Federal Trade Commission’s EnergyGuide label program, including white goods, water heaters, and, to a lesser degree, heating and cooling equipment. The task force is conducting primary and secondary research along with extensive stakeholder outreach. The goal of this project is to develop an EnergyGuide label that is easy to understand by the vast majority of consumers; provides motivating and comprehensible information on appliance efficiency; and positively impacts the consideration of energy efficiency in consumer appliance purchase decisions. The project includes two major activities: research and communications. See the end of this chapter for a sample U.S. EnergyGuide label.



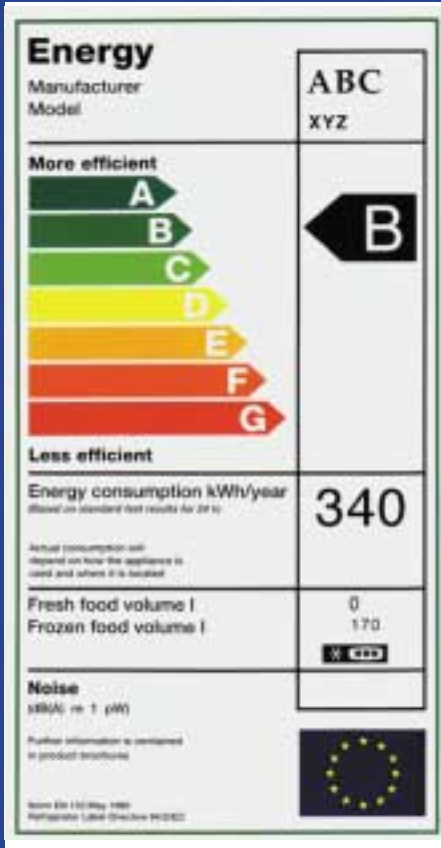
ENERGY STAR® Label



Indian Label



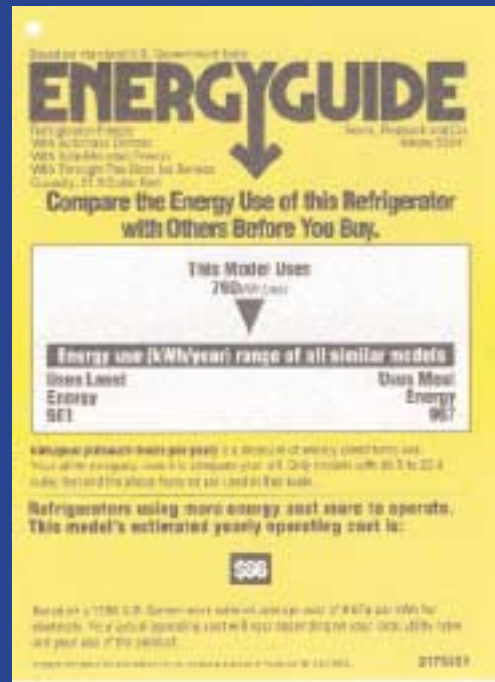
Thai Label



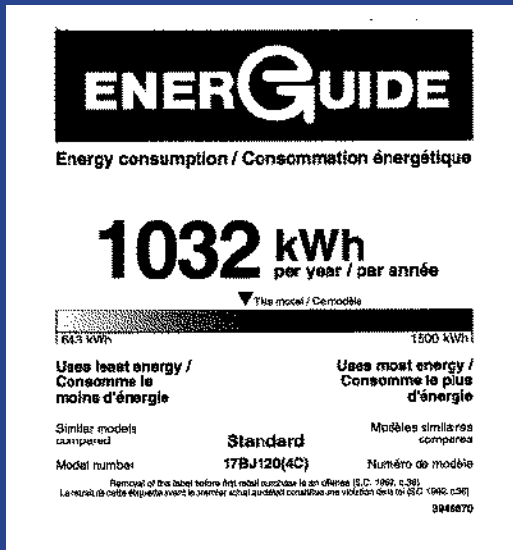
European Union Label



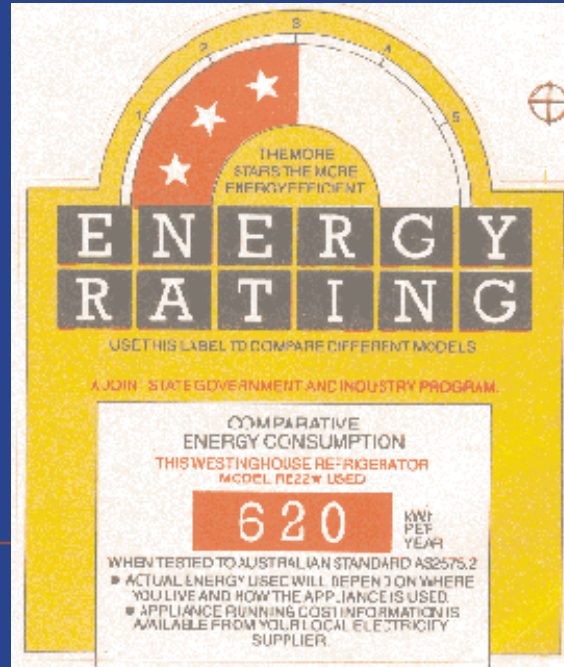
Iranian Label



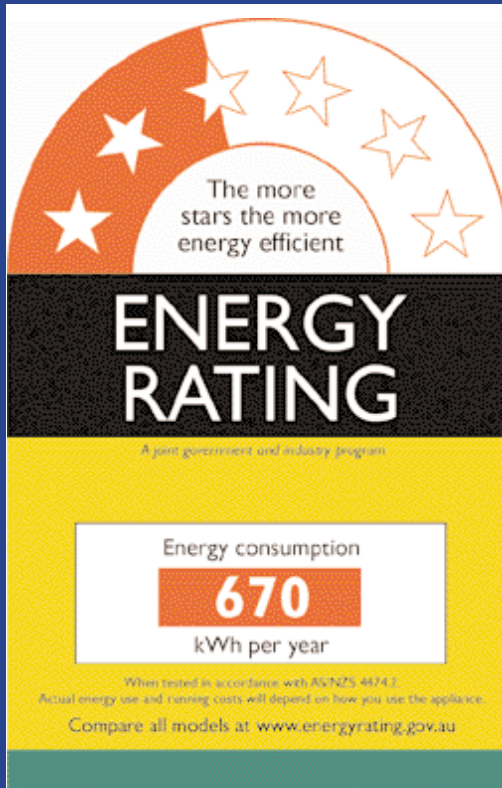
United States Label



Canadian Label



Australian (Old) Label



Australian (New) Label



Swiss Label





## 6. ANALYZING AND SETTING STANDARDS

### Guidebook Prescriptions for Analyzing Standards

- 1 Plan a continuous process over a period of years with an opportunity for updates.
- 2 Prepare to negotiate. Develop a process for involving stakeholders (manufacturers, distributors, retailers, consumers, environmental organizations, and energy suppliers), for identifying their concerns, and for addressing those concerns.
- 3 Establish an objective research team. Have the members gather information from diverse sources.
- 4 Thoroughly document assumptions, methods, and results for review.
- 5 Use the information collected to characterize current and potential markets and technologies.
- 6 Construct a base case and several alternative policy scenarios.
- 7 Select among existing analysis methodologies. Customize methods whenever appropriate.
- 8 Estimate impacts of possible policies on consumers, manufacturers, energy suppliers, the national economy, and the environment. Use quantitative estimates of observable impacts as much as possible, supplemented by qualitative analysis.
- 9 Consider uncertainty explicitly, including estimating maximum and minimum impacts and distribution of impacts among diverse populations and identifying the most important assumptions that influence the policy impacts.
- 10 Eliminate untenable policy options. Repeat the analyses to account for comments from reviewers. Support efforts to build consensus.

#### 6.1

### Establishing a Technical and Economic Basis for Standards

A transparent and robust analytical study can greatly aid in the regulation or negotiation of energy-efficiency standards. Key elements of an analysis include selecting the products to be analyzed, defining a methodology for the analysis, and setting the criteria for the evaluation of energy performance. Documentation of all assumptions, methods, and results is essential. It is extremely beneficial to clearly include an open process of review and stakeholder consultation.

An analysis estimates the potential impacts of policies and the uncertainties in those estimates. The purpose of the analysis is to provide sufficient information to decision makers to enable good decisions and discourage bad decisions. A sign of a successful analysis is that it is accepted as a reasonable estimate of likely impacts by all parties, including advocates of regulation, regulated industries, and government agencies. The analysis may include:

- documentation and assessment of available information (quality, quantity/coverage, applicability);
- collection of new data;
- synthesis of information from diverse sources, including data analysis, model building, and consistency checks;
- scenario analysis to account for alternative assumptions or different possible future conditions;
- uncertainty analysis to build confidence in the policy; and
- importance analysis to determine which assumptions are the key factors.

Policy makers looking to implement minimum energy-performance standards generally require objective analyses to assess the impacts of alternative policies. The stakeholders (all interested parties) in a standards proceeding also look to objective analyses to focus their supportive or critical comments.

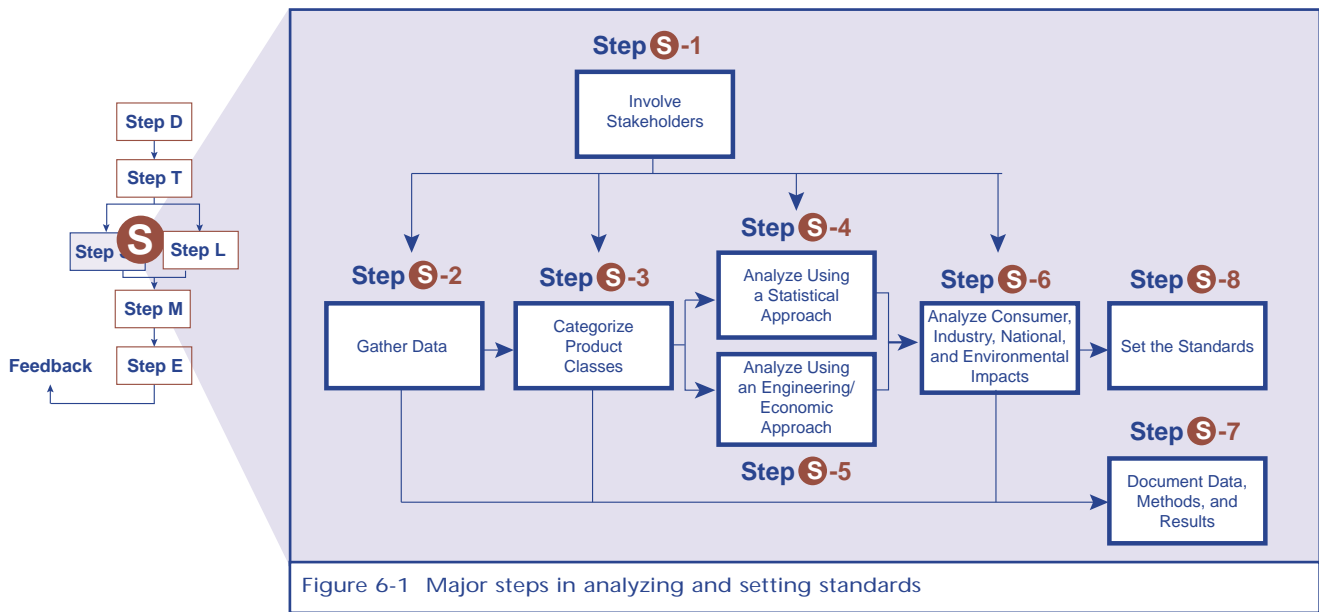
This chapter describes some of the methodologies that have been developed to select efficiency levels and to analyze the energy, economic, and environmental impacts of alternative efficiency standards. Two main approaches to carrying out analyses, statistical and engineering/economic, are discussed in detail. The actual approach or combination of approaches chosen by a country depends on the resources and time available to policy makers and also on the quality and quantity of the data that can be obtained for specific appliances.

### 6.1.1 The Process of Analyzing and Setting Standards

The steps in conducting the analysis and negotiation needed for the development and promulgation of standards are shown in **Figure 6-1** and discussed in Sections 6.2 through 6.8.

**Table 6-1** on the following pages presents a basic outline of the analytical elements of the standards development process. The elements of priority setting, initial product (design option) screening, engineering review, and economic impact review are generally applicable. The second element, initial product screening, will differ according to whether an engineering/economic or statistical standards-setting approach is used.

The analytical process is not a one-time-only exercise. Standards are updated periodically to keep current with local, regional, or international technology and market trends. Thus, the priority-setting step may be undertaken frequently—every year or two. The other standards development steps are generally done every four or five years, depending on technology trends and product development cycles. It is very



important that the standards revision process is rigorously scheduled so that manufacturers are kept aware of the need for continued efficiency improvement.

### 6.1.2 Types of Efficiency Standards

This section describes three types of energy-efficiency standards:

- prescriptive standards,
- minimum energy performance standards (MEPS), and
- class-average standards,

any of which could be either mandatory or voluntary.

Prescriptive standards require a particular feature or device to be installed in all new products. For example, beginning in January 1987, all new gas-fired clothes dryers in the U.S. had to eliminate standing pilot lights. Determining compliance is simplest for prescriptive standards, requiring only inspection of the product.

Performance standards prescribe minimum efficiencies (or maximum energy consumption) that manufacturers must achieve in all products manufactured after a certain date. These standards specify the energy performance but not the technology or design specifications of the energy-efficient product. Performance standards permit innovation and competing designs, and compliance is determined by laboratory tests. For example, some refrigerator standards require that each unit use no more than a maximum amount of energy per year under test conditions.



**Table 6-1**

**Analytical Elements of U.S. Standards-Setting Process, as Revised in 1996**

Stages, Primary Inputs (•), and Outputs (⇒)	Factors Considered
<p><b>PRIORITY SETTING</b></p> <ul style="list-style-type: none"> <li>• Preliminary Analysis</li> <li>• Stakeholder Consultation on Draft Agenda</li> </ul> <p>⇒ Regulatory Agenda—annual publication of rule-making priorities and accompanying analysis and schedules for all priority rule makings anticipated within the upcoming two years</p>	<ul style="list-style-type: none"> <li>• Potential energy savings</li> <li>• Potential economic benefits and costs</li> <li>• Potential environmental and energy security benefits</li> <li>• Applicable rule-making deadlines</li> <li>• Incremental government resources required to complete the rule making</li> <li>• Other regulatory actions affecting products</li> <li>• Stakeholder recommendations</li> <li>• Evidence of energy-efficiency gains in the market in the absence of new or revised standards</li> <li>• Status of required changes to test procedures</li> <li>• Other relevant factors</li> </ul>
<p><b>DESIGN-OPTION SCREENING</b></p> <ul style="list-style-type: none"> <li>• Expert and Stakeholder Consultation</li> </ul> <p>⇒ Identification of product categories and design options to be analyzed further or to be eliminated from further consideration</p> <p>⇒ Identification of key issues and expertise necessary to conduct further analysis</p> <p>⇒ Identification of any needed modifications to test procedures</p>	<ul style="list-style-type: none"> <li>• Technological feasibility</li> <li>• Practicability of manufacture, installation, and service</li> <li>• Adverse impacts on product utility or availability</li> <li>• Adverse impacts on health or safety</li> </ul> <p>(Note: initial criteria for screening according to these factors are written directly into the rules, e.g., design options not incorporated in commercial products or in working prototypes will not be considered further nor shall design options having significant adverse impacts on the utility of the product to significant subgroups of consumers.)</p>

*continued on next page*

Standards can also be based on the average efficiency of a class of manufactured products in a year. This approach has been used in the U.S. for automobile fuel efficiency and in Japan for several products where a sales-weighted average efficiency must be achieved or exceeded by each manufacturer. The sales-weighted approach can be particularly useful to promote a leap in technology (e.g., from incandescent lamps to compact fluorescent lamps or from electric-resistance storage water heaters to heat-pump water heaters). Raising the average efficiency can be accomplished by increasing the share of the new technology without completely eliminating the old technology. Class-average standards require more record keeping than other approaches, and verifying compliance is more difficult. However, this type of standard allows manufacturers more flexibility and innovation in meeting the goal of improving energy efficiency than do the other types. Unlike the first two types, class-average standards require that manufacturers or governments implement methods to induce consumers to purchase enough of the higher energy-efficiency product to meet the sales-weighted average efficiency goal (see Insert Box: *Performance or Class-Average Standards?* on the following page).

Most appliance efficiency standards (e.g., North America and China) are in the form of mandatory MEPS. Some countries (e.g., Japan, Brazil, and Switzerland) have instituted voluntary or target levels rather than mandatory efficiency standards. Voluntary agreements are usually worked out in a consensus

*Extensive analysis is prescribed in the U.S. standards-setting process.*

**Stages, Primary Inputs (•), and Outputs (⇒)**

**Factors Considered**

**ENGINEERING REVIEW**

- Engineering Analysis—to establish the likely cost and energy performance of each design option or efficiency level
- Expert and Stakeholder Consultation
- ⇒ Candidate Standards—Advance Notice of Proposed Rule (ANOPR) that specifies a range of candidate standards but does not propose a particular standard
- ⇒ Technical Support Document (TSD)

- Excluding design options that do not meet the screening criteria or that have payback periods greater than the average life of the product, the candidate standards levels will typically include:
- the most energy-efficient combination of design options,
  - the combination of design options with the lowest life-cycle cost,
  - the combination of design options with a payback period of not more than three years, and
  - other options to provide a more continuous range of opportunities.

**ECONOMIC IMPACT REVIEW**

- Economic Impact Analysis—impacts on manufacturers, consumers, competition, utilities, non-regulatory approaches, environment and energy security, and the national energy, economic, and employment situation
- Public Comments and Stakeholder Negotiation
- Stakeholder Review
- ⇒ Proposed Standards—Notice of Proposed Rule (NOPR)
- ⇒ TSD

- A high priority is placed on consensus stakeholder recommendations and supporting analysis.
- Principles for the analysis of the impacts on manufacturers (in terms of costs, sales, net cash flow, etc.) and consumers (in terms of product availability, first costs, payback period, etc.) are written directly into the rules.
- Analytical assumptions are specified for cross-cutting factors, such as economic growth, energy prices, discount rates, and product-specific energy-efficiency trends in the absence of new standards.

**STANDARDS SETTING**

- Final Public Comments and Stakeholder Negotiation
- ⇒ Final Standards
- ⇒ TSD

- Standards must meet statutory requirements to be:
- technologically feasible and economically justified,
  - likely to result in significant energy conservation,
  - unlikely to result in the unavailability of any covered product type with performance characteristics, features, sizes, capacities, and volumes generally available in the U.S.,
  - unlikely to cause substantial increase in consumer costs, and
  - unlikely to create an anti-competitive environment.

arrangement between the government and manufacturers. In some cases (e.g., Switzerland), manufacturers are formally given a set time period to reach the voluntary standard, and if they do not comply, the regulatory agency can substitute mandatory standards.

**6.1.3 Types of Analysis**

This section describes the two most widely used analytical approaches for standards setting:

- statistical analysis of current products, and
- engineering/economic analysis of future possibilities.

These approaches, and others, can be used in combination and are not mutually exclusive. One example of another approach, used in Japan, is to establish standards by a group of industry and government participants relying less on analysis and more on expert knowledge of the marketplace and available technologies for a particular product.

No single methodology is appropriate for establishing a standard in all circumstances. The best approach or combination of approaches may differ with appliance type, policy goals, and local conditions (including data availability). Most approaches begin with a data collection phase, followed by an analysis phase and then the standards-setting process. Analytical approaches range from simple estimates based on limited data to statistical analysis of the energy efficiencies of currently available products to engineering analysis of possible future designs. Economic analysis can include average payback period, consumer life-cycle costs (LCCs), manufacturer or industry cash flow, energy-sector impacts, and national expenditures.

Different standards-setting methodologies have been successful in achieving their objectives—new or revised efficiency standards—in different settings and at different times. Analyses have been used to generate prospective data on the impact of efficiency standards on consumers, manufacturers, utilities, and the environment. These data have been used to focus discussions of possibilities and to quantify the implications of uncertain assumptions. In most cases, decision makers have used these data to implement effective policies.

## Performance or Class-Average Standards?

Heat-pump electric storage water heaters, compact fluorescent lamps, and condensing furnaces are three examples of the discontinuity in energy efficiency between the old and these new technologies; no conventional technologies are available to improve efficiency much beyond that of existing models. In 1994, the U.S. DOE proposed a MEPS for electric storage water heaters that required use of a new technology, the heat-pump water heater (DOEa 1994). Two problems with a step transition were that few heat-pump water heaters were being manufactured and their first cost was relatively high (at least twice that of electric-storage-type water heaters with electric resistance heating). The first problem is that a mature market with high-quality, reliable products is difficult to create in a few years' time, and the necessary infrastructure of trained installers and service technicians might not be in place in time. The second problem is that some consumers in some parts of the country (with lower electricity prices, colder ambient temperatures, and lower hot-water use) might not recover, through decreased operating costs, the increased purchase price of this more expensive product. One solution would be to require class-average fuel-economy-type standards. Such standards would require an average efficiency higher than that of current technology but lower than that of the new technology, to be achieved by a set date, instead of requiring all models to meet the same MEPS. This approach encourages phase-in of a fixed fraction of production capacity simultaneous with building consumer acceptance of the new technology.

## Statistical analysis of current products

The statistical approach is most appropriate where a wide range of efficiencies is currently available and the goal is eliminating the least efficient products. The statistical approach requires data that may be easier to obtain and analyze than with the engineering/economic approach, but it typically results in standards that are restricted to efficiency levels within the range of currently available products. The data required are those that characterize the current marketplace for the products of interest—i.e., the number of models, by efficiency rating, currently available for sale or the sales of products of each efficiency rating. Data can be collected for only those already available in a country or can include products available internationally. The impact of possible efficiency standards is analyzed as the number of models that would remain if standards were imposed and the number of manufacturers producing them. A standard can be selected after a decision is made regarding the desired energy savings or the number of models that it is acceptable to eliminate (i.e., the minimum number of manufacturers or models to retain to ensure adequate consumer choice). The energy savings can be estimated from the change in average efficiency before and after standards.

The statistical approach has advantages and disadvantages. Because the costs of achieving the energy savings are not explicitly determined, it avoids the need for cost data from appliance manufacturers or suppliers. Cost data are often very difficult to obtain for reasons of confidentiality. The statistical approach also has political advantages because it avoids explicitly disclosing the cost of compliance. However, by masking the costs, it prevents economic optimization of the program and therefore likely results to some degree in either an overly costly investment in efficiency or a lost opportunity to obtain more cost-effective efficiency improvements than the standard will achieve.

Statistical analysis of current products is discussed in more detail in Section 6.5. The statistical approach has been utilized in the EU (Group for Efficient Appliances 1993) and in Australia (Wilkenfeld 1993). In Japan, the Ministry of International Trade and Industry (MITI) has recently used statistical data to define minimum energy-efficiency targets for several products, including refrigerators, televisions, and air conditioners. This “Top Runner” program requires the future sales-weighted average of any brand of appliance sold on the Japanese market to meet efficiency thresholds set at or above the level of the most efficient products on the market at the time the legislation was announced (Murakoshi and Nakagami 1999).

## Engineering/economic analysis of future possibilities

Engineering/economic analysis seeks to determine the full range of potential energy-efficiency improvements and their costs. In contrast to the statistical approach, the engineering/economic approach has a significant advantage: it can consider new designs or technologies or combinations of designs that are not commercially available and can therefore result in products with higher efficiencies than those available on the market at the time. A potential disadvantage of this approach is the need to estimate the efficiency and costs of new designs not yet in mass production, which may be subject to

significant uncertainty. The economic analysis associated with this approach addresses the impact of standards on consumers, including LCC and payback period calculations. It can also include impacts on national or regional energy use, manufacturers, and electric or gas utilities. Section 6.6 presents engineering/economic analysis in more detail.

#### **6.1.4 Addressing the Perspectives of Interested Parties**

The purposes of analysis are to integrate information from diverse sources into a consistent picture, to quantify likely impacts of new regulations, and to consider the uncertainty in these estimates. The analysis can be useful to all parties as standards are being formulated, including policy makers in the government, regulated parties (appliance manufacturers and importers), environmental advocates, energy advocates, energy providers, and, ultimately, consumers. If communicated well, the analysis can provide commonly available and understood results to support various stakeholder perspectives, focus attention and discussion on a relatively narrow range of potential outcomes, and preclude unfounded speculation.

Key outputs from the analysis include a diversity of factors representing costs and benefits that must be considered: projected energy savings and associated environmental consequences; economic impacts, both costs and savings, on the populations of consumers; and investment and employment impacts on manufacturers, energy suppliers, and the general economy.

##### **Government/public sector**

Typically, most of the research on the impacts of standards is conducted under the sponsorship of the government agency that is responsible for the rule making. Policy makers need enough information, both qualitative and quantitative, to feel comfortable with their decisions. The specific elements of the analysis depend upon the legislative requirements and upon the degree to which there are substantive disagreements among interested parties. Those overseeing the process need to find balance: doing too little analysis can lead to policies with serious unintended consequences, which could, if early policies are discredited or reversed, threaten the long-term success of the program. Doing too much analysis could reduce the effectiveness of the program by taking too much time or money (with the risks that political support will diminish or resources, such as the budget, will get used up without a successful conclusion).

As with any policy, it is generally impossible to resolve all uncertainties and to arrive at a single scientifically defensible conclusion. Demonstrating that the likely impacts are favorable under a range of plausible scenarios of future conditions, consistent with the level of political support, is generally sufficient. If the political or legal environment is particularly challenging, additional analysis may be required.

##### **Appliance manufacturers and importers**

Energy-efficiency regulations limit the set of products that may legally be produced or imported. Manufacturers and importers are the parties directly impacted by these regulations, which can in-

crease the costs of doing business. The standards must be technologically achievable and affordable and should preserve adequate competition among manufacturers. Manufacturers and industry experts have valuable information about production costs and market structure. Some manufacturers oppose government regulations as unwarranted or ineffective interference in markets or as barriers to trade, but most manufacturers are practical about the authority of governments to impose standards if the standards are perceived to be fair.

Depending upon the degree of competition in the market and the strategic positions of each company, including the structure of distribution channels, the impacts of a regulation vary, potentially stressing some manufacturers more than others. Policies must be applied uniformly without favoritism and provide manufacturers with sufficient time to adapt. Standards are most cost effective when they are timed so that marginal increases in investment are minimized—for example, by coordination with normal investment cycles or with investments required to meet other regulations. Manufacturers' and importers' interests may be partially served by analysis that:

- demonstrates technological or market solutions to the challenge of improving energy efficiency (e.g., performance standards permit different companies to adopt different technological solutions),
- fairly considers manufacturers' and importers' increased costs,
- estimates the effect on total volume and value of future sales, and
- considers the effects of competition on regulated parties.

As an example of the first point, the Thai government is working with Thai refrigerator manufacturers to develop and test prototypes that will meet or exceed proposed standards.

## Consumers

Typically, energy-efficiency standards decrease operating expenses but may increase the price of regulated appliances. Analysis of payback periods or LCCs illustrates the tradeoff and helps identify policies that will have net benefit for consumers. Other important elements of the analysis may include variations on impacts among consumers based on energy price and actual appliance usage (as potentially different from laboratory or test procedure conditions); possible impacts on the service provided, or consumer utility, as a result of changes in design; and possible shifts to competing technologies (e.g., switching between electricity- and gas-fueled storage water heaters).

## Energy providers

Energy-efficiency standards reduce energy consumption, which may reduce the need for new energy supply or make more new supply available for applications other than energy use in buildings. Governments involved in planning and investing in both energy supply and energy demand have an opportunity to use energy-efficiency standards to reduce overall system costs.

In some cases, fuel competition (e.g., between electricity and natural gas for space conditioning or water heating) may be an important concern to energy suppliers. The analysis of impacts can address the likely market shares by fuel type.

Private energy providers may be affected by reduced demand among regulated end uses. If other uses can be found for the energy supply, this is not problematic. In any case, energy-efficiency regulations typically benefit utility planners by reducing uncertainty about future demand. The analysis can provide quantitative estimates of these impacts.

### Environmental advocates

In addition to reducing energy consumption, energy-efficiency standards reduce combustion of fossil fuels and associated environmental emissions such as carbon dioxide and oxides of sulfur and nitrogen. Environmental advocates will be especially interested in the magnitude of such impacts. Other environmental factors subject to analysis include tradeoffs between ozone-depleting chemicals and global warming potential—for example, considerations of chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and other alternative refrigerants or insulation-blowing agents. Tradeoffs can occur. For example, eliminating ozone-depleting chemicals (such as replacing CFCs as blowing agents for insulation) may lead to less effective insulation and therefore higher energy consumption and associated carbon emissions. Past analyses have identified solutions that both protect the ozone layer and improve energy efficiency (e.g., in the 1993 U.S. standards, alternative insulation for refrigerators).

## 6.2

### Step **S**-1: Involve Stakeholders

Experience from many countries has shown that effective standards programs are difficult to establish without stakeholder involvement—that is, involvement by representatives of all of the stakeholders identified in Section 6.1.4 and any others that may exist for any specific product in any specific country. At a minimum, there needs to be an open and transparent way through all steps of the standards-setting process for these stakeholders to make their concerns known and for their substantive concerns to be addressed as well as for the implementing agency to obtain the technical support of all stakeholders in providing data and reviewing analytical methodologies and results. The stakeholders should be included in the analytical stages of the standards development process. Standards are most likely to be successful if the implementing agency can engender a spirit of trust among stakeholders. Once trust is established, it is easier to conduct good-faith negotiations, concentrating on issues of legitimate disagreement.

Rules for managing confidential information should be established so that policy makers can have access to key information—for instance, individual sales figures or sales-weighted data. Confidentiality can be organized directly between regulators and the concerned industry or through an independent third party (see Insert Box: *Stakeholder Involvement*).

## Stakeholder Involvement

Stakeholder discontent with the standards revision process in the U.S. led to extensive reform of the process in 1996. The general findings of the process improvement exercise are applicable elsewhere. The exercise involved many stakeholders, manufacturers, and environmental public interest groups deliberating issues of planning, input and analysis, and decision making. The major objectives of the new rules fall into three categories:

**Procedural**—provide for early input from stakeholders; increase the predictability of the rule-making timetable; reduce the time and cost of developing standards.

**Analytic**—increase the use of outside expertise; eliminate less feasible design options early in the process; conduct thorough analyses of impacts; use transparent and robust analytical methods.

**Interpretive**—fully consider non-regulatory approaches; articulate policies to guide the selection of standards; support efforts to build consensus on standards.

### 6.2.1 Exchanging Technical Information

In the early stages of a standards program, there is likely to be an information asymmetry problem during stakeholder discussions. The government, depending on the openness of the deliberations, may know more about the overall program plans. Manufacturers and other industrial interests will almost certainly know more about the technical aspects of the products, the processes (and costs) involved in manufacturing, and the markets in which the products are sold. This information imbalance will probably never be eliminated completely, but it can be made more equitable by establishing a practice of full exchange of technical information, with appropriate protections for confidential information.

### 6.2.2 Defining Fair Representation of Interests

The issue of what constitutes “fair representation” of stakeholder interests should be left to the discretion of the political

bodies setting standards. At a minimum, there should be representation from the principal stakeholders—manufacturers, consumers, utilities, local governments, and representatives of environmental or energy-efficiency interest groups. The inclusion of representatives from importers and international organizations, where applicable, is useful to ensure that programs are feasible internationally.

### 6.2.3 Establishing a Schedule for Standards Development, Compliance, and Updates

Stakeholder involvement is valuable in establishing a schedule for standards development, compliance, and updates. One reason is that industrial stakeholders will push to synchronize the program with product and process development cycles. This synchronization lowers the overall cost of the standards



program because efficiency improvements made during routine product changes have lower marginal costs and can be more readily accommodated by manufacturers. This timing is particularly important where other government agencies are imposing regulations affecting the products. For example, making a design change that at once achieves both improvement in energy efficiency and elimination of ozone-depleting chemicals (e.g., refrigerants or insulation blowing agents) is less expensive than making two uncoordinated design changes.

Although the benefits of synchronizing the timing of standards-driven product changes with the timing of changes driven by other factors can be significant, different manufacturers will generally have different timing preferences (a possible exception is the example cited above of the synchronization of response to two regulatory drivers). This difference in product and process life-cycle timing is one of the reasons for variability in the impact of regulations on manufacturers, which contributes to there being winners and losers in response to regulatory actions.

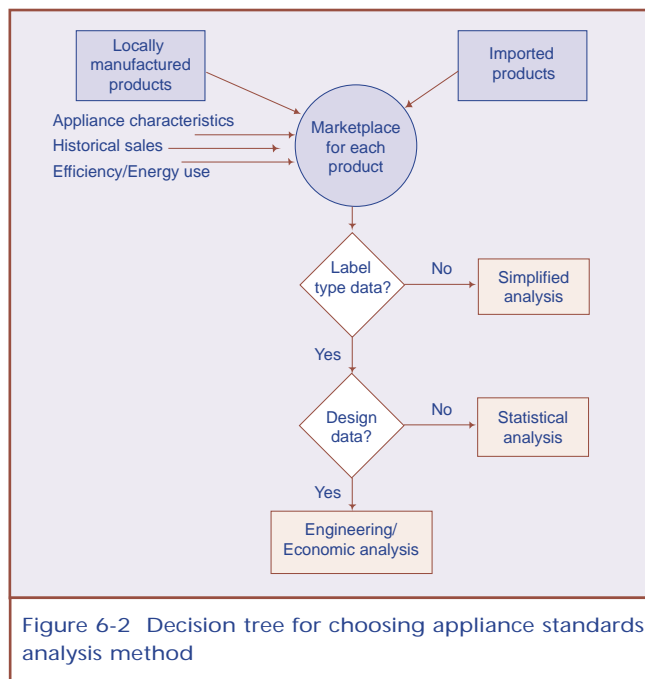
At every stage, the usefulness and feasibility of international cooperation should be assessed for the design, execution, and evaluation of standards. In the best case, international experience can usefully be duplicated. Often, because of the integration of the market on a regional or even wider scale, regulators in different jurisdictions are working with the same multinational companies or their subsidiaries.

## 6.3

### Step S-2: Gather Data

#### 6.3.1 Effect of Data Availability on Selection of Analytical Methodology

The information needed to perform a standards analysis depends on the method used to establish standards, or, for governments with severely limited resources, on the information that is readily available. **Figure 6-2** is a schematic diagram showing the decision logic for analyzing standards depending upon what data are available. We have already briefly described two analysis methods (statistical and engineering) and will give detailed examples of each below. For some developing countries, there will not be



The analytical approach to standards-setting depends on data availability.

enough available information to utilize either of these methods. In such cases, a simplified method will be necessary. We will give an example (for China) where a moderate amount of information was available but not enough to perform a statistical analysis. Statistical data on efficiency or energy use by model number are difficult to obtain unless test procedures and energy-use or -efficiency labels have been in effect for some time. Without labels, it is still possible to collect (or request that manufacturers provide) energy use or efficiency data for each model produced (or imported) if government or manufacturers are familiar with an existing test procedure and have testing laboratories available to them. Statistical data on efficiency by model number are also needed for a thorough engineering/economic analysis, to establish baseline models.

**6.3.2 Deciding What Data to Collect**

Table 6-2 shows the type of data that energy analysts would, ideally, like to have to thoroughly analyze appliance energy-efficiency standards. To select products for analysis, it is necessary to first understand the market structure, including the manufacturers, importers, and distributors. Second, enough data should be collected to estimate roughly the percentage of energy use that is accounted for by each major end use. Examples of end uses are refrigerators, air conditioners, lighting equipment, and televisions. An end-use analysis allows policy makers to select the products that offer the greatest potential for energy savings from efficiency standards. Third, the products contributing the most to the growth in energy demand should be considered for standards; these may be products with high unit energy consumption (UEC) that are gaining in ownership. Fourth, if information on the technologies available for improving

*Data needs for standards-setting analyses can be extensive.*

**Table 6-2** | **Data Needs for a Complete Appliance Standards Analysis**

Data Type
<ul style="list-style-type: none"> <li>• Market structure: manufacturers, importers, and distribution channels</li> <li>• Percent of households that own each major energy-using product</li> <li>• Unit energy consumption (UEC) for existing models of each class of those products</li> <li>• Historical annual shipments of those products</li> <li>• Average lifetime of those products</li> <li>• UEC for more efficient models (or technologies) of each class of those products</li> <li>• Incremental cost to consumers of more efficient models (or technologies) relative to baseline models</li> <li>• Average energy cost (e.g., electricity cost per kWh)</li> <li>• Consumer discount rate</li> </ul>

the efficiency of each product is available, the potential energy savings from these improvements should be estimated. Some products may represent a larger percentage of national residential energy use, but their energy savings potential could be smaller than that of another, less efficient product.

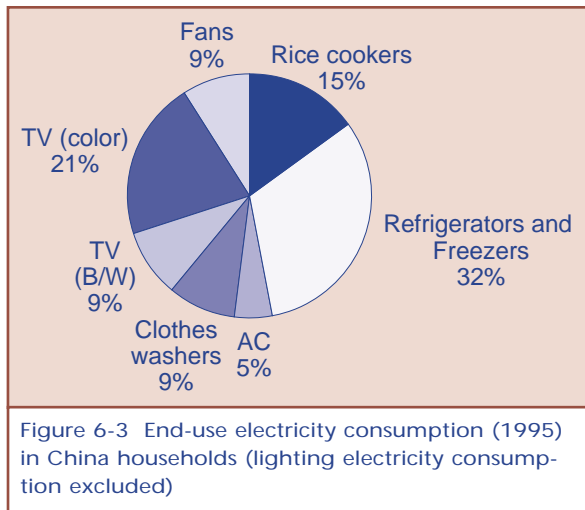
Although collecting data can be difficult, approximate information is much better than none at all. To collect enough information for analysis, it is often necessary to search out many different sources of information, sometimes partial and incomplete and sometimes derived. Because even official or well-accepted data can be inaccurate, analysts should address important information needs through several independent approaches to identify where good agreement is found and where large uncertainty indicates the need for additional data collection or analysis.

End-use metering can be the most accurate method for collecting energy consumption data, but it is also the most expensive and time consuming. Laboratory measurements or engineering estimates are less accurate representations than metered end-use data of actual household energy consumption but may be substituted if necessary. The minimum data needed depend on whether the statistical or engineering approach is used. In many developing countries, sufficient data may not be available to perform a standards analysis using either of the two methods described. China is an example of such a situation. In China, official stock figures have not been publicly reported since 1992, so current stock figures were derived from the known saturation rates of appliances in urban and rural households by multiplying the number of households by the saturation rate (percent of households owning each appliance, as determined by surveying a sample of households). End-use metering was done in a small sample of urban Chinese households to test the viability of an energy-efficient prototype refrigerator and to compare the prototype's energy performance to that of ordinary refrigerators. These annual energy consumption data for refrigerators are useful for analyzing potential impacts of new standards. A similar study, with even fewer data, was done for lighting, refrigerator, and air conditioner energy use in Ghana (Constantine et al. 1999).

In countries without energy-use labels or end-use metering data, it is often difficult to collect UEC data; in this case, it is necessary to make rough estimates until these data can be collected. For example, in the study on air conditioners in Ghana described here, an estimated power demand was multiplied by an estimated hours of operation to get the UEC. In China, end-use metering was recently used to obtain air-conditioner UECs. Refrigerators are a prime example of a product type for which household surveys will not yield a UEC. Occupants will not know how many hours a refrigerator compressor is in operation, and the power demand is also usually unknown.

**Figure 6-3** shows that the largest electricity users (not counting lighting) in China are refrigerators, televisions, clothes washers, rice cookers, and fans. In order to decide which appliances to consider for standards analysis, it is also necessary to evaluate possible technological efficiency improvements for each appliance type. Based on potential efficiency improvements, China modified and announced its efficiency standards for refrigerators, which went into effect on June 1, 2000. Air conditioners are of interest because of their rapidly increasing popularity in urban households even though their share of household electricity use was only about 5% in China in 1995. In fact, new standards for air conditioners are due

Household surveys show relative use of different appliances.



in 2001 and for clothes washers in 2002. For clothes washers and fans, the main efficiency improvement would be in electric motors. Clothes washers do not use hot water in China. Of the other products shown in the figure, only color TVs are currently being considered for efficiency standards. Although the efficiency of color TVs could be improved by reducing standby power, the magnitude of energy savings is unclear because surveys indicate that TV owners either plug TVs into a power strip that they turn

off after use or unplug the TVs directly. Rice cookers, assuming they work by using resistance heating, only have the possibility of improved insulation to retain energy released by the heating element.

### 6.3.3 Data for Estimating National Energy Savings

In order to project potential national energy savings from energy-efficiency standards over time, it is necessary to combine the current saturation rate of ownership and energy consumption data, as in the case of China, with projections of future saturation rates of each appliance type. Section 6.7.3 discusses methods to calculate national energy use and energy savings from standards.

### 6.3.4 Data for Assessing Economic Factors

Many inputs are needed for economic analyses of such quantities as LCC, payback period, and net present value. For example, to calculate LCC (see Section 6.7.1), data are needed on the incremental purchase price for the more efficient product, energy savings, fuel price, appliance lifetime, and consumer discount rate. For payback, only the first three terms are needed. Fuel or electricity price should also be projected into the future if it is expected that this price will change appreciably from the current price. Discount rates are needed to determine the present value of future energy cost savings for the more efficient product, to calculate either LCC or national net present value.

## 6.4

### Step S-3: Categorize Product Classes

Depending upon the product to be analyzed for energy-efficiency standards, there are usually reasons to create separate product classes based on consumer amenity. Manufacturers often argue that it is critical that product classes be developed to avoid hindering commerce and limiting consumer choice and welfare. Separate product classes allow for differences in energy consumption resulting from additional

features or utility in different models. Without these distinctions, standards might decrease the level of service being provided by the product. A reduction in service is undesirable because the intent of standards is usually to provide the most service for the least energy rather than simply discouraging energy use. For example, manual versus automatic defrost of freezers and the different configurations of freezers and fresh food compartments (side-by-side or freezer on top of fresh food compartment) are typically distinguished by product class. In the EU, there are separate product classes for refrigerator-freezers with different capacities to reach specific freezer temperatures. If there were only one product class for all refrigerator-freezers, models with more energy-intensive features (that provide consumers particular amenities) would have greater difficulty achieving an efficiency standard than models without those same features.

Another issue is whether to develop efficiency standards that are dependent upon the capacity or volume of the product. In all countries with mandatory refrigerator and freezer standards, the standards are expressed as a linear function of adjusted volume. Adjusted volume accounts for the different temperatures in the fresh food and freezer compartments of refrigerators, refrigerator-freezers, and freezers. If maximum allowable energy consumption were not a function of volume but instead a constant for all capacities, then larger models would have a harder time meeting the standard, which would discourage manufacturers from producing larger models. If policy makers wish to retain consumers' option to purchase larger-volume models, then the standard should be a function of volume.

A particular product can be divided into product classes in many ways, and this division can be both contentious and very important to the energy savings that will result from efficiency standards. For example, when electric resistance storage water heaters were analyzed in the U.S., there was a debate about whether heat-pump water heaters (HPWHs) should be considered as a design to improve the efficiency of electric water heaters or whether a special product class should be established for them. Some arguments in favor of a separate product class were that HPWHs were very different from standard electric water heaters in that HPWHs require more space, need sufficient air circulation, and must have a provision for condensate drainage. The U.S. DOE decided that a separate product class was not needed because HPWHs provide the same utility as electric resistance storage water heaters and that all of the issues related to the debate were economic in nature and were treated as such in the analyses of standards for these products (DOEa 1994).

## 6.5

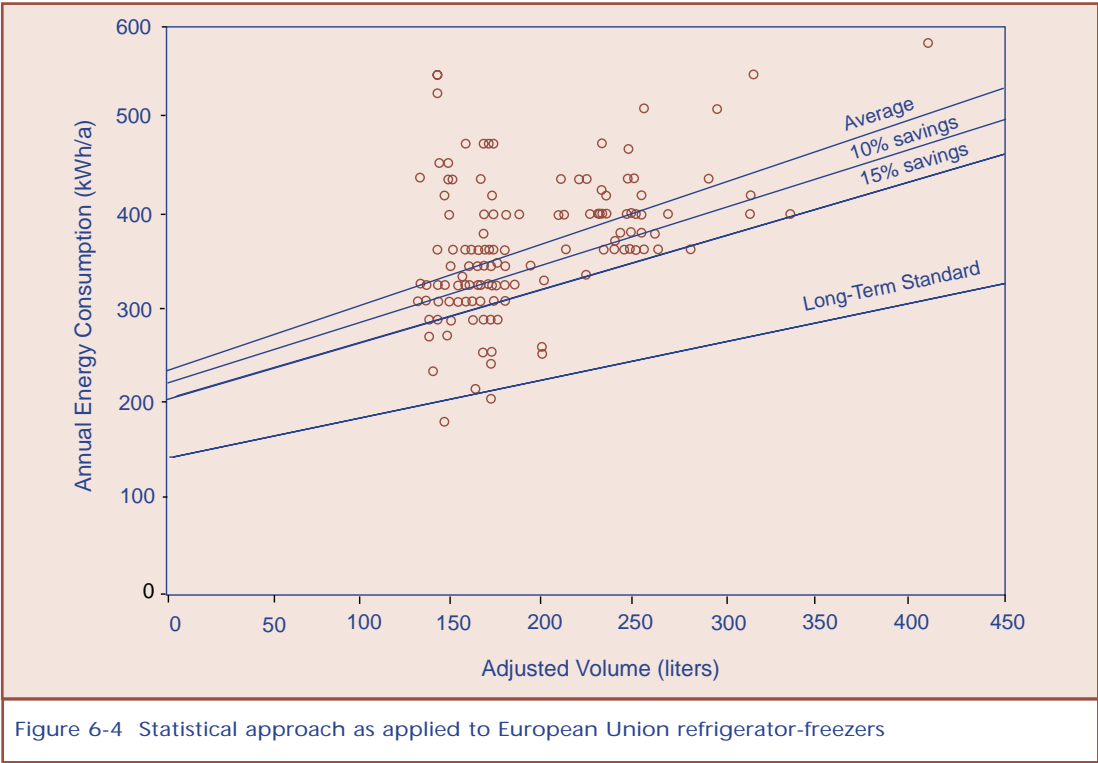
### Step S-4: Analyze Using a Statistical Approach (Method 1)

A statistical approach is one option for analyzing the desirable level of a proposed standard. An example of the statistical method is the analysis performed by the Group for Efficient Appliances (GEA) for three-star refrigerator-freezers. Adjusted volume (AV) accounts for the different temperatures in the fresh food and freezer compartments of refrigerators, refrigerator-freezers, and freezers. **Figure 6-4** shows a statistical analysis of a set of energy-use data for three-star refrigerator-freezer models available in EU countries

in 1992. For each model, energy use is plotted as a function of adjusted volume. For this product class and for the European test procedure (EN 153), AV is equal to the fresh food volume plus 2.15 times the freezer volume (volumes are in liters) to account for different internal temperatures in the compartments. Four lines are shown in this figure; they represent the average energy use obtained through a regression analysis of all of the data points, a 10% energy savings line, a 15% energy savings line, and a long-term standards line. The method used to obtain the first three of these energy savings equations is described immediately below. The fourth line was obtained through an engineering/economic approach, described in Section 6.6.

After the regression line is calculated, the least energy-efficient model is found and replaced with a model of higher efficiency. The number of models stays constant. The energy savings for the higher-efficiency model is calculated, and energy savings are aggregated until the total reaches the goal (10%, 15%, etc.). Then the resulting data points are used to derive a new regression line. An efficiency index was defined to aid in this process, namely the percentage by which the energy use of each model is above or below the reference line. The GEA studied four of the many possible ways to replace the least efficient models with more efficient ones:

- replace each model with a fictitious unit of similar adjusted volume and the closest energy-efficiency index;



Statistical analysis is one method that can be used for setting a standard.

Figure 6-4 Statistical approach as applied to European Union refrigerator-freezers

- replace each model with an existing unit with the closest adjusted volume and energy-efficiency index;
- replace each model with a fictitious unit with an adjusted volume and an energy-efficiency index, both calculated as averages of the other units within the same volume interval; or
- replace each model with a fictitious unit of similar adjusted volume and an energy-efficiency index that is the average of the other units within the same volume interval. The volume interval is arbitrary but should not be too large.

The analyses performed by the GEA utilized the fourth method. The report stated that this method is thought to represent the appliance industry's behavior in the process of replacing inefficient appliances with improved units.

The analyses described in this section are very simple compared to the engineering/economic analyses, which require extensive manpower from both direct employees and contractors. The statistical approach can be used to simply raise the average efficiency of products by periodically eliminating the least efficient 10, 20, or 50% of products. This strategy might achieve a similar effect over time as other approaches, without many of their complexities.

6.6

Step **S**-5: Analyze Using an Engineering/Economic Approach (Method 2)

An engineering/economic approach has been widely used by the U.S. DOE since 1979 for analysis of all U.S. standards. An engineering/economic approach has also been used to propose long-term refrigerator efficiency standards in the EU (Group for Efficient Appliances 1993). An engineering analysis is

*Engineering/Economic analysis is considerably more complex than statistical analysis.*

Table 6-3

Steps for Engineering Analysis

**Approach**

1. Select appliance classes
2. Select baseline units
3. Select design options for each class
4. Calculate efficiency improvement from each design option
5. Combine design options and calculate efficiency improvements
6. Develop cost estimates (include installation and maintenance) for each design option
7. Generate cost-efficiency curves

first carried out for each product class within a product type to estimate manufacturing costs for improving efficiency compared to a baseline model. Installation and maintenance costs are also calculated. The engineering analysis can be described in seven steps (see **Table 6-3**).

As with the statistical approach, the first step in the engineering analysis is the segregation of product types into separate classes to which different energy-efficiency standards apply. Classes are differentiated by the type of energy used (oil, natural gas, or electricity) and capacity or performance-based features that provide utility to consumers and affect efficiency.

Selecting a baseline unit from a distribution of models is step two in the analysis. A baseline unit is the starting point for analyzing design options for improving energy efficiency. The baseline model should be representative of its class. For products that already have standards, a baseline model with energy use approximately equal to the minimum efficiency requirement is usually chosen. For products without an existing standard, a baseline model can be chosen with energy efficiency equal to the minimum or the average of the existing distribution of models. Selecting the least efficient model as the baseline is recommended because this permits analysis of all possible levels of efficiency standards starting with eliminating the least efficient ones.

Design options are changes to the design of a baseline model that improve its energy efficiency. These options are considered individually and in combinations when appropriate. For each design option or combination of design options, energy use or efficiency is determined through measurements or calculations using the appropriate test procedure. These calculations are usually performed with spreadsheets or engineering simulation models that account for the various energy-using components of a product.

The expected costs of manufacturing, installing, and maintaining each design option must be estimated, including the ability of the after-market service sector to effectively maintain the performance of high-efficiency equipment. Data are usually obtained from appliance manufacturers and component suppliers (e.g., compressor and fan motor manufacturers). In some cases, manufacturer costs are very difficult to obtain, and it may be necessary to go directly to retail prices; this is a feasible approach if all the designs under consideration already exist in the marketplace. This approach was used in the U.S. analysis of fluorescent lamp ballasts (Lawrence Berkeley National Laboratory 1999). Obtaining average retail prices of particular designs can also be very difficult because of the significant temporal and regional variations in consumer prices. It can also be difficult to find two models of a product that only differ in the presence or absence of a particular design feature.

**Figure 6-5** illustrates the results of an engineering/economic analysis for an 18.2-ft<sup>3</sup> (515-liter), top-mount, auto-defrost refrigerator-freezer. In large part, this analysis was used as the basis for the consensus efficiency standards established by the U.S. DOE for July 2001 (DOEb 1995). Manufacturer cost is plotted as a function of refrigerator annual energy use. Efficiency gains become more expensive as energy use decreases. Most of the design options are self explanatory. The compressor efficiency increases from a coefficient of performance (COP) of 1.37 to 1.60 (or an energy-efficiency ratio, EER, of 4.7 to 5.45). Door insulation thickness is first increased from 3.8 to 5.1 cm (1.5 to 2.0 inches) and then from 5.1 cm



to 6.3 cm (2.0 to 2.5 inches). Insulation in the sides of the cabinet is also increased by similar amounts. The evaporator and condenser fan motor efficiencies are improved so that their power consumption decreases from 9.1W and 12.0W, respectively, to 4.5W each. Other design options shown are reduced gasket heat leak, adaptive defrost, and increased heat exchanger area. The use of vacuum-panel insulation was also studied although it is not shown here.

An engineering/economic analysis shows the extra manufacturing costs that accompany increases in energy efficiency. These must be weighed against the targeted reductions in energy costs.

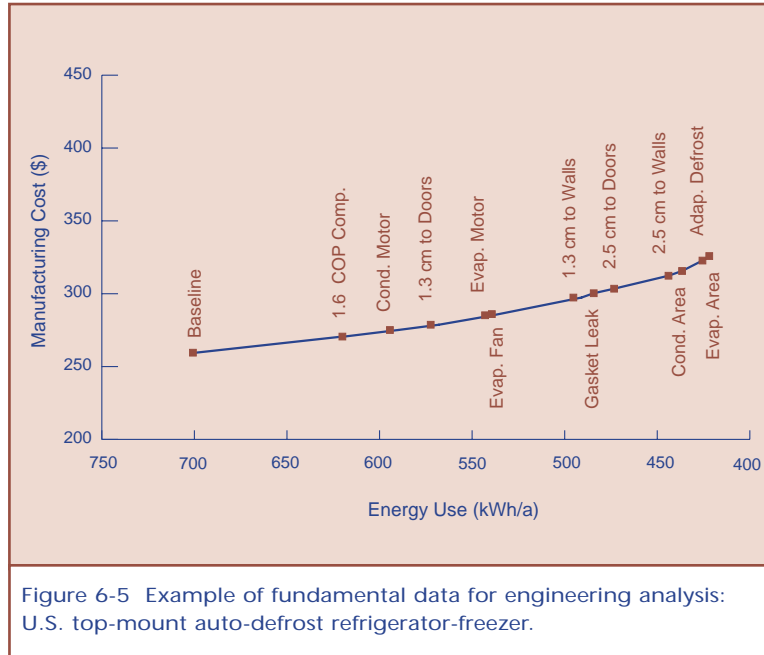


Figure 6-5 Example of fundamental data for engineering analysis: U.S. top-mount auto-defrost refrigerator-freezer.

This engineering/economic analysis suggested a standard more stringent than any that could have been considered using a statistical analysis. Calculations of consumer LCCs based on the engineering/economic analysis led to a maximum energy-use standard for an 18-ft<sup>3</sup>, top-mount, auto-defrost refrigerator-freezer below 500 kWh/y at a time when no models with such a low energy use were commercially avail-

able. The engineering/economic analysis doesn't prescribe that manufacturers meet the standard using the technical options used in the analysis. It simply ensures that there is at least one practical way to meet the standards. The history of responses to new standards shows great design ingenuity among manufacturers.

## 6.7

### Step S-6: Analyze Consumer, Industry, National, and Environmental Impacts

There are separate methodologies for estimating consumer LCC and payback period, national energy savings and economic impact, manufacturer impact, energy supply impacts, and environmental impacts. **Figure 6-6** shows the connection between the engineering analysis and the other analyses described in the sections that follow.

#### 6.7.1 Consumer Payback Period and Life-Cycle Cost

Once the engineering analysis is completed, it is customary to analyze the economic impact of potential efficiency improvements on consumers by analyzing consumer payback period and LCC.

## Retail prices

Future consumer prices for more efficient designs are estimated by applying markups (multipliers that translate manufacturer costs into retail prices) to the expected manufacturer costs or by using a survey to determine retail prices directly. The survey approach works only if the designs being assessed exist in products that are currently manufactured in large quantities; otherwise, current prices for models in limited production may be high compared to future prices of those models in full production. Surveys of retail prices can be difficult to interpret when variability in retail prices resulting from different

features and among brands, regions, and retailers obscures the underlying relationship between efficiency and manufacturer cost. Additionally, it is often difficult to find two models of a product that differ only in the presence or absence of the particular efficiency option being evaluated.

The alternative is to develop a markup, typically the ratio of the retail price of a baseline model to the manufacturer's cost. Where market statistics are available, the markup is often developed from aggregate industrywide data.

## Payback Period

The payback period measures the amount of time needed to recover the additional consumer investment (P) for an efficient model through lower operating costs (O). The payback period is the ratio of the increase in purchase price and installation cost (from the base case to the standards case) to the decrease in annual operating expenses (including energy and maintenance). For example, if the increased price for an efficient unit is \$30 and the energy savings are \$10 per year, the payback period is three years. Appliance lifetimes range from several years to several decades. A payback period less than the lifetime of the appliance means that the increased purchase price is recovered in reduced operating expenses.

Payback periods can be computed in two ways: by calculating cumulative payback for each design option relative to the baseline from the engineering analysis or by using a distribution of design options projected for the base case without standards. In the second payback calculation (which is

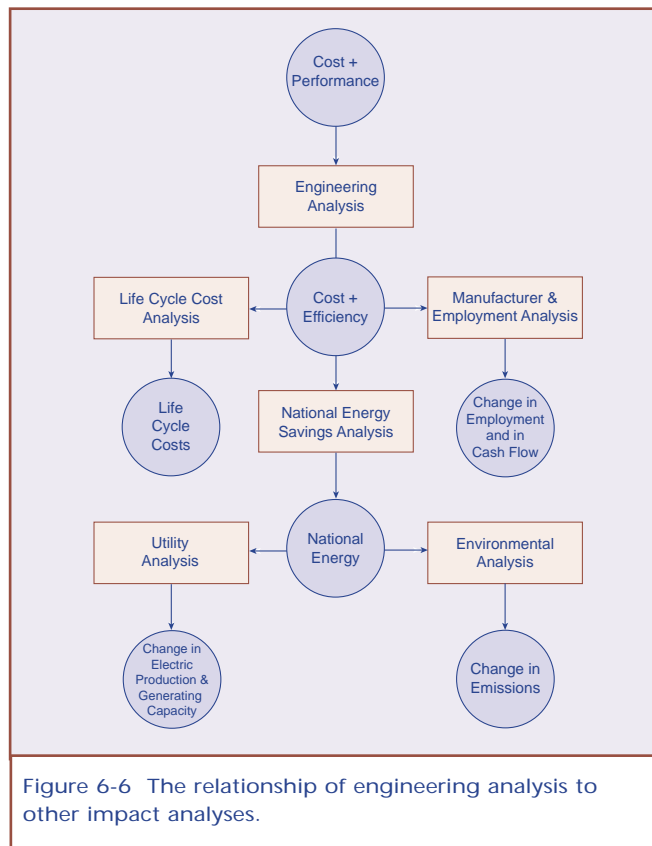


Figure 6-6 The relationship of engineering analysis to other impact analyses.

An engineering analysis is only one of several analyses that must be performed to assess the potential consumer, industry, national, and environmental impacts of proposed standards.

Payback period analyses demonstrate the enormous cost-effectiveness for consumers of some standards.

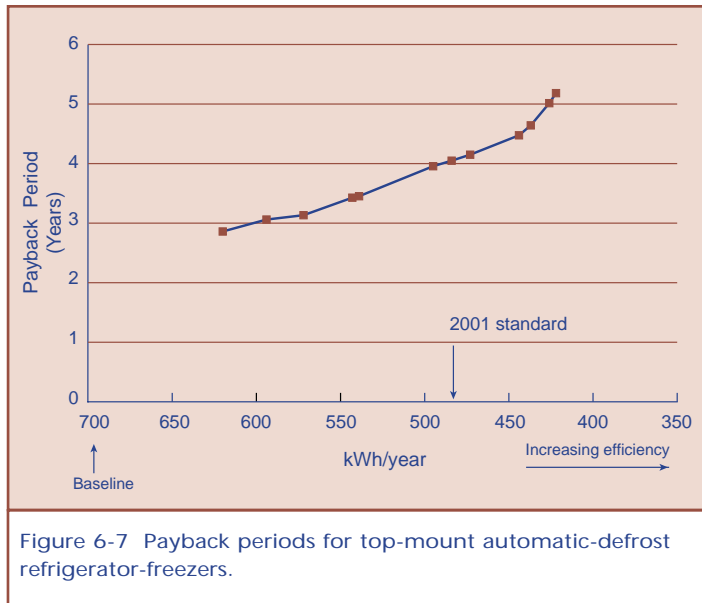


Figure 6-7 Payback periods for top-mount automatic-defrost refrigerator-freezers.

usually used to evaluate potential standards levels), only designs that would be eliminated by the standard are included in the calculation of paybacks; the fraction of the market that is already more efficient is ignored as unaffected. Consumers whose base-case choice is eliminated by standards are assumed to purchase the design option corresponding to the minimum compliance with the standard under consideration. The second method tends to yield payback periods that are a little

longer than those of the first method (see Insert Box: *Calculating Payback Period and Life-Cycle Cost*).

Figure 6-7 shows the payback periods obtained by the second method applied to the various design options from Figure 6-5. The consumer payback period for the design option, with an energy use close to the U.S. consensus standard for 2001, is less than four years. Incremental payback periods can also be calculated to determine the marginal benefit of adding the last design option compared to the previous design level (rather than to the baseline) although that approach has been rarely used.

### Life-cycle cost (LCC)

The LCC is the sum of the purchase cost (P) and the annual operating costs (O) discounted over the lifetime (N, in years) of the appliance (see Insert Box: *Calculating Payback Period and Life-Cycle Cost*). Compared to the payback period, LCC includes consideration of two additional factors: lifetime of the appliance and consumer discount rate. The LCC is calculated with inputs for the year standards are to become effective, using a discount rate (r), to determine the present value of future

### Calculating Payback Period and Life-Cycle Cost

Payback period (PAY) is found by solving the equation

$$\Delta P + \sum_{t=1}^{PAY} \frac{\Delta O_t}{1} = 0$$

for PAY. The  $\Delta$  signifies the difference from the base case to the standards case.  $\Delta P$  is an increase in price and  $\Delta O$  is a decrease in operating costs. In general, PAY is found by interpolating between the two years when the above expression changes sign. If the operating cost (O) is constant over time (t), the equation has the simple solution

$$PAY = - \frac{\Delta P}{\Delta O}$$

The equation for LCC is a function of price (P) and annual operating cost (O)

$$LCC = P + \sum_{t=1}^N \frac{O_t}{(1+r)^t}$$

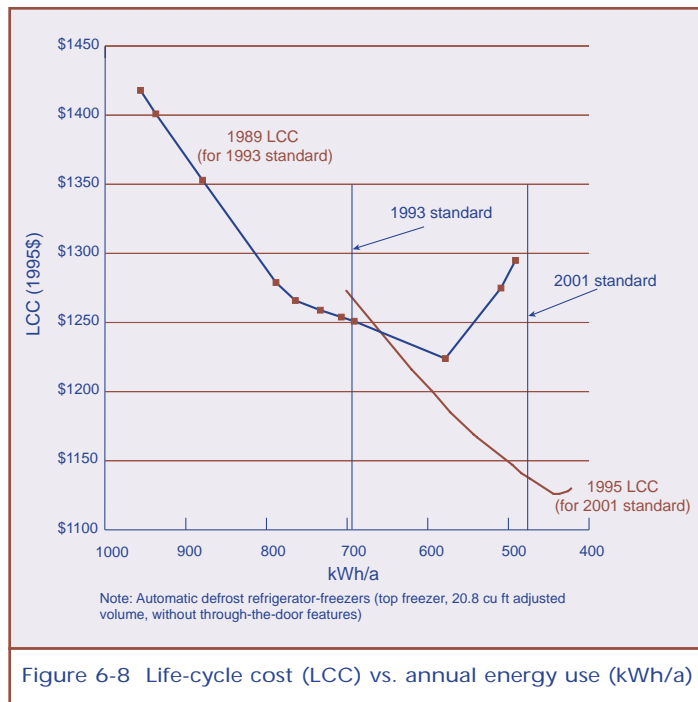
If operating expenses are constant over time, the above equation reduces to  $LCC = P + PWF \cdot O$  where the present worth factor (PWF) equals

$$PWF = \sum_{t=1}^N \frac{1}{(1+r)^t} = \frac{1}{r} \left[ 1 - \frac{1}{(1+r)^N} \right]$$

where N is lifetime (years), and r is the discount rate.

energy savings in energy costs over the life of the appliance. The determination of the appropriate discount rate to use in the calculation is often quite controversial.

**Figure 6-8** shows the LCC analysis results for two sets of U.S. standards for a top-mount, auto-defrost refrigerator-freezer. The earlier curve was used by the U.S. DOE as part of the basis for setting standards effective in 1993. The more recent curve was used by negotiators to determine the consensus standards that will take effect in 2001. In the latter case, the minimum LCC (where the consumer receives the most benefit) occurs around 450 kWh/a. At a lower discount rate, the LCC minimum shifts toward lower energy consumption options; at higher discount rates, the LCC minimum shifts toward higher energy consumption options. Options below 470 kWh/a were rejected for use in a proposed standard because increased insulation thickness would make these refrigerators too wide to fit into fixed spaces in some existing kitchens, assuming that internal volume remains constant as insulation thickness increases. If the goal were to maximize energy rather than economic savings, a policy maker could choose a standard that is beyond the LCC minimum as long as there is still a reduction in LCC relative to the baseline. In any event, the LCC minimum is not always the point chosen for a new standard because many other factors must be considered.



A life-cycle cost analysis identifies the standard level that will minimize the combined purchase price plus ongoing energy costs.

### Other consumer costs

Installation and maintenance costs need to be included in the payback and LCC analysis only if they change with energy efficiency. Installation costs are added directly to the purchase cost, and annual maintenance costs are added to the annual operating cost and discounted along with the energy cost. For water-using appliances, such as clothes washers, the cost of water and detergent should also be considered.

### Standard depends on size

To determine how energy use varies with size—for example, with adjusted volume of refrigerator-freezers—one method is to calculate the energy performance for several top-freezer models with different adjusted volumes but otherwise similar characteristics. A regression equation for each standard level can be fit to the combined results for all design options. Once the standard level is selected, the

standard is expressed as a linear equation for energy use as a function of adjusted volume (Hakim and Turiel 1996).

### 6.7.2 Manufacturer and Industry Impacts

The impact on manufacturers and their employees, distributors, retailers, and customers is an integral part of standards analysis. In order to avoid disrupting the product market being regulated, policy makers and analysts must understand the sources of products, whether domestic or imported, and their distribution channels. Significant issues can include effects on consumer demand; competition among manufacturers, including between domestic and foreign producers; and cumulative impacts of regulations, including employment impacts. In Thailand, an analysis of the refrigerator industry as a whole rather than of individual manufacturers was adequate to determine general trends and to address uncertainty by sensitivity analysis. Elsewhere outside the U.S., manufacturer impacts are usually discussed using an informal, consensus-type approach. In the U.S., interviews are usually conducted with many of the manufacturers of the product under consideration in order to gain insight into the potential impacts of standards. During the interviews, both qualitative and quantitative information is solicited to evaluate cash flows and to assess employment and capacity impacts.

In the U.S. (DOEc 1999) and the EU (Commission of the European Communities 1999), quantitative analyses have been performed to determine the impact of potential efficiency standards on appliance manufacturers. For the cash-flow analysis, information is requested on the possible impacts of standards on manufacturing costs, product prices, and sales. The cash-flow analyses are performed using a spreadsheet model on a company-by-company basis and then aggregated to the whole industry. The cash-flow analysis uses annual shipments, selling price, and manufacturer costs (such as materials and labor, selling and administration, taxes, and capital expenditures) to generate annual cash flows. The industry net present value (NPV) can be calculated by discounting to the present the annual cash flows over the period from before implementation of standards to some future point in time.

Accurate estimation of the benefits of energy improvement options is difficult, and errors can compound when options accumulate. Probabilistic treatment is prudent with a goal of identifying the likely range of impacts among different manufacturers. In the U.S., a flexible, transparent tool, the Government Regulatory Impact Model (GRIM), has been developed for analyzing impact on manufacturers. This model uses readily obtainable financial information to consider the impact on profitability and cash flow of government-imposed costs, based on a variety of assumptions that can be varied to model alternative scenarios.

### 6.7.3 National Energy and Economic Impacts

Policy makers are often interested in knowing the national or regional (e.g., for the EU) energy savings from proposed energy-efficiency standards. These energy savings estimates can be converted into reduced emissions of carbon dioxide and other combustion products. Also of interest are peak-load reductions, reduced oil imports, and avoided power plant construction. The expected national energy savings from alternative standards are calculated by using forecasting models (usually spreadsheets) that estimate

annual energy use for several decades under different scenarios. Summing discounted energy cost savings and subtracting additional first costs over a time period provides the NPV for the policy.

National energy savings are calculated by subtracting energy use under a standards scenario from energy use in a base case (no-standards) scenario. Inputs to a typical national energy savings model include the:

- effective date of the standard,
- annual shipments forecast,
- UEC with and without standards,
- projected energy price trend,
- discount rate, and
- time period, initial year and final year of analysis (sufficient to account for at least one replacement of existing appliances).

A probability function is often used to account for retiring appliances as their useful lifetime is reached. Additionally, a time series of conversion factors is used to convert from site (at the appliance) energy to source (or primary) energy, accounting for power-plant efficiency and transmission and distribution losses.

An example of national energy savings and NPV results is shown in **Table 6-4** for fluorescent lamp ballasts. The range of cumulative direct energy savings (for the period 2005 to 2030) is from 1.27 to 5.17 exajoules for the three shipment scenarios analyzed.

**Table 6-4**

**Energy Savings and Net Present Value from U.S. Standards for Fluorescent Lamp Ballasts Starting in 2005**

*National energy savings analyses often show significant savings from standards over a wide range of future scenarios.*

<b>Electronic Standards for Units Sold from 2005 to 2030</b>			
<b>Scenario</b>	<b>Low</b>	<b>Middle</b>	<b>High</b>
Total Energy Saved*, Quads (Exajoules)	1.20 (1.27)	2.32 (2.45)	4.90 (5.17)
Total Energy Bill Savings (billion \$)**	1.95	3.51	7.24
Total Equipment Cost Increase (billion \$)**	0.53	0.91	1.83
Net Present Value (billion \$)**	1.42	2.60	5.41

\*Associated net heating, ventilation, and air-conditioning (HVAC) savings contribute about 6% additional national savings, not included here.

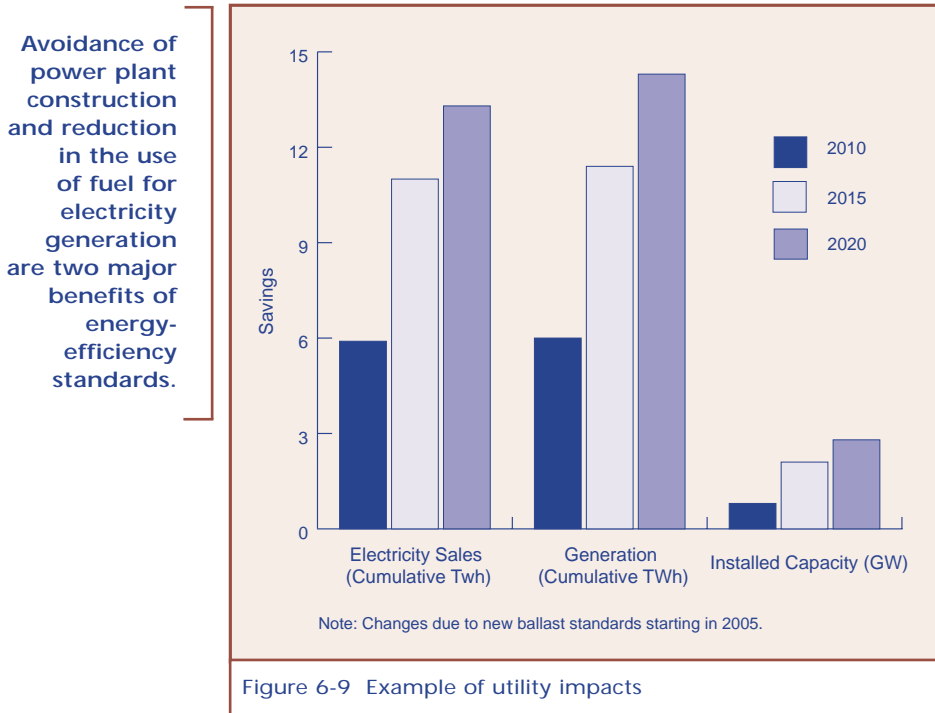
\*\*In billion 1997 dollars, discounted to 1997 at 7% real.

Although these impacts are the major energy and economic effects of standards, an input/output or general equilibrium model may be used, if sufficient data are available, to refine the estimated national economic impacts, including job loss or creation by sector. Standards typically shift consumer spending by decreasing energy expenditures, and consumers typically spend the savings on other items. The result can be job creation in other sectors, offsetting possible job losses in the appliance-manufacturing and energy-supply sectors.

### 6.7.4 Energy Supply Impacts

Analysis of the effects of proposed standards on the electric (or natural gas) utility industry has historically taken the form of estimated fuel savings and capital cost savings relative to the likely reduction in revenues implied by lower electricity (or natural gas) sales. The impacts of standards on utilities are reported using several key industry parameters, notably electricity (or fuel) sales, generation, and capacity. **Figure 6-9** shows energy supply analysis results for the ballast energy-efficiency standard recently enacted by the U.S. DOE. The results are expressed as a change in electricity sales, generation, and installed generating capacity relative to the reference case.

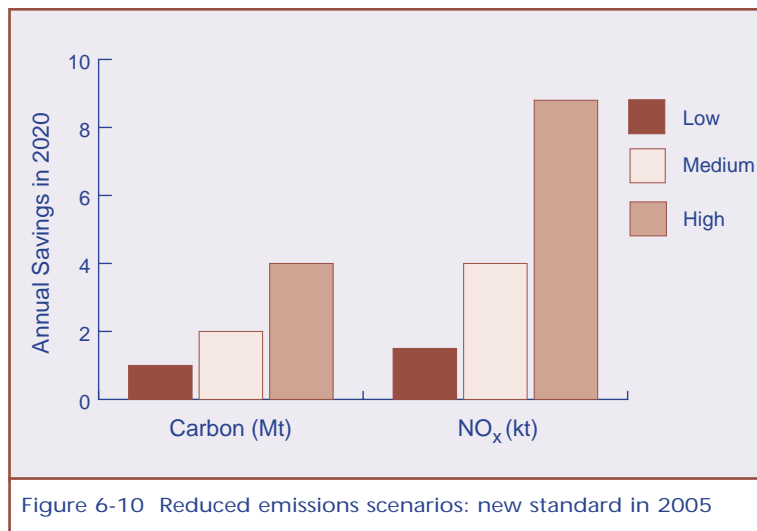
In the U.S., the effects of proposed energy-efficiency standards on the electric utility industry have been analyzed using a variant of the Energy Information Administration (EIA) National Energy Modeling System (NEMS) called NEMS-BRS, together with some exogenous calculations (EIA 1998). NEMS is a large, multi-sector, partial-equilibrium model of the U.S. energy sector. NEMS produces a widely used baseline forecast for the U.S. through 2020, titled Annual Energy Outlook, which is available in the public domain.



The comprehensiveness of NEMS-BRS permits modeling of interactions among the various energy supply and demand sectors and the economy as a whole, so it produces a sophisticated picture of the effect of standards, including environmental impacts. Perhaps most importantly, because it explicitly simulates dispatch and capacity expansion of the industry, NEMS-BRS can estimate marginal effects, which yield better indicators of actual effects than estimates based on industrywide average values.

### 6.7.5 Environmental Impacts

The environmental analysis provides information about the effect that new standards would have on pollutants (such as sulfur oxides and nitrogen oxides) and other emissions (CO<sub>2</sub>). Energy savings are typically converted to emission reductions using conversion factors (e.g., grams of emission per unit energy saved). The conversion factors can account for average current emissions or emissions associated with marginal energy supply when new supply is avoided. In-house emissions (e.g., from gas- or oil-fired water heaters, furnaces, or boilers) must be estimated separately from those for the energy-supply sector (e.g., central electricity generating stations and associated fuel-supply effects).



Reductions of CO<sub>2</sub> and NO<sub>x</sub> are major environmental benefits of energy-efficiency standards programs.

Figure 6-10 Reduced emissions scenarios: new standard in 2005

**Figure 6-10** shows examples of environmental impacts from three ballast standards scenarios, representing a range of possible base-case shipments (Low, Medium, and High). The annual carbon emission reductions range up to 4 million metric tons and the nitrogen oxides emission reductions range up to 8.8 million metric tons.

### 6.7.6 Improving Analytical Methodologies

All analytical methodologies and standards-setting processes can be improved over time. In the international arena, discussions of the harmonization of test procedures and appliance efficiency standards continue. In the long-running U.S. standards program, many significant changes have already occurred, including increased participation of manufacturers in the process and development of more transparent and robust analytical methods. Some enhancements to the current methodologies may be needed to assess standards across countries or regions. One such methodology, emphasizing uncertainty analysis, was described previously (Turiel et al. 1993). Uncertainty analysis allows explicit consideration of uncertainty in inputs and model parameters and an assessment of which of the various factors that influence analysis results are most important (importance analysis). Combined with scenario analysis, these techniques provide means for comparing alternative policies and for choosing among them with greater confidence in the outcome.



### 6.8.1 Documentation

#### Objectives

The objectives of documentation are to:

- identify precisely and thoroughly the source of each component of the analysis (e.g., quantitative and qualitative information, expert judgments, models, other analytical tools);
- trace the use of each of these components throughout the analysis so that, if any component changes in value or formulation, the individual components that will be affected are known; and
- enable staff to retrieve information efficiently and, if necessary, to reconstruct how the analysis was conducted to reach the conclusions that were reported at various points in time.

Upon project completion, archiving of the documentation should meet another set of objectives:

- to enable staff to redo parts of the analysis if legal challenges are raised and
- to find information or simulations that may be helpful for subsequent projects.

#### Benefits

The benefits of documentation are significant but may not be realized immediately. The benefits include improved:

- preparation of the report that supports efficiency labeling or standards,
- control of the version of the analysis that is used for various types of work within the project,
- ability to respond to comments and defend work questioned by stakeholders or other interested parties,
- internal quality control,
- transfer of work among staff,
- peer review,
- resumption of the analysis and rule-making process after delays, and
- consensus rule making.

The immediate pressures of project deadlines, difficulties in obtaining data, and schedule changes all work against maintenance of thorough documentation. Nevertheless, neglect of documentation is risky because it leaves the work vulnerable if staff leave the project or if methods or data sources are questioned, and it makes it more difficult to realize the benefits listed above. Staff who analyze labeling and standards must ensure that every effort has been made to eliminate mistakes before their work is circulated to government agencies, legislators, and stakeholders. Documentation contributes to this assurance.

## Frequency of documentation efforts

For the data collection stage that is part of any labeling or standards project, documentation should be conducted as the data are collected and not at the completion of this stage. The objective is to document as frequently as possible so that the total time spent on documentation is minimized and the chances for identifying errors early are maximized. Documentation entries should be recorded at least weekly and more frequently if small, distinct portions of work are completed in shorter time intervals.

## Mechanics

To facilitate documentation of labeling and standards efforts conducted by several individuals, a template with titles and space for documentation contents can be developed. The space available for each item should be designed so that it can be expanded as needed. For each project, the template should be stored in a separate, dedicated documentation subdirectory on a shared computer drive. It should not be maintained in any other location. Only one documentation subdirectory per project should be created, but the template may be used many times for a given project. The project manager should review the documentation files periodically to insure that they are kept up to date.

To the extent that it is practical, the same subdirectory structure should be maintained for each project. For example, there should be a designated subdirectory for the most current version of each type of work, for older versions, for data, for models, etc. This helps staff to retrieve information efficiently, especially when it is transferred from one project to another or when work stops on the project for significant periods of time. It is also helpful for controlling which version of the work is being used and eliminating confusion about which version is the current one.

One approach to organizing project documentation is to create a database that contains summary information about reports, models, data, and simulations. If each staff member adheres to protocols established at the beginning of the project regarding what information is documented, where it is stored in each file, and which key (e.g., most current) files are stored in designated directories, these contents can be extracted automatically to populate the database. Supplementary, more detailed documentation may be entered manually after the summary information, especially information concerning interdependencies among files, is stored.

A log should be included at the beginning of the documentation contents so that each person who contributes to project documentation can record his or her name, the date, the portion of the work being documented, and the revision number. This serves as a record of all documentation entries made. Only one person per project should be permitted to make entries at any given time. If another person attempts to open the documentation file while entries are being made to it, that person should receive a message to make the entry at a later time.

Templates, directory structure, documentation protocols for frequency and content, logs of documentation activity, and documentation databases are examples of approaches to structuring the documentation process. In the implementation of any structure, however, care must be exercised to account for the prevailing culture of the work environment, the manner in which the individuals involved think

and organize their work, the project objectives, and problems encountered in past efforts. Not all structures are suited to all individuals and all work environments.

## Contents

The following pages list documentation contents for the major types of work performed in efficiency labeling or standards (see Insert Box: *Contents of Documentation*). The major types of work anticipated are:

- project management,
- analysis and/or reporting,
- data collection,
- software or model development, and
- computer simulation runs.

Some of the documentation contents listed may be contained in automated documentation procedures associated with software that is used or developed by the project staff. If this is the case, reference to the document, page number, and/or item number in the automated procedure that contains the required information is sufficient.

6.9

### Step S-8: Set the Standards

After all analyses have been completed and documented and stakeholder comments have been collected and reviewed, government officials are responsible for weighing the various costs and benefits of each alternative and deciding which standards levels to implement. Finally, there needs to be a public announcement of the standards levels, the effective dates, and the procedure for compliance. In most countries, national law prescribes this. For example, in Mexico, the law prescribes that final standards must be published in the *Diario Oficial* for a final six-month review before they become law and the clock starts ticking toward the specified future effective date. The name of the official government publication and the period of review vary by country, but the process is similar in most places. There should be no surprises for the stakeholders at this point. The process and schedule for the final promulgation of the standards should have been set publicly and collaboratively early in the development process. Typically, manufacturers are given several years' lead time (between publication of a standard and its effective date) to make changes to their designs and production processes to meet the new standard.

The analytical process of a standards-setting program may be a lengthy one, and policy makers and their technical staff should plan ahead for the years of effort it may take to get a good standard in place. It is one of the more time-consuming steps in the overall process of developing a standards and labeling program. This is true not only because of the need to involve all relevant stakeholders but also because of the time required to gather data; categorize the product classes; conduct the proper analysis (statistical

or engineering/ economic); assess the consumer, industry, national, and environmental impacts; and document the data, methods, and results. These processes have been described in this chapter. The next step, that of maintaining and enforcing the standards-setting program described here, is explained in Chapter 7.

## CONTENTS OF DOCUMENTATION

### I. PROJECT MANAGEMENT

#### A. Overall project identification

1. Project name (e.g., equipment to which the labeling or standard applies)
2. Project stage (e.g., Advanced Notice of Proposed Rule Making, Notice of Proposed Rule Making, Response to Comments)
3. Account number
4. Project manager
5. Agency contact(s) for the project

#### B. Update log

1. Version number being revised
2. Name of person making revisions
3. Date of the revision
4. Section revised
5. Purpose of the revision, i.e., what is changed and why
6. At the response-to-comment stage include the following:
  - a) Name of the individual submitting the comment
  - b) Page number of the individual's document on which the comment appears
  - c) Organization, if applicable
  - d) Date received
  - e) Date of the response

### II. ANALYSIS AND/OR REPORT

#### A. Date

#### B. Time

#### C. Version number

#### D. Author

#### E. Objective

#### F. Target audience

#### G. Description of approach to meet objectives,

including major tasks and how they fit together

#### H. Assumptions

#### I. Caveats (limitations, omissions)

#### J. Results

1. Calculations and models on which results rely
2. How results are used as input to subsequent phases of the analysis
3. Transfer mechanism to subsequent phases of the analysis

#### K. Data used

1. Person responsible
2. Source (see data collection below for list of contents required)
3. How used as input to subsequent phases of the analysis
4. Transfer mechanism to subsequent phases of the analysis

#### L. Models used (see software and model development below for list of contents required)

#### M. Bibliography

#### N. Experts consulted

### III. DATA COLLECTION

#### A. For data sources that are documents or electronic storage media

1. Author
2. Title
3. Organization
4. Publisher
5. Place of publication
6. Date of publication
7. Publication number

8. Page number(s)
9. See item “C” (all data sources) below for additional contents that must be included

**B. For data sources that are telephone conversations, faxes, email transmittals, letters**

1. Name of speaker or sender
2. Title
3. Institution
4. Location of the institution
5. Date
6. See item “C” (all data sources) below for additional contents that must be included

**C. For all data sources above**

1. Data name (e.g., manufacturing cost, maintenance cost, installation cost, energy efficiency, energy use, retail price, producer price, shipments)
2. Value or range of values
3. Type of data (e.g., empirical observation, survey response, expert judgment, averages, other statistical measures)
4. Purpose for which the data are used (e.g., baseline design, design option, test procedure, consumption forecast, profit forecast, cost-effectiveness forecast)
5. Estimated error bars associated with the data
6. Storage location
  - a) Electronic copy (directory\subdirectory)
  - b) Location of computer, if not stored on a shared drive
  - c) Hard copy (physical location)
7. Names of reports, models, and equations in which the data are used

**IV. SOFTWARE AND MODEL DEVELOPMENT**

**A. Software developed outside of the group conducting the analysis (purchased or free)**

1. Name of product
2. Version number
3. Generic type of software (e.g., building energy simulation, economic forecast)
4. Software developer name

5. Storage location
  - a) Electronic copy (directory\subdirectory)
  - b) Location of computer, if not stored on a shared drive
  - c) CD (physical location)
6. Uses or purposes of the software or model in the analysis
7. Output of the model
  - a) Variable name
  - b) Variable definition
  - c) Units of measure
  - d) Level of disaggregation
  - e) Descriptions of table(s) and/or output file(s) in which the output occurs
    - 1) Table and/or file names
    - 2) Variables included
    - 3) Format options
8. Names of reports, models, and equations in which the results are used
9. Data requirements
  - a) Data name
  - b) Data description
  - c) Units of measure
  - d) Level of disaggregation
  - e) Format
  - f) Name of table(s) and/or input file(s), etc., in which data appear
  - g) Storage location
    - 1) Electronic copy (directory\subdirectory)
    - 2) Location of computer, if not stored on a shared drive
    - 3) Hard copy (physical location)

**B. Original software and models written in-house, and modifications written in-house to existing models**

1. Author(s)
2. Version number
3. Date
4. Language in or platform for which the software is written
5. Storage location

- a) Electronic copy (directory\subdirectory)
- b) Location of computer, if not stored on a shared drive
- c) CD (physical location)
- 6. Purpose of the software in the analysis
- 7. Overview of the approach used to accomplish the purpose
  - a) Capabilities of the software
  - b) Limitations
- 8. Output
  - a) Variable name
  - b) Variable definition
  - c) Units of measure
  - d) Level of disaggregation
  - e) Descriptions of table(s) and/or output file(s) in which modifications occur
    - 1) Table and/or file names
    - 2) Variables included
    - 3) Format options
- 9. Names of reports, models, and equations in which the results are used
- 10. Description of calculations for the portions developed (line by line of code or equations, or in blocks of lines, whichever is appropriate)
  - a) Purpose
  - b) Explanation of equation form and interaction of the variables
  - c) Relationship to other equations
  - d) Links to other spreadsheets or models
  - e) Assumptions
- 11. Variables in the models developed
  - a) Names
  - b) Definitions
  - c) Source
  - d) Number of characters
  - e) Units of measure
  - f) Level of disaggregation
  - g) Format
  - h) Name of table(s) and/or file(s) in which variable occurs
  - i) Field type (e.g., character, alphanumeric, note, date)
  - j) Field length of the data
  - k) Validation criteria, for example:
    - 1) Value range
    - 2) Computational check related to other fields
    - 3) Number of digits
    - 4) Number of decimal places
    - 5) Letters only
    - 6) Numbers only
    - 7) Upper or lower case only
  - l) Status of each variable by name (proposed, in use, obsolete)
  - m) Date of status
  - n) Storage location
    - 1) Electronic copy (directory\subdirectory)
    - 2) Location of computer, if not stored on a shared drive
    - 3) Hard copy (physical location)
- 12. Operating instructions
- 13. Debugging instructions

## V. COMPUTER SIMULATION RUNS

- A. Objective**
- B. Name of model, application, or software used**
- C. Version number of model, application, or software**
- D. Simulation run identification (denoted by input and output file identification numbers that are identical except for the prefix “input” or “output”)**
  - 1. Input file identification number and location
  - 2. Output file identification number and location
- E. Description of parameters and/or assumptions that characterize the uniqueness of simulation run**
- F. Date and time**
- G. Operator of the simulation run**





## 7. MAINTAINING AND ENFORCING ENERGY-EFFICIENCY LABELS AND STANDARDS

### Guidebook Prescriptions for Maintaining and Enforcing Standards

- 1 Minimize the need for enforcement through active participation of the regulated parties in the design and implementation of the program.
- 2 Establish fair, consistent, and practical criteria for certifying the energy efficiency of products.
- 3 Tailor the compliance approach to practicalities and available public and private resources.
- 4 Regularly monitor progress. Report both compliance and non-compliance.
- 5 Establish a graduated response to non-compliance, including private warning, public notification, and ordering of changes.
- 6 Establish sufficient penalties and adequate administrative processes to pose a credible threat to transgressors.
- 7 Resolve questions, disputes, and allegations promptly with clear decisions.

#### 7.1

#### What are Certification and Compliance?

Two activities are at the heart of maintaining and enforcing labeling and standards-setting programs: certification and compliance. In addition, test procedures, labels, and standards must be periodically updated to foster the continued infusion of new energy-efficiency technology into the marketplace.

##### 7.1.1 The Definitions of Certification and Compliance

Certification is the process by which a manufacturer or another entity (such as a private labeler or an authorized third party) affirms that an energy-consuming product meets a specified energy-efficiency threshold. In order to ensure consistency in and give credibility to claims about product energy efficiency, certification procedures should provide a clear direction about how to meet labeling or standards requirements. Compliance is the process of ensuring that a product meets energy-efficiency thresholds



and certification requirements. Compliance ensures that errors in reporting of energy efficiency and violations of standards are found and corrected so that product performance is returned to the permitted range, or, if necessary, that manufacturers whose products do not comply are punished. By making willful non-compliance unacceptable and unprofitable, certification and compliance protect the majority of manufacturers, who act in good faith to meet requirements.

### 7.1.2 The Importance of Certification and Compliance

Because of a high level of competition among manufacturers, there is a tendency to make every attempt to reduce the initial cost of most goods. In the absence of a certification program with a possible threat of enforcement actions, some manufacturers may be tempted to take shortcuts, trying to reduce first costs by leaving out more efficient (but costlier) design options, which will adversely affect products' energy efficiency. The existence of firm enforcement policies facilitates a level playing field for all manufacturers, stimulating the production of products with a higher energy efficiency while causing minimal increases in cost and simultaneously providing the benefit of large-scale energy savings for the nation.

In Australia, for example, the labeling scheme was developed from the outset as a joint initiative of governments and appliance suppliers. The major manufacturers and importers and their trade associations recognized the commercial value of a government-endorsed energy-labeling program and have generally remained very supportive. Initial industry misgivings about government involvement in regulating appliances has given way to a strong desire by the vast majority of suppliers to ensure that the system operates effectively. This support bears practical fruit; many suppliers, not wanting another supplier to gain a commercial advantage, provide government enforcement agencies with information about labeling misrepresentation made by other suppliers.

### 7.1.3 Authority for Labeling and Standards-Setting Programs

The specific authority that enables a labeling or standards program will generally specify the approach to be taken for its maintenance and enforcement. The approach must include the steps involved and the responsible agencies.

In some cases, the agencies responsible for labels differ from those responsible for standards. For example, the U.S. Federal Trade Commission (FTC) is responsible for the labeling of consumer products (National Archives and Records Administration 1998, 16 CFR) and the U.S. DOE implements the test procedures, standards, certification, and enforcement.

Amendments to the initial legislation may establish new standards, add or remove products from consideration, or change the procedures (see Insert Box: *Amending Legislation: the U.S. Energy Policy and Conservation Act*). For example, in the U.S., one of the amendments to the Energy Policy and Conservation Act (EPCA) added "Energy Efficiency of Industrial Equipment," which included air-conditioning equipment, furnaces, and some other types of equipment (Public Law 95-619). Subsequently, the Energy Policy Act (EPACT) also amended EPCA with respect to industrial equipment. It provided definitions, test procedures, labeling provisions, energy conservation standards, and

authority to require information and reports from manufacturers (42 U.S.C. 6311-6316). EPCACT also extended certain powers, originally granted to DOE under the National Appliance Energy Conservation Act (NAECA), to require manufacturers of covered equipment to submit information and reports for a variety of purposes, including ensuring compliance with requirements (42 U.S.C. 6316a).

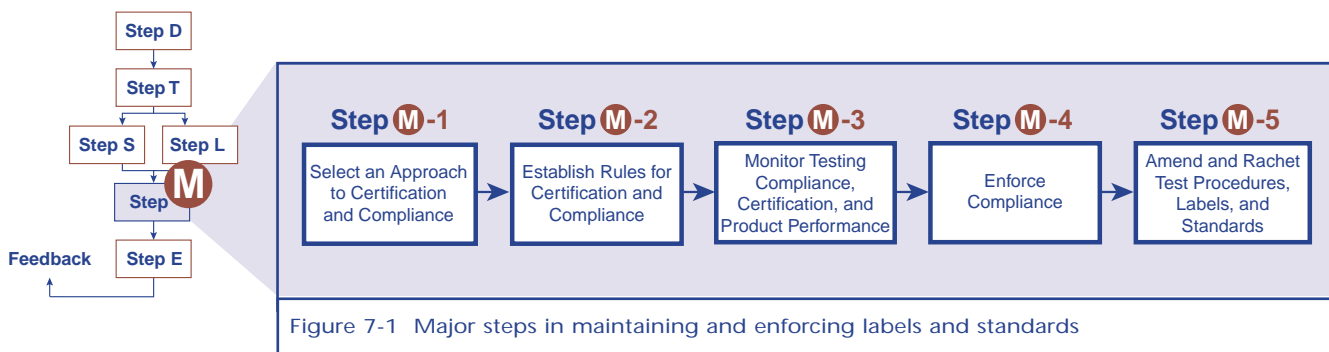
Because existing DOE regulations cover mostly residential consumer products, DOE recently created a new regulation to implement its program for the commercial and industrial equipment covered under EPCA. These include commercial heating, air-conditioning, and water heating equipment. This new program consists of test procedures, labeling, energy conservation standards, and certification and enforcement procedures. EPCA directs DOE, rather than the FTC, to administer the statute's efficiency labeling provisions for commercial equipment.

#### 7.1.4 The Steps in Maintaining and Enforcing Labeling and Standards-Setting Programs

Once a mandate is established for energy-efficiency labels or standards, significant, ongoing effort is required to administer the program if it is to have the intended impact on energy consumption. Manufacturers, distributors, and retailers need assistance in the mechanics of complying, and some need the threat of enforcement action to stimulate their compliance. As technology changes, test procedures require revision. Furthermore, standards need to be made more stringent over the years to bring the latest technology into the marketplace. The steps that make up the essence of any maintenance and enforcement program are shown in Figure 7-1.

### Amending Legislation: the U.S. Energy Policy and Conservation Act

In the U.S., the Energy Policy and Conservation Act of 1975 (EPCA, Public Law 94-163) authorized an energy-conservation program to set mandatory national standards for residential consumer products other than automobiles. Under EPCA, the U.S. DOE is responsible for implementing the energy conservation program. The law was subsequently amended several times: the National Energy Conservation Policy Act of 1978 (Public Law 95-619), the National Appliance Energy Conservation Act of 1987 (Public Law 100-12), the National Appliance Energy Conservation Amendments of 1988 (Public Law 100-357), and most recently by the Energy Policy Act of 1992 (Public Law 102-486).



Certification is most often done by manufacturers. Testing is done in the manufacturers' laboratories or in independent laboratories. Sometimes the government certifies testing laboratories. Possible approaches to verifying manufacturers' reported results include government testing and enforcement, cross-checking by competing manufacturers, and independent testing by consumer organizations. In different countries, each of these methods has been successful in identifying incorrect labels, leading to corrective action by the manufacturers. Duplication of certification and compliance, whether intentional or unintentional, creates the effect of a non-tariff barrier to trade and should not be allowed.

Different countries mandate different levels of enforcement. In the European Union (EU), it is the responsibility of each member state to ensure that EU law is applied and enforced in the state (Waide 1997). The situation is similar in Canada and Australia where standards and labeling authority rests with the individual provinces or states, not the national government.

Authority in the U.S. rests with the federal government. Once an enforcement action has been initiated in the U.S., DOE must proceed with the steps prescribed by statute (see Sections 7.4 through 7.6). However, other parts of the law (42 U.S.C. 6307) provide for consumer education that would prevent inadvertent violations and thus avoid the need for enforcement, especially for smaller manufacturers. Legislation requires the national government to carry out a program to educate consumers, in close cooperation and coordination with the agency responsible for labels and with appropriate industry trade associations and industry members, including retailers and interested consumer and environmental organizations. The program addresses:

- the significance of estimated annual operating costs;
- the way in which comparative shopping, including comparisons of estimated annual operating costs, can save energy for the nation and money for consumers; and
- other matters that DOE determines may encourage the conservation of energy in the use of consumer products.

Steps to educate consumers can include publications, audiovisual presentations, demonstrations, and the sponsorship of national and regional conferences involving manufacturers, distributors, retailers, and consumers, as well as state, local, and federal government representatives.

### 7.2.1 Compliance Verification Performed by Government

Australia is a good example of how a government can certify compliance. In Australia, energy labeling is mandatory under state government legislation and regulations that give force to the relevant Australian Standards (Harrington 1999). Regulations also specify the requirements for energy labels for appliances, including offenses and penalties for non-compliance with the requirements. In order to ensure a high

degree of credibility and compliance, the governments of Australia undertake a national testing program in which appliances are purchased from retail outlets and tested in accredited independent laboratories to verify the claims on the energy label and compliance with minimum energy performance standards (MEPS). This “check-testing” program publishes selection criteria that target appliances that appear likely to have a chance of failing rather than using statistical sampling methods to verify the detailed registration test reports that regulators require from suppliers registering appliances. The vast majority of check tests confirm the accuracy of suppliers’ labeling representations.

Appliances that fail check testing in Australia are subject to a range of sanctions under state laws. Regulatory agencies ensure that appliance suppliers that fail check testing are given a reasonable opportunity to respond. In circumstances where a supplier agrees with the check test, the appliance is “deregistered” (the supplier’s right to sell the appliance is withdrawn). In circumstances where a supplier disputes the check-test finding, the supplier is required to supply three additional units for testing at an independent laboratory. Statistical modeling has shown that failure of four units carries very high levels of probability that the model could not meet the standard’s requirements.

Australia acknowledges that significant public resources are required by check testing, not only for the cost of purchasing models and actual testing but also for fostering the skills of the accredited testing laboratories to undertake this work. The costs of the overall check-testing program are shared between the public and private sectors. All initial check tests are funded by government agencies, but any subsequent testing to verify or overturn the check-test result is at the supplier’s expense.

The Australian Greenhouse Office (AGO) is in the process of entering into an enforcement memorandum of understanding with the Australian Competition and Consumer Commission (ACCC). If necessary, the commission will use a range of sanctions for misleading and deceptive conduct arising from wrongly labeled or non-MEPS-compliant appliances and equipment. These sanctions could include fines of millions of dollars.

### **7.2.2 Self-Certification by Manufacturers**

The EU is a good example of a government relying on self-certification by manufacturers. In Europe, self-certification is the general rule for any application of norms, including energy-efficiency regulation. Test standards agencies (the European Committee for Standardization, CEN, and European Committee for Electrotechnical Standardization, CENELEC) are an important component of the market harmonization process embodied in the original treaty establishing the European Economic Community and in the Single European Act of 1986. These bodies issue European appliance testing protocols and safety standards that apply in all the nations that make up the European Economic Area (EEA) (i.e., the European Free Trade Association [EFTA], and EU states). Neither CEN nor CENELEC standards are mandatory within any European state unless they are incorporated in separate government legislation; however, in practice, CEN and CENELEC standards are almost always adopted by the standards bodies in all these states.

There is an opt-out clause in the European Treaty that stipulates that local trade protocols within EU member states can take precedence over the European protocols in some circumstances, although the legal precedents for doing so are complex. In order to ensure uniform implementation of standards within Europe, the European Organization of Testing and Certification (EOTC) was established in 1993. The EOTC has formed a group to cover electrical products and to ensure that European testing laboratories and certification bodies recognize each other's work.

In general, all the European energy-labeling and minimum energy-efficiency standards (MEES) directives rely on self-declaration by manufacturers, similar to the manner in which safety or performance norms are handled.

## 7.3

### Step **M**-2: Establish Rules for Certification and Compliance

The U.S. is a good example of how a government can establish prescriptive rules that help manufacturers certify their products and comply with energy-labeling requirements and energy-efficiency standards.

#### 7.3.1 Certification Rules

To fulfill its statutory obligations, the DOE Building Research and Standards Office (BRS) set up minimum performance standards for consumer products, developed test procedures, and proposed amendments to standards as needed. All appliance manufacturers and private labelers are affected by these standards. Affected companies are required to submit compliance statements and certification reports documenting compliance with specific requirements listed in the Code of Federal Regulations (CFR) (National Archives and Records Administration 1998, 10 CFR). Compliance documentation is accepted from the original equipment manufacturer of an appliance, private labelers for the appliance, or third-party agents acting on their behalf.

#### 7.3.2 Certification Requirements

##### Residential products

For residential consumer products marketed in the U.S., manufacturers must test a sample of each basic model of the product to establish its efficiency level and verify its compliance with the applicable energy-efficiency descriptor value specified by law. The test procedure for each product incorporates a sampling plan designed to give reasonable assurance that the true mean performance of the equipment being manufactured and sold meets or exceeds the applicable value and is accurately determined. The mean performance is a critical characteristic of a covered product because it determines the overall energy usage of a covered product population and thus the impact of the product on national energy consumption. Individual units produced from a single design may vary in energy efficiency, however, for a number of valid reasons, including variability in manufacturing.

In order to comply with energy-efficiency standards, companies involved in the manufacture, labeling, or assembly of regulated appliances must certify (in a compliance statement) that each model meets specific energy-conservation standards and must also document (in a certification report) the model's energy-consumption characteristics.

The compliance statement must certify that:

- the basic models comply with the appropriate energy-conservation standards;
- all required testing was conducted in conformance with appropriate test procedures;
- the reported information is true, accurate, and complete; and
- the manufacturer or private labeler is aware of the penalties for violations of the act.

For each basic model of an appliance, the certification report documents the model's energy-consumption characteristics and capacity. The CFR (National Archives and Records Administration 1998, 10 CFR) mandates specific design criteria for individual appliances. Additionally, for each covered product, a set of energy-consumption characteristics must be reported to DOE. **Table 7-1** summarizes the reporting requirements for each appliance. Each of the products listed in the table

**Table 7-1**

**Reporting Requirements for Residential Appliances in the U.S.**

*Each appliance has a definitive performance characteristic that must be measured and reported.*

Appliance	Reporting Requirements
Central air conditioners (cooling only)	Seasonal energy-efficiency ratio (SEER)
Heat pumps (cooling and heating)	SEER and Heating seasonal performance factor (HSPF)
Clothes dryers	Energy factor, capacity, and supply voltage
Clothes washers	Energy factor and capacity
Dishwashers	Energy factor and exterior width
Fluorescent lamp ballasts	Power factor and ballast efficacy factor
Pool heaters	Thermal efficiency
Refrigerators, refrigerator-freezers, freezers	Annual energy use and adjusted volume
Room air conditioners	Energy-efficiency ratio and capacity
Water heaters	Energy factor, rated storage volume

is also covered by the FTC's residential appliance-labeling program (National Archives and Records Administration 1998, 16 CFR).

### Commercial products

The enactment of EPACT substantially expanded DOE's role in the area of appliance labeling. EPACT addresses new labeling requirements. It mandates that DOE develop labeling rules for small and large commercial-package air-conditioning and heating equipment, packaged terminal air conditioners and heat pumps, warm-air furnaces, packaged boilers, storage water heaters, instantaneous water heaters, unfired hot-water storage tanks, and large electric motors (one to 250 horsepower). It also directs DOE to develop labeling requirements for high-intensity discharge lamps and small electric motors (less than one horsepower). It assigns most of the labeling responsibility for plumbing fixtures and certain lamps, commercial office equipment, and luminaires to industry and/or the FTC. EPACT requires DOE to provide industry with technical assistance on voluntary labeling and to assist the FTC in developing labeling guidelines and rules.

DOE is currently finalizing the rules governing the certification requirements for commercial products that were added by EPACT to the list of covered products. The currently proposed approach envisages using the services of voluntary independent certification programs (VICPs), typically trade associations, to certify that the product meets the minimum efficiency levels required by law.

#### 7.3.3 Exemption from Energy-Efficiency Standards and Labeling

Certain products are exempt from energy-efficiency standards and labeling either because they do not meet the definition of a covered product or because they have been specifically identified as exempt by the statute. For example, refrigerators and refrigerator-freezers with total refrigerated capacity of more than 39 cubic feet are exempt from U.S. standards. In Europe, absorption refrigeration appliances are excluded from energy-labeling and minimum performance standards. At one time in the U.S., within the first two years of the effective date of standards, small manufacturers of residential products with revenues less than \$8 million during the preceding 12 months could petition for a small-manufacturer exemption. However, the deadline for applying and the maximum available time limit for such an exemption is now past. For commercial equipment, there are no exemption provisions for small manufacturers.

Labeling rules which include the location, format, and content of each label for residential products, are prescribed in the U.S. by the FTC. For covered products, no exemptions are available unless the FTC determines by rule that labeling is not technologically or economically feasible for a certain product. For commercial products, DOE is assigned the task of developing the labeling rule, provided it is technically and economically feasible, leads to significant national energy savings, and is likely to assist consumers in making purchasing decisions. Because the necessary analysis to verify whether these criteria are being met has not been conducted, no labeling rules have been prescribed so far for commercial equipment.

## Step **M**-3: Monitor Testing Compliance, Certification, and Product Performance

Labeling and standards-setting programs may be implemented and enforced through participation by a variety of governmental agencies, typically including resource agencies (e.g., DOE), environmental agencies (e.g., AGO), and trade or consumer protection agencies (e.g., FTC or ACCC). Trade associations can also play an important role as the manufacturers' agent in providing compliance claims through industry certification programs and corresponding directories (see Insert Boxes: *Compliance Monitoring in Australia*, below, and *Compliance Monitoring in the EU*, next page).

### 7.4.1 Establishing a Compliance Office

Labeling and standards-setting programs inherently establish rules that prohibit specific actions. For example, U.S. law specifies that it is unlawful for any manufacturer of private labels to:

- sell any covered product that is not labeled in accordance with energy-efficiency labeling rules;
- remove from any new covered product or render illegible any required label;
- fail to permit access to, or copying of, records required to be supplied, or fail to make reports available or provide other information required to be supplied as part of an enforcement action;
- fail to comply with an applicable requirement to submit information; or
- sell any new covered product not in conformity with an applicable energy-conservation standard.

Because of the large volume of appliances and equipment being produced in the U.S., it is not practical for DOE to keep track of the energy efficiency of each product model. The enforcement strategy relies on the assumption that if a manufacturer overstates the energy efficiency of its product, competing manufacturers will be scrutinizing the efficiency claim and filing complaints with DOE if they suspect fraud.

### Compliance Monitoring in Australia

Australia surveys retail outlets to monitor compliance in showrooms. In November 1998, more than 29,000 appliances in almost 400 retail stores in the eight major cities in Australia were inspected. More than 92% of all appliances carried the ENERGY STAR® label. Regulators have committed to conducting similar surveys in the future.

The check-testing program is used to monitor compliance by manufacturers and importers. As many as 100 units a year (usually far fewer) of the more than 1,500 current appliance registrations recorded on regulator databases are examined. The number of deregistrations arising from check testing totals, on average, approximately 10% of the check tests undertaken. Australian regulators are confident that the system works and that consumers benefit from the current enforcement regime.



In Europe, the accuracy of the information presented on the EU energy label is the subject of much discussion, especially because manufacturers have the responsibility of ensuring that the information they supply is correct, and there is no automatic system of independent testing. Generally, manufacturers test their own products in certified test laboratories and report the testing results on the label; occasionally, third-party testing agencies are used. One of the difficulties of EU law is that it is up to all member states to ensure that EU law is applied and enforced in their states; the European Commission does not have the authority to initiate a centralized enforcement agency. Consequently, different enforcement regimes exist in each state, which means different systems of checking labeling compliance and different penalties for a violation of national law.

An additional problem is the range of tolerances used in the measurement tests for energy and product characteristics. These tolerances may be too generous in view of the increasing capacity for reproducibility that is possible with modern manufacturing processes.

Some serious cases of inaccurate energy consumption reporting are known to have occurred since the EU labeling scheme was introduced; however, thus far, in all cases where manufacturers have been challenged concerning the accuracy of the information they have supplied on their label, they have relabeled their products after third-party testing. In practice, offending manufacturers can be caught either by random independent testing conducted by consumer groups or by product testing conducted by competing manufacturers. Independent testing of the appliances where energy consumption was questioned has shown that manufacturers' reported values are generally optimistic but usually only to the point of taking advantage of the existing 15% reported energy consumption tolerance. As yet, there is no systematically gathered evidence to indicate how the accuracy of manufacturer-reported energy consumption has changed during the period since the energy label has been introduced.

Manufacturer trade associations have privately admitted some start-up problems when the energy label was first introduced that may have caused some inaccurate declarations to be

The same holds true in the EU. Several consumer associations (in Denmark, France, Germany, the Netherlands, and the UK) have identified some differences between what is being reported by manufacturers on energy labels and what the associations are finding through their own testing. When refrigerator manufacturers have been challenged about the accuracy of their labels, they have relabeled their products after third-party testing. As of the publication date of this guidebook, we are not aware of any action taken by any government agencies against these manufacturers.

### 7.4.2 Enforcement Tools

To comply with labeling requirements, appliance testing is required. Approaches to enforcement can include establishing a government program of random product testing, relying on independent con-

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made on labels; however, the associations claim that they are making progress in warning offenders and that the accuracy of the declared information has now improved to an acceptable level.

In October 1997, self-policing came into force among manufacturers. This system, which is run under the auspices of CECED, the European Committee of Domestic Equipment Manufacturers, allows any manufacturer or supplier that is a signatory to the agreement to challenge an energy label issued by another supplier. If the challenge cannot be resolved directly, the appliance in question will be tested in a company laboratory or, if agreement on this cannot be reached, in an independent laboratory. Costs are recovered from the party proved to be wrong. Few challenges have been made using this system. It appears that, in Denmark, suppliers are already operating a dispute resolution mechanism, similar to the CECED agreement, through the Danish trade association (FEHA). These self-policing systems complement the European self-conformity mechanism and may be responsible for some improvements in appliance energy-efficiency policies.

In Europe, the other major concern is compliance at the point of sale. A survey performed in 1997 on the labeling of “cold” appliances in retail stores showed that half of the appliances examined were not correctly labeled and failed to comply fully with the requirements set out in the European Directive. The most common type of non-compliance was the absence of all or part of the label.

To work properly, the label needs to be displayed prominently. If it is left inside the appliance, obscured, or placed at the base or on the side of the appliance, its impact will be reduced. The framework directive requires the label to be “placed on the outside of the front or top of the appliance, in such a way as to be clearly visible and not obscured” (Article 2.3).

Some countries, such as France, have already notified some retailers who failed to correctly display the label. The next logical step is to take them to court if the situation is not remedied.

sumer groups or competing manufacturers to test competitors’ products and report discrepancies to the government, and relying on an industry certification program to provide enforcement, as is done in the U.S. with the Association of Home Appliance Manufacturers’ (AHAM) certification program for room air conditioners. Tracking the information and making it publicly available are traditional means of facilitating independent checking of the test results for specific models and of comprehensiveness of the list (any model sold on the market can be checked to see if it is on the list). The information can be provided as directories or, preferably, as electronic databases (see Insert Box: *Compliance Monitoring in the U.S.*, next page).

### 7.4.3 Penalties

Before penalties are imposed, a process for communicating the concern to the affected manufacturer or importer is necessary. The steps necessary to obtain correction cover a broad range of possibilities depending on the culture. Some examples are:

#### Japan

In Japan, the sequence of enforcement actions is:

- the government notifies the manufacturer of non-compliance and recommends proper labeling;
- if non-compliance continues, the government makes public the failure;
- if non-compliance continues, the manufacturer is ordered to take measures to bring the product into compliance.

#### Australia

Australia is currently reviewing its enforcement regime. Deregistration has been the major sanction for appliances that fail the labeling standard. With the advent of MEPS, regulators are reassessing the need for sanctions commensurate with the scale of the breach. Regulators are considering annual public reporting of the outcome of the check-testing program.

The AGO, on behalf of all regulators, is in the process of entering into an enforcement memorandum of understanding with the ACCC. The commission may seek a range of legally imposed sanctions under the federal Trade Practices Act for misleading and deceptive conduct arising from wrongly labeled or non-MEPS-compliant appliances. These sanctions could include fines of millions of dollars. State regulators have agreed to supply the commission with details of check tests that could be used to mount federal court action.

#### United States

An allegation of fraudulent behavior in the U.S. can trigger an enforcement action that, if proven, can result in a civil penalty of up to \$100 for each violation. Depending upon the violation, the penalty may be assessed on a per-product-per-day basis.

The FTC imposes many of the penalties. However, DOE also imposes some penalties. For example, DOE can impose a penalty for failing to permit access to records or failing to provide copies of

### Compliance Monitoring in the U.S.

In 1992, responding to a committee request from the House of Representatives, the General Accounting Office (GAO) examined the federal residential appliance energy-efficiency program. In its report (U.S. GAO 1993), the GAO listed a number of shortcomings in this program and made recommendations to overcome them. As one of its results, the BRS Compliance Monitoring System (CMS) was created. The CMS is a database and associated tools that enable the BRS to quickly analyze missing compliance information and identify companies whose products are non-compliant. The CMS monitors the submission of compliance statements and certification reports to BRS by regulated companies and produces a summary report based on the missing information.

records required by DOE. It can also impose penalties for a manufacturer or private labeler failing to make a report or provide other information required by DOE during an investigation and a penalty for selling a covered product that does not meet minimum required efficiency levels.

DOE or an authorized officer can mediate civil penalties by taking into account the nature and degree of the violation and the impact of the penalty upon a particular respondent. Each violation for selling a product that does not meet standards and for removing a label constitutes a separate violation for the product, and each day that passes without some requested information being provided also counts as a separate violation.

As described below, penalties can only be imposed following an elaborate procedure that can be subject to a judicial review.

## 7.5

### Step **M**-4: Enforce Compliance

#### 7.5.1 Judicial Review of Labels and Standards Rules

Under U.S. law, standards and labeling rules must afford any interested persons an opportunity to present written and oral data, views, and arguments on any proposed rule. Additionally, for standards and labeling rules, DOE must use conferences or other informal procedures to allow an interested party an opportunity to question others who make oral presentations. Interested parties must also be allowed to question the DOE personnel who made presentations with respect to disputed issues of material fact. These opportunities must be afforded if DOE determines that such questioning is likely to result in a timely and effective resolution of the issues. A transcript must be kept of any oral presentations.

Any person who could be adversely affected by a standards rule may file, within 60 days after the rule is prescribed, a petition with the U.S. court of appeals for a judicial review of the rule. The court then sends a copy of the petition to DOE. The agency must file the written submissions and transcript of the rule proceedings. The court has the jurisdiction to review the rule and to grant appropriate relief under the law. No rule may be affirmed unless supported by substantial evidence. The judgment of the court affirming or setting aside any rule in whole or in part is final but is subject to review by the Supreme Court. These remedies are in addition to, and not in place of, any other remedies provided by law. These provisions are not considered modified, affected, or superseded by other laws unless this is explicitly allowed by the provisions themselves. The jurisdiction over all such legal actions is vested in the federal district courts.

#### 7.5.2 Judicial Review of an Enforcement Action

A civil penalty can be assessed on any person who knowingly violates provisions of U.S. law related to energy-efficiency standards and labeling. Depending on the specific provision involved, either DOE or the FTC is authorized to impose this penalty. However, before issuing an order assessing a civil penalty, DOE or the FTC must provide notice of the proposed penalty. At that time:

- The person can do nothing, in which case DOE will wait for 30 days and then provide the person an opportunity for an agency hearing before an administrative law judge. If the judge makes a determination (which will be on record) that a violation has occurred, DOE will assess a penalty and issue an assessment order that will include the administrative law judge's findings and will explain the basis for the assessment.
- The person then has 60 calendar days to either pay the fine or appeal for a judicial review in the U.S. court of appeals. If not appealed within 60 days, the order becomes final and cannot be appealed. If the order is appealed, the court has jurisdiction to enter a judgment affirming, modifying, or setting aside all or part of the assessment order, or to remand the proceeding to DOE with directions for further action.
- Alternately, the person can request, within 30 days, an expedited procedure, in which case DOE will promptly impose the civil penalty without going through the hearing on record. At this point, the person has a 60-calendar-day period to either pay the fine or appeal for a judicial review, as described above.
- If a civil penalty assessment order is issued and is not paid within 60 calendar days, DOE must institute an action in the appropriate U.S. district court for an order affirming the assessment of the civil penalty. The court has the authority to review the law and the facts involved and the jurisdiction to enter a judgment enforcing the assessment, modifying and enforcing it as modified, or setting it aside in whole or in part.
- After the above steps are completed, if the civil penalty assessment still stands and the person fails to pay it, DOE must institute an action to recover the amount in any appropriate U.S. district court. At this point, the validity and appropriateness of the final assessment order or judgment cannot be subject to review.
- For violations where the FTC is authorized to impose the civil penalty, the FTC would take similar steps.

### **7.5.3 Role of the Threat of Legal Action**

We are not aware of any research or analysis that shows the extent to which the threat of legal action for violating standards plays a role in compliance by individual manufacturers. Anecdotal data for Australia, Canada, Europe, Japan, and the U.S. indicates that few established manufacturers are willing to violate the law knowingly. Most large manufacturers of residential products are members of their respective trade associations and have their product models listed in the product directory. Trade association directories typically do not list any products with efficiencies below the levels required by law, which has a kind of filtering effect. Also, the certification programs of these associations usually contain provisions that penalize a manufacturer by dropping the listing of all models of their product even if the efficiency of just one model is proven to be overstated. Although the associations may not actively carry out checks of the accuracy of manufacturer-reported efficiencies, other manufacturers typically scrutinize the

efficiencies reported by their competitors and report suspect models to the trade association as well as to the government. Some violations reported in the U.S. concern small manufacturers who are not members of a trade association and may not be familiar with the law. For commercial equipment, DOE is currently finalizing rules that would allow the trade associations to act as conduits for certifying products' compliance with federal standards.

If the government maintains a list of registered products, the government can deregister or remove models from the approved listing. Then those models cannot be sold in that jurisdiction. Most major manufacturers prefer to avoid the costs and bad publicity that might be associated with the need to withdraw a model from the market.

## 7.6

### Step **M**-5: Amend and Ratchet Test Procedures, Labels, and Standards

#### 7.6.1 The Importance of Ratcheting

Technologies are continuously evolving, offering new opportunities for energy conservation. For example, as detergents have improved, clothes can be effectively washed with cold water where previously hot water had been necessary. Furthermore, as technologies evolve, consumer usage patterns change. The agency implementing energy-efficiency labels and standards must periodically update test methods, label requirements, and standards levels to maximize the country's economic and energy efficiency.

Key reasons for updating test methods include the need to:

- keep test methods relevant to consumers' actual usage,
- adopt the relevant international (IEC or ISO) standard wherever feasible,
- maintain repeatability and reproducibility in testing, and
- cater to every design on the market.

Labels need updating as the energy performance of products changes over time. If labels involve classifying products into categories (e.g., A through F, with A being most efficient and F being least efficient), changes in the range of products available for sale may dictate the need to change the definitions of the range. For example, if a new design arrives that is significantly more efficient than any previous design, the definition of the A category may need revision. Alternatively, if, thanks to standards or changes in consumer environmental consciousness, all products have moved out of the inefficient categories (D-F) and up to the efficient categories (A-C), then the definitions need to be reset to better inform consumers of the differences among current products.

Standards are designed based on current new technology that can be mass produced in a few years' time. Technological possibilities change over time, and so do consumer tastes and usage behaviors.

Furthermore, new materials (plastics, electronics) become available and the costs of materials and of energy change. For technological as well as economic reasons, standards need to be updated regularly. As an example of regular updating, the U.S. refrigerator, refrigerator-freezers, and freezer energy-efficiency standards originally set in 1987 with effective dates in 1990 were updated in 1989 to become effective in 1993, and updated again in 1997 to become effective in 2001. Given the practicalities of the need to recover the investments required each time standards are made more stringent, the frequency of update should be about every 3-10 years.

### 7.6.2 Amending or Expanding Energy Standards-Setting Programs

U.S. law allows the DOE to prescribe new or amended energy conservation standards for certain products by following a well-defined set of guidelines and procedures (42 U.S.C. 6295 o, p). These provisions of the law authorize the Secretary of Energy to prescribe amended or new energy conservation standards for each covered product. Any person may petition DOE to conduct a rule making to determine whether a covered product's standard specified in the most current rule should be amended. By law, DOE must grant such a petition if it finds that the petition contains evidence that, on its own, provides an adequate basis for amending the standard under the set of criteria described below. Granting this petition sets in motion the rule-making process, a sequence of events that can, depending on the outcome of the public hearings and other activities, result in a new or amended standard for a product. The granting of the petition does not, however, guarantee that the rule-making process will lead to any particular outcome.

The following are the criteria that the U.S. law requires DOE to use in setting new energy conservation standards or amending existing energy conservation standards. DOE must determine whether:

- the amended standards will result in significant energy conservation,
- the amended standards are technologically feasible, and
- the amended standards are economically justified.

The determination of whether a standard is economically justified requires DOE to find, after receiving public views and comments (usually by announcing and holding public meetings and workshops), whether the benefits of the standard exceed its burdens by considering, to the greatest extent practicable:

- the economic impact of the standard on manufacturers and on consumers of the products subject to the standard;
- the savings in operating costs throughout the estimated average life of the covered product compared to any increases in the price of, the initial charges for, or the maintenance expenses of the covered products that are likely to result from the imposition of the standard;
- the total projected energy savings likely to result directly from the imposition of the standard;
- any decrease in the utility or the performance of the covered products that is likely to result from the imposition of the standard;

- the impact of any decrease in competition, as determined in writing by the U.S. Attorney General, that is likely to result from the imposition of the standard;
- the need for national energy conservation; and
- other factors DOE considers relevant (these have included oil security and environmental concerns but are not limited to those areas).

DOE may not prescribe any amended standard that increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered product. Also, an amendment can only apply to products manufactured not less than five years after the effective date of any previous amendment and not less than three years after publication of the final rule for a currently covered product.


The U.S. Attorney General must make a determination of the impact, if any, of any lessening of competition likely to result from a new standard and transmit this determination, along with an analysis of the nature and extent of the impact, to DOE within 60 days of the publication of a proposed standard. This determination and analysis must be published by DOE in the Federal Register.

For purposes of the benefit-cost analyses, if it is found that the new standards levels offer a payback period of three years or shorter, DOE has a sufficient (but not a necessary) basis to presume that the standards level is economically justified. However, this presumption can be rebutted during the public comment process.

Labeling and minimum performance standards-setting programs need continuous maintenance and enforcement to be effective. This chapter has described some approaches to certification, compliance, and updating that can help make labeling and standards effective. The final step in labeling and standards setting, evaluating the processes and outcomes of the program and providing feedback on the actions taken in all the previous steps, is described in Chapter 8.







## 8. EVALUATING THE IMPACT OF APPLIANCE ENERGY-EFFICIENCY LABELING AND STANDARDS

### Guidebook Prescriptions for Evaluating the Impact of Labeling and Standards

- 1 To achieve efficient program design and data collection, begin the evaluation process as soon as you decide to establish a labeling or standards-setting program.
- 2 Before conducting the evaluation, make sure that all the key stakeholders understand the objectives of the evaluation and the resources that are available and necessary for conducting the evaluation.
- 3 In order to minimize costs, try to leverage existing data sources, so data collection efforts can focus on primary data collection. Allocate some of the evaluation budget to up-front costs.
- 4 Establish a national appliance database and develop a baseline of the market (“market characterization”) of appliances that are being promoted.
- 5 Evaluate both the process of program implementation and the impact of the program on energy consumption, emissions, energy bills, and the appliance market.
- 6 Use a diverse group of data collection methods rather than relying on just one method.
- 7 Evaluate the impacts on all key stakeholders, including consumers, manufacturers, retailers, and policy makers. Focus on how the evaluation findings will be used in:  
a) refining appliance labels and standards, b) improving the implementation of the labeling and standards program, c) supporting other energy programs and policies, and d) forecasting energy use and strategic planning.

Once appliance labeling and standards programs have been implemented, it is necessary to evaluate their effectiveness. Evaluation is important to identify areas of weakness in the program design and implementation so that these can be strengthened and to measure the program impacts on product efficiency, energy consumption, operating costs, manufacturing/retailing, and the environment. Measuring impacts is important to justify allocating resources to the project and to ensure that it receives sufficient funding to be effective. Policy makers will find evaluation results useful during internal governmental resource allocation discussions where they may be asked to prove that a program is saving sufficient resources. An evaluation can be designed with almost any level of resources to meet prioritized needs of time, cost, or accuracy.

## Comprehensive Evaluation of the EU's Labeling Program

The EU introduced framework legislation for mandatory energy labeling in 1992 and has since issued product-specific energy-labeling directives for refrigerators and freezers, clothes washers, clothes dryers, combined clothes washers and dryers, dishwashers, and household lamps.

Evaluation of the labeling scheme has been concerned with monitoring retailer, distributor, and manufacturer compliance with the legislation and with evaluating the impact of the labeling scheme on energy use, energy efficiency, CO<sub>2</sub> emissions, and cost trends. As the energy label for refrigeration appliances (refrigerators, freezers, and their combinations) was the first to be introduced, this category has received the most attention to date. Two years after the implementation of the labeling program for refrigerators, the European Commission launched a study to assess legislative compliance and program implementation issues and a separate study to assess quantitative sales-weighted energy efficiency, energy, and emissions trends. The implementation/compliance study involved the following steps:

- surveys of representatives to the European Commission's Energy Labeling Committee, 10 retail outlets in each member state, 16 mail-order catalogs in eight member states, and numerous customers, to assess compliance, learn about consumer attitudes and responses, and discover any legal and governmental issues that may have arisen in each country;
- independent tests in consumer association laboratories across the EU to evaluate the accuracy of manufacturer product performance declarations; and
- interviews with manufacturers and retailers to assess their attitudes and responses and discover any concerns that may have arisen.

The quantitative study evaluated the sales-weighted efficiency trends of refrigeration appliances sold in the EU from 1994 to 1996 and compared them to the prelabeling legislation levels circa 1992. Although this study examines the impact of labels, several interlocking policies, of which labeling was one, were in effect during this time period. Yearly data on the sales volume and average retail prices of individual refrigeration appliances were purchased on a country-by-country basis from established market research agencies. These data were then matched to separate technical databases containing model-by-model information on the technical characteristics of the appliances, including all aspects needed to evaluate their energy consumption and efficiency. The quantitative assessment found that the sales-weighted efficiency of refrigeration appliances had improved by 10% from 1992 to 1996. More recent data indicate that this is likely to reach 30% by early 2000. Compared to a static-efficiency base-case scenario (but assuming that average efficiency is also frozen after 1999 at late 1999 levels), it is now estimated that the improvements in refrigeration appliance

efficiency will lead to energy savings of 398 TWh, avoided electricity bills of 56 billion Euro, and avoided CO<sub>2</sub> emissions of 237 megatons for the 25-year period ending in 2020. These figures are based on the assumption that declared energy consumption equals actual consumption, which is supported by some regionally specific end-use metering studies. The accuracy of the consumption numbers for individual models has sometimes been questioned based on concern that the results of these studies may not be applicable to the entire EU. The uncertainty results primarily from assuming that energy consumption under standard test conditions is representative of energy consumption in consumers' homes.

It has further been calculated that each Euro spent under the labeling program for refrigerators has led to actions by manufacturers and member states that will result in avoided consumer electricity bills worth 100,000 Euro. This process is now being extended to include data for the years 1997 and 1998 and to add data for clothes washers, washer-dryers, and household lamps.

The compliance/implementation assessment found that implementation of the legislation varied considerably among member states. Both Germany and Italy implemented the legislation within their borders only in 1998 and 1999, respectively, after receiving formal warnings from the European Commission. Retailer compliance was low, with an average of only 56% of refrigeration appliances on display across the EU in the summer of 1997 being correctly labeled and considerable variation among member states. This issue was recently reexamined, and the variation among countries was high, with compliance being higher in countries where the legislation had been implemented the longest. The accuracy of the declared performance was low, with efficiency levels declared by consumer associations and manufacturers diverging by up to four labeling classes, with an average of one. By contrast, the stated impact of the label on consumer purchasing patterns was found to be substantial, from 4% (Greece) to 56% (Denmark), and to be strongly related to the level of compliance. Overall, the data show that, together with the suite of concurrent market transformation policies, the labeling scheme has had a very strong impact on both the efficiency of the products being offered by manufacturers and the purchasing behavior of consumers. Since the 1997 analysis, recent data show that the degree of discrepancy between manufacturer declarations and consumer perceptions has fallen considerably.

The two keys to improving the effectiveness of the labeling scheme are to increase the proportion of labeled appliances in shops and to persuade individual consumers that energy use is an important criterion in buying appliances. The EU used the evaluation results to take measures to improve the situation. The sales-weighted average energy efficiency of refrigeration appliances improved by 29% between 1992 and late 1999. It is estimated that 16% of the impacts is due to minimum efficiency standards and 10% is due to the impact of labeling.

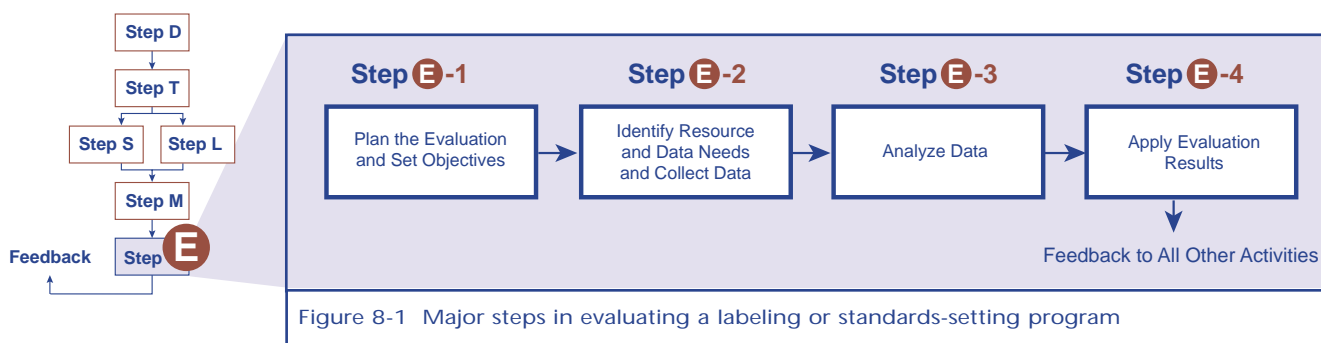
*Sources: Boardman 1997, Windward et al. 1998, Waide 1998 and 1999, Bertoldi 2000.*

Unfortunately, there has been very little post-implementation evaluation of appliance labeling programs, although this situation is beginning to change. In the U.S., most impact assessments of efficiency standards have taken place in the period just prior to adoption of new efficiency standards, based on forecasted information about product shipments and customer use (Nadel 1997). These evaluations rarely use any field measurements, nor do they attempt to systematically examine what would have happened if standards had not been adopted (Meier 1997, Nadel 1997). Similarly, many past evaluations of appliance-labeling programs have focused on consumer awareness of the label and have not explicitly linked the label to actual behavior (i.e., to the efficiency of the appliances purchased). However, some recent evaluations of appliance labeling programs include data on actual sales and behavior. Examples include evaluations of the European Commission's labeling program (Beslay 1999; Schiellerup and Windward 1999; Waide 1997, 1998; Windward et al. 1998; Bertoldi 2000) and the labeling programs in Australia (Harrington and Wilkenfeld 1997), Thailand, and the U.S. (du Pont 1998a, 1998b) (see Insert Box: *Comprehensive Evaluation of the EU's Labeling Program*, previous pages).

Future evaluations of labeling and standards-setting programs are likely to be more comprehensive than existing ones as labeling and standards programs are designed to be market-transformation strategies (e.g., see Barbagallo and Ledyard 1998, Hagler Bailly 1996 and 1998, HBRS 1995, Hewitt et al. 1998, Pacific Energy Associates 1998, Xenergy 1998). As labeling and standards programs are increasingly implemented in developing countries, evaluation is expected to play a critical role in enhancing their effectiveness.

The evaluation process should begin when the process of establishing labeling and standards programs begins. That way, programs can be designed effectively, data collection can be conducted efficiently, and key stakeholders can be made aware of the importance of the evaluation and will likely feel more receptive to the evaluation's findings. In this chapter, we describe the types of activities that occur in the evaluation of labeling and standards programs and give a few examples of how labeling programs have been evaluated.

Figure 8-1 shows the four steps necessary in evaluating labeling and standards-setting programs. Some of these steps are interactive and, as noted above, the conceptualization of them should be incorporated



into an evaluation research plan early in the process of designing and implementing energy-efficiency labeling and standards-setting programs.

The rest of this chapter discusses these evaluation steps in more detail.

## 8.1

### Step **E**-1: Plan the Evaluation and Set Objectives

#### 8.1.1 Evaluating Labeling vs. Standards Programs

For both labeling and standards-setting programs, it is important to evaluate the program's process as well as its energy and economic impacts. For appliance standards, an evaluation should focus on manufacturers' decisions and changes in the efficiency of models sold in the marketplace. Although manufacturer decisions are also affected by energy labels, an evaluation of a labeling program should place more emphasis on understanding the sales and purchase process in order to assess the impact of labeling on retailer and consumer decisions. An evaluation of a labeling program will generally involve qualitative research to understand the process of consumer decision making and the actions of multiple stakeholders involved in the manufacture, sale, and distribution of appliances. In addition, the impacts of labeling programs affect behavior during a longer period of time and are often more subtle than the impacts of standards, which take effect relatively abruptly and can be fully observed during a reasonably short time period.

#### 8.1.2 The Objectives of Evaluation

An evaluation can focus on a program's process and/or its impact on energy and demand. The best evaluations should have both process and impact components.

##### Process evaluation

Process evaluation is often qualitative and measures how well a program is functioning. Unfortunately, policy makers sometimes see process elements as less important than impacts on energy use. However, process elements are critical to the implementation and success of a program. Process elements include:

- assessing consumer priorities in purchasing an appliance,
- tracking consumer awareness,
- monitoring correct display of labels in retail showrooms,
- measuring administrative efficiency (e.g., registration times), and
- checking and verifying manufacturer claims (maintaining program credibility).

## Impact evaluation

Impact evaluation determines the energy and environmental impacts of a labeling program. Impact data can also be used to determine cost effectiveness. Impact evaluations can assist in stock modeling and end-use (bottom-up) forecasting of future trends as well. Impact elements include:

- influence of the label on purchase decisions,
- tracking of sales-weighted efficiency trends, and
- determination of energy and demand savings.

Impacts can be very difficult to determine accurately, especially for a labeling program. One of the fundamental problems is that, once a program such as energy labeling has been in place for some period, it becomes increasingly difficult and hypothetical to determine a “base case” against which to compare the program impact.

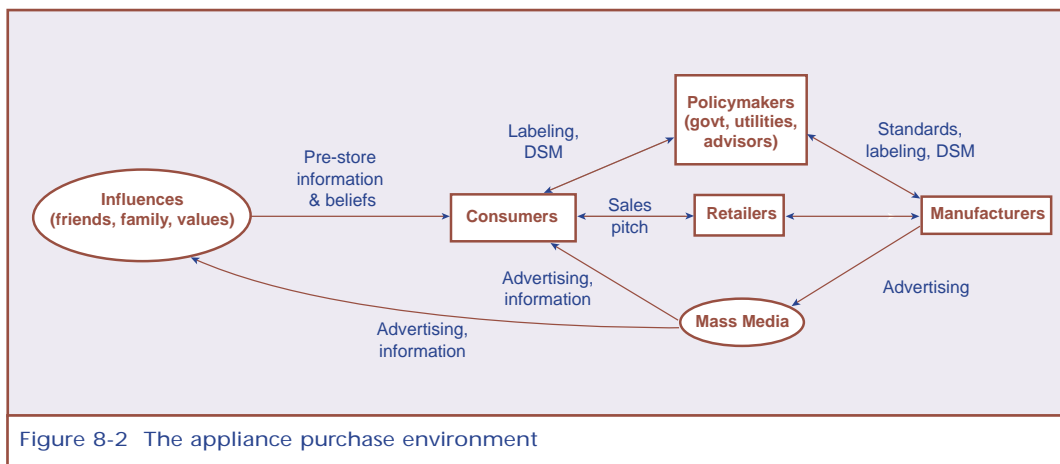
Both process and impact evaluation should occur regularly during the life of a labeling and standards program, especially during initial implementation.

Process and impact evaluations of labels and standards can be conducted based on either “resource acquisition” or “market transformation” objectives. Using a resource acquisition perspective, the primary objective of evaluation is to calculate energy and demand savings and greenhouse gas (GHG) emissions reductions (i.e., the reduced need to purchase energy from a power plant). Using a market transformation perspective, the primary objective of evaluation is to see whether sustainable changes in the marketplace have occurred as a result of labels and standards programs.

Program designers using market transformation as a goal are increasingly using theories that contain hypotheses about how the program might affect market players (Theory Evaluation). Program designers with this perspective benefit from evaluations that test their hypotheses both through interview and by tracking market indicators, which can then be translated into impacts. In addition, there are short-term theories of how a market will evolve so that private actors might shift toward promoting more efficient products in the absence of a program. A theory-based approach, similar to a process evaluation, would test many of the hypotheses presented in this chapter, such as “most/some/all consumers will use labels as part of their purchase decisions” or “labels will encourage manufacturers to improve the energy performance of their products.”

An appliance-labeling program influences the activities of many market players, including consumers, retailers, and manufacturers. **Figure 8-2** shows how the various actors interact and affect the purchase environment and, ultimately, the purchase decision of the consumer. Evaluators initially focus on changes in the attitudes and behavior of market players (“leading indicators”), which can be measured in shorter periods of time than energy savings, appliance sales, and GHG emissions reductions (“lagging indicators”).

Planning the evaluation of a program with complex interaction among stakeholders can be a challenge.



## 8.2

### Step E-2: Identify Resource and Data Needs and Collect Data

#### 8.2.1 Resources Needed for Evaluation

The costs of evaluating labeling and standards programs will vary depending on a number of factors, such as the quantity and type of available data and whether energy savings are calculated by engineering estimates or with end-use metering of a sample of products. Most comprehensive evaluations rely on the collection of survey, sales, and billing data. The use of end-use monitoring equipment to measure energy consumption for specific appliances will increase the cost of evaluation, as would the purchase of commercially available market research data on sales of different models. Although most evaluation costs occur after a program has been implemented, it is important to allocate some of the evaluation budget for up-front costs when the labeling and standards-setting programs are being discussed and the evaluation research plan is being developed.

#### 8.2.2 Data Needed for Evaluation

Many types of data are useful for evaluating the impact of labeling and standards-setting programs, and many methods are available for collecting these data. The data requirements for evaluating the impacts of labeling programs are similar to those for standards-setting programs in many ways and different in others. For example, label impact evaluations are likely to rely more heavily on consumer surveys although some assessment of individual consumer attitudes is useful in standards-setting evaluations as well. Whenever possible, secondary data sources (e.g., industry and government reports) should be analyzed first because these are the most cost-effective sources of information. Once these sources are used, primary data collection should begin based on interviewing and surveys and focusing first on the most important data needs for the country in question. **Table 8-1** provides information on the types of data needed and how they should be collected.



A caution is in order. Definitive data to support assessment of the impact of labeling and standards programs is, at best, difficult to obtain. Understanding true consumer purchase behavior requires a carefully constructed research protocol, and ad hoc research is not likely to provide the necessary information. Consumers' verbal endorsements of the value of a specific appliance attribute or label may not coincide with their financial decision actions. Manufacturing costs and mark-up rates throughout the distribution chain are generally not available. Market share and consumer purchase choices are also influenced by many factors unrelated to relative energy efficiency. The amount of time and resources appropriate for evaluation is often greater than initially anticipated and budgeted.

### 8.2.3 Types of Data

A first step in evaluation is to collect model-specific data for establishing a national appliance database. This database will contain information on the models that are manufactured and their annual sales, prices, and technology characteristics. The database can be used to monitor national appliance efficiency trends. When energy use is analyzed, utility bill data or, in some cases, end-use metered energy data should be collected. Other types of data needed include the attitudes and behavior of key market players

Table 8-1

Evaluation Data Types and Data Sources

*Labeling and standards-setting program evaluation uses a variety of data from a variety of sources*

Data Type	Main Data Source
Customer and retailer knowledge, awareness, and understanding	Surveys of customers and retailers
Availability of products	Sales data from manufacturers, trade associations, or government Surveys of manufacturers and retailers
Prices for efficient products	Surveys of customers, retailers, and manufacturers
Market penetration	Sales data from manufacturers, trade associations, or government Surveys of participant and non-participant customers Surveys of suppliers
Energy use	Manufacturer data Independent laboratory data Engineering specifications Metered end-use data
GHG emissions	Reported emissions factors Utility dispatch model data

and market characteristics (e.g., number of manufacturers and retailers, percent of appliances in stock that are energy efficient). Finally, it is important to note that it is always possible to carry out some level of evaluation, no matter how crude the data sources and how limited the resources. Evaluators should not be discouraged if they cannot gather data of the highest quality; compromises in accuracy can be made to limit cost.

#### 8.2.4 Data-Collection Methods

It is very important to collect data at the beginning of the process of designing and implementing standards and labeling programs. Whenever possible, cooperative agreements with industry should be encouraged to gather data on sales and efficiency levels. Sales data can be obtained from surveys of manufacturers, retailers, and/or contractors. Products in stores can be inspected visually to assess compliance with labeling programs and to collect information on stocking practices (sometimes this is done by a “mystery shopper” who visits stores unannounced and unidentified). Appliances can be tested in laboratories to measure energy use and assess the accuracy of labels. Finally, interviews with consumers, retailers, manufacturers, and contractors often play a central role in assessing the extent of market transformation (see Insert Box: *Evaluation of Thai Labeling Programs Using Manufacturer and Consumer Surveys*, next page).

### 8.3

#### Step E-3: Analyze Data

A comprehensive analysis is needed to evaluate resource acquisition and market transformation. Although this type of analysis has usually been focused on labeling programs, it can also be used to evaluate appliance standards.

#### 8.3.1 Baseline

It is critical for an evaluation to establish a realistic and credible baseline—that is, a description of what would have happened to energy use if labels and/or standards had not been implemented. Determining a baseline is inherently problematic because it requires answering the hypothetical question “what would have happened in the absence of labels and/or standards?” To accurately evaluate energy savings, it is necessary to analyze energy use of a sample of households/facilities before and after the installation of an energy-efficient product. For example, energy use might be measured for a full year before the date of the installation of the efficient appliance and then for several years after the installation. Some types of appliances may not require a full year of monitoring, however. If loads and operating conditions are constant over time, short-term (e.g., one-week) measurements may be sufficient to estimate equipment performance and efficiency. These data would then be used for calibrating engineering estimates that could generally be applied to the population of energy-efficient products. Frequently, load research data are available for establishing product baselines (see Chapter 3, Section 3.4).

## Evaluation of Thai Labeling Programs Using Manufacturer and Consumer Surveys

In early 1994, the Electricity Generating Authority of Thailand (EGAT) approached the five Thai manufacturers of household refrigerators and quickly gained their cooperation for a voluntary energy-labeling program. The efficiency scale on the energy label ranges from 1 to 5, with 3 as the average and 5 as the most efficient. A selection of the models in this size range was tested during fall 1994 to establish the average efficiency level. Models that fell within 10% of the mean were rated at 3; models that were 10 to 25% more efficient than the mean were rated at 4; and models that were more than 25% more efficient than the mean were rated at 5.

A similar labeling program for air conditioners began in early 1996. Negotiations with air conditioner manufacturers were more difficult than those with refrigeration manufacturers because of the diverse and fragmented nature of the Thai air-conditioner industry, which consists of 200 manufacturers, many of which are small, local assembly operations. Most Thai air conditioners are produced by the 15 largest firms. Unlike in the refrigerator market, where efficiency levels were relatively similar among manufacturers, the Thai air-conditioner market has a trimodal distribution: low-cost, low-efficiency locally produced models; higher cost, moderate-efficiency locally produced models; and high-end, high-efficiency models dominated by imports. The air-conditioner manufacturers chose to place energy labels only on the most efficient units, those with a rating of 5. Thus, consumers were faced with a choice between buying a unit with a label (i.e. a rating of 5) or a unit with no label (i.e. an invisible rating of 4, 3, or worse).

In 1999, the Thai demand-side management (DSM) office commissioned a comprehensive evaluation of its energy-labeling programs. The evaluation had three major components:

- a process evaluation, to gather qualitative data about the behavior and attitudes of consumers and manufacturers and their reactions to the program;
- a market evaluation, to assess the impact of the program on manufacturer decisions and market penetrations; and
- an impact evaluation, to assess the program impact in terms of energy and demand savings.

The study was carried out using two primary data collection techniques:

- a manufacturer survey, which entailed development of a detailed survey questionnaire that was administered through in-person interviews with marketing and production personnel at 50 manufacturing and distribution firms, and
- a residential survey that was conducted by a team of 18 surveyors who administered a detailed, five-page survey to 2,000 households in Bangkok and three upcountry cities in Thailand.

The evaluation found a high level of awareness of the label among Thai consumers. Non-participants (consumers who purchased a refrigerator or an air conditioner without a label) indicated that they did not buy a labeled refrigerator for the following reasons:

- they were not aware of energy-efficient refrigerators,

- labeled units were not available where they purchased the unit, or
- the salesperson recommended a non-labeled unit.

The evaluation yielded the following findings specific to the air-conditioner program:

- participants tended to have higher incomes than non-participants,
- testing and labeling had a high degree of credibility among consumers,
- the zero-interest loan program offered by EGAT for air conditioners had a very low participation rate because of lack of support by retailers and the perception that the process was complicated and involved intensive paperwork.

The manufacturers of both refrigerators and air conditioners reported that they were highly satisfied with the program. For air conditioners, however, the retailers were not satisfied; only 29% of the Green Shops surveyed (stores that participated in EGAT's no-interest loan offer for models rated 4 and 5) felt that the marketing campaign by EGAT was adequate. A number of the manufacturers also suggested that the program could be improved by increasing the speed and accuracy of the testing process. They also recommended that EGAT consider targeting promotional and educational campaigns toward salespeople in order to increase their interest and ability to market the higher-efficiency models.

The impact evaluation was based on direct metering of air conditioners and refrigerators in several hundred homes. The metered savings were combined with data from the surveys of residential households and manufacturers and with program data on the size and efficiency of models, to estimate the energy and demand savings attributable to the program. The table below summarizes the savings for the Thai energy-labeling programs.

#### Summary of evaluated savings from Thailand's energy-labeling programs

	Number of Labels	Energy Saving (GWh/yr)	Demand Savings (MW)		Benefit-Cost Ratio		
			Avg.	At Peak	Consumer Resource Cost	Utility Resource Cost	Total Resource Costs*
Refrigerators	3,698,177	235	80	14.0	2.2	9.8	2.8
Air conditioners	395,488	173	176	1.4	1.4	5.2	0.67

\*The total resource costs are lower than anticipated because few residential air conditioners are running during the new afternoon system peak (14:00-17:00 hours), and because all differences in the price of efficient and standard units were assumed to be due to differences in the energy efficiency of the unit.

Source: Agra Monenco, Inc. (AMI) 2000a, 2000b.

Market characterization studies are also necessary for developing a baseline of existing technologies and practices. These studies provide detailed data on end users (consumers), including estimates of market size, analyses of decision making, identification of market segments, and analysis of market share by market events (retrofit, renovation, remodeling, replacement). Market characterization studies also provide detailed data on the supply side—manufacturers, retailers, and contractors (e.g., designers and installers)—including information on relationships among supply-side actors, development of market segments, business models of each entity, and the nature of distribution channels, stocking/selling practices, and trade ally reactions to labeling programs.

Baseline development is often highly contentious and, at best, a good guess of what might have been. In many cases, it is as important to quantify the level of efficiency improvement from before the time of the program start-up in order to demonstrate that progress is continuing.

### 8.3.2 Impacts on Consumers

A key point in evaluating the effect of labeling programs on consumers is the degree to which the label's presence affects consumer purchasing decisions in favor of more efficient appliances. In addition to observing actual consumer purchasing and sales trends, consumer evaluations should also focus on consumers' level of awareness and understanding of energy and on the factors that affect their purchases of energy-efficient appliances. Specific types of questions to address in this evaluation include the following:

- What is the level of awareness, among buyers and potential buyers, of the energy label, related product material, and advertising?
- What is the level of importance given to the energy label, related product material, and advertising in the buyer's choice of appliance?
- How well does the customer understand the label, related product material, and advertising?
- What is the customer's perception of the usefulness of the label, related product material, and advertising?
- What sorts of changes do customers propose to the label, related product material, and advertising to make them more effective?
- What is the importance of energy or fuel efficiency in the buyer's choice of the appliance? How does this relate to other buyer purchase priorities?
- How does the customer use the appliance?
- What are the LCC impacts, accounting for possible changes in the price of the equipment, operating expenses, and installation or maintenance expenses?

Socioeconomic data can also be analyzed to help understand the effectiveness of labeling and standards-setting programs for different socio-cultural situations: low-income households versus high-income households, recent purchasers versus the general public, etc. Market segmentation can be used to develop

education, information, and advertising programs that complement labeling and standards-setting programs.

There is an array of econometric and statistical models for analyzing the contributions of many factors to the impacts of programs on consumers. These are generally considered to be advanced evaluation tools and range widely in cost depending on many characteristics, especially their level of accuracy.

### **8.3.3 Impacts on Manufacturers and Retailers**

Evaluators assess the impact of labeling and standards programs on appliance manufacturers by examining the following:

- impact on private-sector advertising in support of labeling programs,
- impact on sales (and market share),
- compliance with the programs,
- promotion of labels to retailers (e.g., direct promotion, print advertising, in-house product presentations and training, trade fairs, product catalogs, help desks),
- direct and indirect costs to manufacturers (increased cost of production, research and development efforts to improve appliance efficiency, distribution of labels, promotion and support of labeling programs),
- changes in the production process to produce more efficient models,
- surveys using questions similar to those posed to consumers (see Section 8.3.2), and
- distribution of energy labels on appliances in retail outlets.

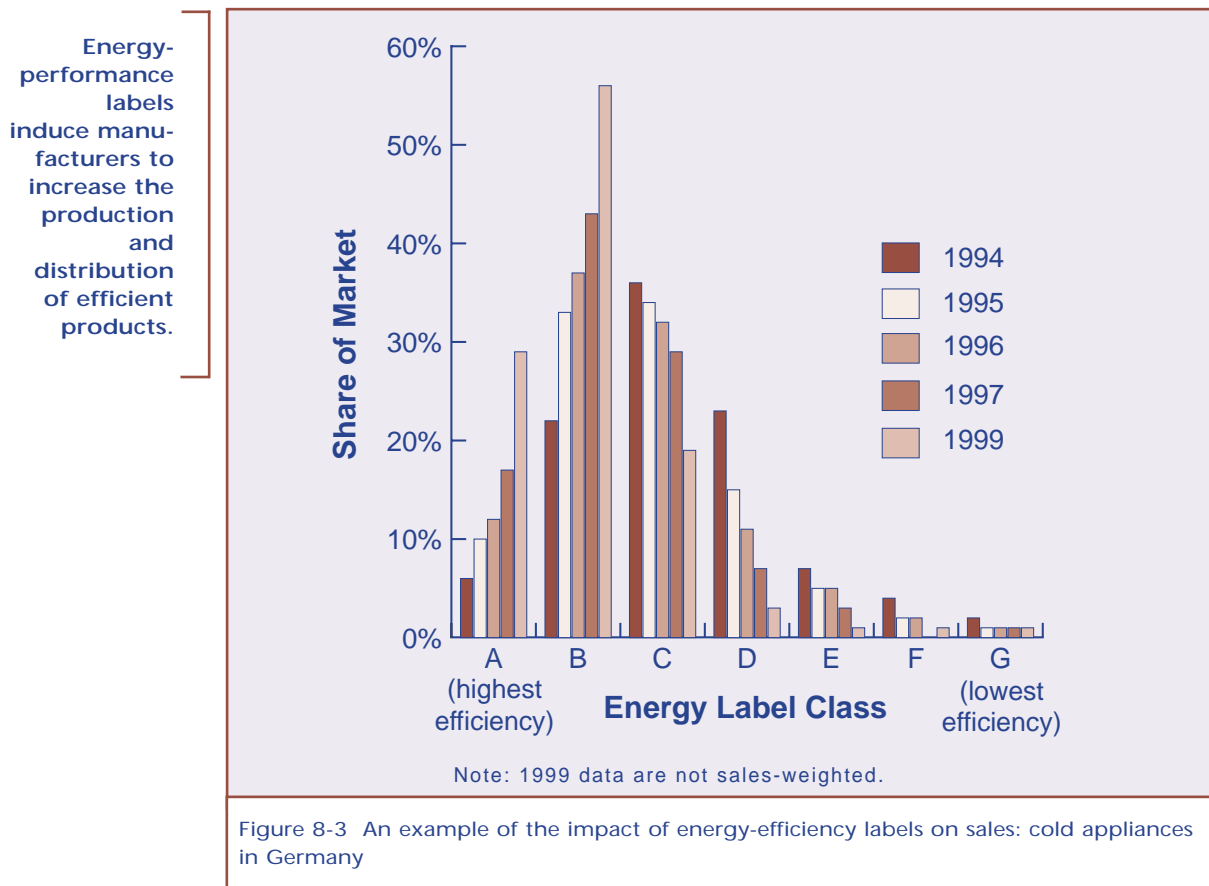
### **8.3.4 Impacts from a Policy Maker’s Perspective**

Policy makers, typically the government and utility companies, are responsible for ensuring that suppliers and dealers comply with labeling and standards-setting programs and legislation. Accordingly, evaluation studies assess the current level of manufacturer compliance and the level of remedial enforcement activity. They may also examine the use of formal legal processes to impose penalties on persistent rule breakers (Windward et al. 1998). In many cases, policy makers are responsible for implementing education and information programs that accompany the use of labels or standards. Hence, the depth and breadth of these programs are also evaluated.

### **8.3.5 Sales**

As noted above, one of the two key “lagging indicators” for evaluation is sales. Market share is also considered a lagging indicator because it occurs after the changes that actually cause purchase habits to change. Market share information is critical for the final analysis of a program’s effects, but it is often not immediately available during program implementation. Nevertheless, by comparing sales-weighted

trends in appliance efficiencies both before the introduction of labels and after the labeling program is implemented, the impact of an appliance labeling program can be evaluated. For example, **Figure 8-3** provides data for sales-weighted, annual-average distribution of refrigerators and freezers by energy-label class in Germany from 1994, the year in which labeling legislation was introduced in the EU, to 1997. It also contains market data for 1999. The figure shows how the predominance of purchases shifted from inefficient models (classes C, D, and E) in 1994 to more efficient classes (A, B, and C) in 1999. Although Germany did not pass labeling legislation until 1998, labels were almost universally supplied with appliances prior to this date and were often displayed. Analyses can focus not only on sales but also on changes in prices and in technology characteristics (e.g., sizes of appliances).



### 8.3.6 Energy Savings and Greenhouse Gas Emissions Reduction

At the household or facility level, it is impossible to measure energy savings directly because, to do so, it is necessary to know how much energy would have been used if a specific appliance had not been purchased, which cannot be determined. Nevertheless, any of a number of evaluation methodologies can be used for estimating energy savings, especially for a large sample. These include engineering methods,

statistical models, end-use metering, short-term monitoring, and combinations of these methodologies (Vine and Sathaye 1999).

For example, changes in market share of energy-efficiency products (sales) can be estimated and multiplied by the amount of energy saved (e.g., on average or by type of product). Tracking changes over time in product and market characteristics gives a good initial indication of the type of market shift that takes place in the early stages of labeling or in the lead-up to a new standard coming into force. Detecting trends in consumer preference toward more efficient products on the market is a more subtle exercise. Here, both sales-weighted and consumer sentiment trends need to be monitored. To maximize the accuracy of the energy savings from shifting between any two models, a sample of products can be metered in situ to determine the actual amount of energy used.

At the national level, energy savings can be determined using simple calculations (e.g., spreadsheets) or detailed energy end-use models. The assumptions used in engineering analyses are adjusted to account for real-world data (e.g., actual consumption in the field, fraction of households owning a particular appliance, usage in hours per year) from surveys and end-use monitoring (McMahon 1997, Greening et al. 1997).

Once the net energy savings have been calculated by subtracting baseline energy use from measured energy use, net GHG emissions reductions can be calculated in one of two ways: average emissions factors can be used, based on utility or non-utility estimates, or emissions factors can be calculated based on specific generation data (Vine and Sathaye 1999). In both methods, emissions factors translate consumption of energy into GHG emissions. Normally, the use of average emission factors is accurate enough for evaluating the impact of energy-efficiency labels and standards. In cases where the other impact analyses are highly sophisticated and regional variations are important, use of plant-specific factors may be warranted.

In contrast to using average emission factors, the advantage of using calculated factors is that they can be specifically tailored to match the characteristics of the activities being implemented by time of day or season of the year. For example, if an appliance-labeling program affects electricity demand at night, then baseload power plants and emissions will probably be affected. Because different fuels are typically used for baseload and peak capacity plants, then baseload emission reductions will also differ from the average.

The calculations become more complex and more realistic if the emission rate of the marginal generating plant is multiplied by the energy saved for each hour of the year instead of multiplying the average emission rate for the entire system (i.e., total emissions divided by total sales) by the total energy saved. For more detailed analysis, the utility's existing system dispatch and expansion plans can be analyzed to determine the generating resources that would be replaced by saved electricity and the emissions associated with these electricity-supply resources.



It is also necessary to determine whether planned energy-efficiency measures would reduce peak demand sufficiently and with enough reliability to defer or eliminate planned capacity expansion. If so, the deferred or replaced baseline source would be the marginal expansion resource. This type of analysis may result in fairly accurate estimates of GHG reductions, but it is more costly than the simpler method and requires expertise in utility system modeling. In addition, this type of analysis is becoming more difficult in regions where the utility industry is being restructured. In restructured markets, energy may come from multiple energy suppliers either within or outside the utility service area, and the marginal source of power is more difficult to forecast.

### 8.3.7 Compliance

In many labeling and standards-setting programs, it is the manufacturers' responsibility to ensure that the information they supply is correct. Often, there is no automatic system of independent testing. Occasionally, third-party testing agencies are used. Generally, manufacturers test their own products in certified test laboratories and report the results on the label. Such a system can work well because a manufacturer can challenge the veracity of a competing manufacturer's claim. This system of self-certification and challenges is used in the U.S. Under EU legislation, it is the responsibility of the member states to ensure that EU law is applied and enforced in their states (Waide 1997). Some serious inaccuracies in energy consumption reporting have been identified for refrigerators and freezers in the EU. Hence, as described in more detail in Chapter 4, there is a need to evaluate how the accuracy of manufacturer-reported energy consumption compares to that of third-party laboratory testing as well as to field monitoring of energy usage in order to determine whether the appliance rating and label should be changed (Meier 1997, Winward et al. 1998).

A labeling program also depends on retailers' efforts to make sure that labels are attached to appliances for consumers to read. Thus, it is imperative for evaluators to assess retailers' compliance with the program (Winward et al. 1998).

## 8.4

### Step E-4: Apply Evaluation Results

The use of evaluation results is a critical component of the evaluation process. If a technically sound evaluation produces significant results, it is imperative that these results be used, where appropriate, to:

- refine the design, implementation, and evaluation of labeling and standards-setting programs,
- support other energy programs and policies, and
- support accurate forecasting of energy demand for strategic planning.

#### 8.4.1 Refining the Labeling and Standards Programs

The results from evaluations can be used to improve the design, implementation, and future evaluations of labeling and standards programs. For example, evaluation results can be used to reexamine the a

accuracy of the inputs used in designing the program. In addition, they can be used to assess whether the programs can (or should) be extended to other appliances that are not currently covered. Ideally, the program designers become the clients of the evaluation department, and the evaluation results feed directly into the next round of program design or improvement.

#### 8.4.2 Supporting Other Energy Programs and Policies

The evaluation of labeling and standards-setting programs can be used for designing appliance rebate programs, appliance standards or negotiated agreements (if none exist), procurement actions, and labeling programs for other appliances. Chapter 9 elaborates on these topics.

#### 8.4.3 Forecasting Energy Use and Strategic Planning

Evaluation results can be used, with caution, to support forecasting and resource planning. In particular, the following elements of an evaluation should be considered prior to attempting to use the results:

- the representation of the study sample in relation to the population of interest to planners,
- the accuracy and precision of energy and demand impact results, and
- the appropriate use of control samples.

If comprehensive data on market energy-efficiency trends, sales volumes, and usage patterns are established as part of the evaluation process, these data can be used as inputs to an end-use stock model to make long-range energy consumption and emissions forecasts. This kind of forecasting is useful to guide policy development because it enables the estimated impact of various policy and implementation changes to be simulated in advance.

## 8.5

### Considering Key Evaluation Issues

Evaluation of labeling and standards programs must address a number of key issues; for example, in addition to developing a credible baseline (Section 8.3.1), it must account for free riders, accuracy and uncertainty, and complexity.

#### 8.5.1 Free Riders

In evaluating the impacts of standards and labeling programs, one needs to know what customers would do in the absence of these programs. Labeling and standards programs affect only some purchases. Further-more, some consumers would have purchased the same efficient products even if there had been no program. In an evaluation analysis, these consumers are called “free riders.” The savings associated with free riders are not “additional” to what would occur in the baseline case (Vine and Sathaye 1999). Therefore, free riders’ savings should be excluded when estimating savings attributed to the programs. This can be accomplished either by accounting for free riders in the baseline or by making an

appropriate adjustment separately. For example, if a comparison group's utility bills show an average reduction in energy use of 5% during some period of time before a label or standard is implemented and then show a total reduction in energy use of 15% during an equivalent period afterward, it may be reasonable to attribute a 10% reduction in energy use to the standards program (15% total less the 5% trend that was already occurring and therefore would likely have continued anyway).

Free riders can be evaluated either explicitly or implicitly. The most common method of developing explicit estimates of free ridership is to ask participants what they would have done in the absence of labeling (sometimes referred to as “but for the project” discussions). Based on answers to carefully designed survey questions, participants are classified as free riders or assigned a free ridership score. The responses are used to estimate the proportion of participants who are classified as free riders. Like other surveys, the questionnaire must be carefully worded; otherwise, inaccurate estimates of free ridership may result. Because estimating the level of the free rider effect is difficult, simple and highly uncertain assumptions about free ridership are often made.

### 8.5.2 Accuracy and Uncertainty

Because of the difficulties and uncertainties in all aspects of estimating energy savings, the levels of precision and confidence associated with the measurement of savings should be identified. Evaluators need to report the precision of their measurements and results in one of three ways:

- by specifying the standard deviation around the mean of an assumed bell-shaped normal distribution;
- quantitatively, by providing confidence intervals around mean estimates; or
- qualitatively, by indicating the general level of precision of the measurement using categories such as “low,” “medium,” and “high.”

### 8.5.3 Policy and Market Complexity

One of the criteria for examining the success of a market transformation program is whether observed market changes can be appropriately attributed to the program. Analysis can be conducted more reliably when there is a single type of intervention than when multiple actions (e.g., standards, labeling, procurement, rebates, the phaseout of chlorofluorocarbons, and industrial changes) are occurring simultaneously. It is difficult to separate the contributions of many factors to observed changes in the market. Although logic diagrams and market influence diagrams are extremely useful tools to structure the analysis, they are generally not powerful enough to handle the evaluation of the complex characteristics of the appliance, equipment, and lighting product markets.

In order to claim that observed efficiency improvements were caused by labeling and standards programs, it is necessary to carefully consider and reject other possible explanations for the market changes. The following possible explanations should be considered:

- the occurrence of multiple interventions (e.g., changes in standards, product offerings, and prices and activities of other market actors),
- the interaction between programs and underlying change factors (e.g., other government programs promoting energy efficiency),
- the likely effects and timing of different programs,
- the likelihood that changes will differ among target segments,
- the lack of an effective external comparison group,
- the availability of data, and
- the fact that large, complex, interconnected socio-technical systems are involved with different sectors changing at different rates and as a result of different influences.

It is possible and useful to broadly conclude that efficiency improvements were caused by a combination of interventions by many actors even if it is difficult to quantitatively allocate the effect among the individual interventions. Some type of causal modeling may provide a useful approach, although it is very difficult to make a quantitative model, and manufacturers are often reluctant to make the necessary data available. Quantitative determinations are often difficult to make and may involve substantial costs that may or may not be worthwhile.

Labeling and standards-setting program planners have a strong interest in the evaluation process. This chapter has shown how achieving evaluation results by defining objectives, identifying necessary resources, monitoring program performance, and assessing program impacts is a valuable output of a labeling and standards-setting program. The results can be used to revise an existing program's objectives or as building blocks in establishing other programs. But the difficulty in measuring a program's performance and impacts is ever present. In some cases it is the result of a lack of data or a lack of resources to obtain the data. In others, it may be that the program's direct results are masked by the effects of complementary programs that are taking place at the same time. Chapter 9, the final chapter in this guidebook, explores how some of those other types of programs relate to labeling and standards-setting programs.





## 9. ENERGY PROGRAMS AND POLICIES THAT COMPLEMENT LABELS AND STANDARDS

### Guidebook Prescriptions for Designing Comprehensive Energy Programs and Policies

- 1 Combine labels and standards with other policy instruments, including incentives, financing, government buying power, marketing, and consumer education.
- 2 Find the right mix of these policy tools to match energy-efficiency objectives and market conditions, and then continue to adjust that mix as conditions change and lessons are learned.
- 3 Draw on the same infrastructure—technology and market information, analyses, and energy testing/rating—to support labels and standards as well as other policy instruments.
- 4 Create well-planned strategies to permanently transform specific markets toward increased sales of energy-efficient products. Consider energy-efficiency labels and standards as part of the overall strategy, and be sure to include an exit strategy.

#### 9.1

### Developing a Program Portfolio: Regulatory Plus Market-Based Programs

This chapter discusses how labels and standards interact with other energy-efficiency policies and programs and how best to combine and sequence these programs to create an effective, sustainable market-transformation process. We do not attempt to provide a comprehensive listing of the many possible policy instruments to help increase efficiency and transform markets. Instead, we select a few promising examples to illustrate the value of combining efficiency labels and standards with other measures.

#### 9.2

### Policy Objectives

Government policy instruments, including efficiency labels and standards, can be designed to achieve a number of objectives that can accelerate the penetration of energy-efficient technology into the marketplace. Specific policies will affect different steps in the flow of energy-consuming products from producers to users. These steps include:

- creation of new technology;
- retail purchasing;
- product development and manufacturing;
- supply, distribution, and wholesale purchasing; and
- design, installation, operation, and maintenance.

The matrix in **Table 9-1** summarizes how various policy instruments can address each of the objectives discussed in the following sections (9.2.1 through 9.2.5).

Usually, a government’s energy strategy addresses several of these steps in the market process, and combinations of policy measures are often most effective. A concept that has become important in the U.S. and some other countries is market transformation, which calls for specific interventions for a limited period, leading to a permanent shift in market structure and to greater energy efficiency (Suozzo and Thorne 1999). There is growing interest in applying market-transformation principles to energy efficiency in developing countries (MMEE 1999).

**Table 9-1**

**Policy Objectives and Program and Policy Instruments**

*This matrix summarizes how various policy instruments can influence key policy objectives.*

	Pricing and Metering	Incentive and Financing	Regulatory (Labels, Standards)	Voluntary Programs	Government Purchasing	Energy Audits, Retrofits	Consumer Education, Information
Stimulate new technology*	L	M	M	M	M	—	—
Influence retail purchasing	M	H	H	M	L	L	M
Influence development and manufacturing	M	M	H	M	M	—	M
Influence supply, distribution, and wholesale purchasing	—	H	H	ML	M	L	M
Influence system design, installation, operation, and maintenance	M	—	—	L	L	H	M

\*improve performance or lower production costs

**Notes:** H = high potential  
M = medium potential  
L = low potential

### 9.2.1 Stimulating New Technology

Although most energy-efficiency programs and policies focus on increasing the use of today's commercially available technologies, it is also important to create opportunities for new and improved technologies. New technologies may be even more energy efficient than current ones, as well as less costly and better adapted to local conditions; they may also perform well in non-energy terms that are attractive to buyers (reliability, safety, low maintenance, etc.). A number of policy instruments can help speed the introduction of new technologies, including support for research and development, designing (or revising) energy-test methods so that they do not preclude technical innovation, and helping to organize buyer demand for improved products to reduce the market risk to innovators.

### 9.2.2 Influencing Retail Purchases

At the heart of an energy-efficiency strategy are the choices made by consumers, private firms, and public agencies when they buy products that either use energy directly (e.g., refrigerators, air conditioners, office copiers) or affect its use (e.g., insulation, windows and other building components, system controls). Although labels and standards can promote energy-efficient choices, in many cases the added first cost and other market barriers to efficient products can be reduced by rebates, attractive loan financing or leasing, tax credits, and government purchasing policies. Broad-based marketing and information campaigns can also draw attention to and explain energy labels.

### 9.2.3 Influencing Product Development and Manufacturing

Buyers can only choose to buy the energy-efficient products that someone else has decided to produce and offer for sale. In many developing countries or subsectors of the economy, efficient products may not even be offered or may be available only as a custom order or an imported product with long delivery time, little or no customer support, and significantly higher cost than other models. Manufacturers may be reluctant (or financially unable) to invest in developing a new energy-efficient product and the manufacturing capacity for it unless they are assured of adequate, sustained buyer demand; they may also be fearful of losing their market share to competitors.

Standards that prohibit the manufacture and sale of inefficient products offer the most certain way to affect the product mix. Encouraging manufacturers to shift toward a more energy-efficient product line may require coordinated actions on both the demand and supply sides of the market. Such actions may include:

- creating initial demand within the public sector,
- offering loans or loan guarantees to manufacturers who retool to produce efficient products, and
- providing rebates to manufacturers to reduce the incremental cost of efficient products at the whole-



sale level, and stimulating competition among manufacturers by identifying (using both labels and product listings) the most efficient brands and models.

#### **9.2.4 Influencing Supply Distribution and Wholesale Purchases**

Providing rebates for efficient products can influence wholesale and retail stocking decisions, bring down the first costs of the products, and stimulate buyer interest. Rebate programs need to be of long enough duration, perhaps several years, that they will effect a lasting change in market/consumer behavior yet not provide a permanent subsidy beyond the period needed to transform purchase habits. Rebates can be targeted at wholesale and retail distributors who may otherwise be reluctant to offer efficient products. Successful rebate programs require advance coordination with distributors and careful planning of rebate timing to avoid problems such as initial supply shortages, which can drive up prices and offset the rebate's intended effect. Educational campaigns specifically targeted at distributors can also play an important role by emphasizing how the sale of efficient products can increase market share and bottom-line profit.

#### **9.2.5 Influencing System Design, Installation, Operation, and Maintenance**

Achieving real energy savings requires more than choosing to purchase an efficient product: that product must be correctly installed, operated, and maintained to perform well throughout its lifetime. Too often, efficiency programs have focused only on individual pieces of equipment while ignoring operation and maintenance (O&M) needs and considerations of how each component fits into an overall system. A common example is the potential energy savings from personal computers and monitors that automatically lower their standby power when the equipment is idle. The power management controls built into individual PCs and other office equipment may not operate properly when connected to an officewide system unless users or system managers check to see that all the software and hardware settings are properly enabled. Similarly, proper installation of residential heating and cooling systems (including correct equipment sizing and good design of air distribution ducts) can save even more energy than the choice of an efficient air conditioner or furnace.

### **9.3**

#### **Program and Policy Tools**

##### **9.3.1 Energy Pricing and Metering**

Energy prices paid by consumers can affect the outcome of labeling and standards-setting programs in a number of important ways. Both energy-pricing policies and metering and billing practices should be designed to strengthen, not detract from, the effects of efficiency labels and standards.

## Market-based energy pricing

If electricity and fuel prices are subsidized (by tax subsidies or price controls), they reduce the motivation for consumers to save energy. Below-market electricity or fuel prices also lower the savings expected from programs such as labeling and standards-setting because fewer efficiency improvements will be economically justified using LCC criteria (see Chapter 6). Finally, below-market energy prices can reduce the effectiveness of energy-efficiency labels by making energy consumption cheaper and sending consumers a conflicting message about the value of saving energy.

Two possible solutions to subsidized energy prices are available to policy makers: one is to allow the market to set energy prices. When this is not feasible, governments can use “shadow prices” (energy prices calculated as if there were no subsidies) to determine economically justified levels for energy-efficiency standards.

## Metering and billing

In many developing countries, billing for electricity and pipeline gas may be infrequent or inaccurate, providing a poor market signal to consumers. Reliable metering, frequent meter reading and billing, and reduced “technical losses” (stolen or unbilled energy) provide a stronger incentive to save energy. In the U.S., significant energy savings were achieved simply by installing submeters in previously master-metered apartment buildings or by adding heat meters to individual buildings served by district heat (Hirschfeld 1998). Metering and billing for some countries may be the most important issue to address in introducing energy-efficiency programs directed at consumers, and, when that is so, cooperation of utility companies is necessary for success.

### 9.3.2 Financing and Incentives

A range of financing and incentive programs has been used to overcome the barrier of higher first cost, which often restricts the purchase of energy-efficient technologies. The most common incentives are consumer rebates or grants, tax credits or accelerated depreciation, loan financing (including shared-savings or performance-based contracting), and equipment leasing. Energy labels and standards provide an important foundation for these programs. Labels and standards provide a verified baseline for judging enhanced performance and establishing appropriate incentives. Incentive programs can use product listings available from the labeling program to establish which products meet higher efficiency levels and to identify the models qualified to receive incentives.

## Rebates, grants, and tax policies

In most cases, either a government agency or utility sponsor offers financial incentives directly to end users. Sometimes incentives are provided to manufacturers or builders to encourage them to supply

more efficient products with the assumption (or requirement) that at least some of the incentive will be reflected in a lower price to the final buyer.

Two programs that used manufacturer incentives are the Poland Efficient Lighting Project (PELP), developed by the International Finance Corporation (IFC) and funded by the GEF, and the Super-Efficient Refrigerator Program (SERP), a consortium of government agencies, utilities, and NGOs in the U.S. SERP was intended to get manufacturers to create and introduce a new product that didn't yet exist; PELP was intended to stimulate manufacturers who were exporting compact fluorescent lamps (CFLs) to produce more, cheaper, and better CFLs and to market them in-country (see Insert Box: *Using Manufacturer Incentives to Reduce Needs for Investment in Electricity Distribution Systems*).

### Using Manufacturer Incentives to Reduce Needs for Investment in Electricity Distribution Systems

#### POLAND

The Poland Efficient Lighting Project (PELP), developed by the International Finance Corporation and funded by GEF, was designed in part to demonstrate to the Polish electric utility industry the benefits of using efficient lighting to reduce peak power loads in geographic areas with inadequate distribution grid capacity to meet existing or projected loads.

One major component of the program was an incentive payment to manufacturers of CFLs that reduced wholesale prices by about US\$2 per CFL. During a two-year period, the project subsidized the sale of more than 1.2 million CFLs. An aggressive CFL discount coupon/promotion program in three Polish cities led to very high CFL installation levels (two to nine CFLs per household) in the target neighborhoods and 15% peak demand reductions for substations serving purely residential loads; there was no adverse impact on power quality as a result of the CFL ballasts. The program was also highly cost effective for the utility compared with traditional approaches to upgrading grid capacity; residential peak demand savings averaged 50% over five years and 20% over 10 years.

#### UNITED STATES

The Super-Efficient Refrigerator Program (SERP), a consortium of government agencies, utilities, and NGOs in the U.S., organized a competition and awarded a US\$30 million incentive (the so-called "golden carrot") to the winning manufacturer to build a new refrigerator that exceeded prevailing efficiency standards by 30%. Many participating utilities offered additional rebates to consumers to encourage them to buy the super-efficient refrigerator. SERP has been widely credited with helping to pave the way for industry and consumer acceptance of a tighter energy-efficiency standard adopted nationally by DOE.

*Sources: Ledbetter et al. 1998, Ledbetter et al. 1998, 1999.*

Some countries have reduced the import duties or sales taxes on energy-efficient equipment, sometimes distinguishing between locally produced and imported products. In Pakistan in 1990, for example, the import duty on CFLs was reduced from 125% to 25%, cutting retail prices almost in half and increasing sales. Because import duties or sales/excise taxes may be an important source of revenue to developing countries, another approach that should be considered is a “revenue-neutral” tax incentive or “feebate” for efficient products. The idea is to keep the total amount of tax revenue about the same but to vary the tax rate so that the import or excise tax is lower on an efficient product and higher on a less efficient one. The performance testing and rating information developed for product energy labels can provide the basis for these differential tax policies.

### **Financing of energy-efficiency investments: loans, leases, performance contracts, and vendor financing**

Providing financing for both the manufacture and purchase of energy-efficient equipment overcomes the barrier of lack of capital by spreading the initial costs over time. This financing can come in several forms.

**Loans**—Although development banks have historically been a major source of funds for energy-efficiency investments in developing countries, commercial banks and other lenders are an important and largely untapped funding source. Commercial financing includes loans and lines of credit, leasing, trade finance, consumer credit, vendor finance, mortgage finance, and project finance (Hagler-Bailly 1996).

**Leasing**—Leasing of energy-efficient equipment allows the user (lessee) to avoid using capital up front to acquire an asset. To date, leasing has not been widely used for energy-efficiency investments in developing and transition countries (see Insert Box: *CFL Leasing Program Defers the Need for New Power Plants in the Caribbean*).

### **CFL Leasing Program Defers the Need for New Power Plants in the Caribbean**

During the late 1980s, electricity demand on the Caribbean island of Guadeloupe was nearing its maximum generating capacity. In response, Electricité de France (EDF) and L’Agence de l’Environnement et de la Maîtrise de l’Energie (ADEME, the French agency for the environment and energy management) began developing the largest leasing program for CFLs ever undertaken by a utility. Called Operation LBC (Lampe Basse Consommation), the program sought to lower evening peak demand by shifting from incandescent lighting to CFLs. Local customers knew very little about CFLs.

In May 1992, EDF and ADEME launched Operation LBC. After an extensive media campaign, EDF sent every customer on Guadeloupe a coupon good for up to 10 CFLs. The coupons allowed customers to lease the CFLs at no initial cost with lease payments designed to be the same as or less than the projected monthly electricity bill savings. Ultimately, 34% of all households redeemed their coupons for an average of 7.8 CFLs each. The success on Guadeloupe prompted EDF and ADEME to implement Operation LBC in 1993 on the nearby island of Martinique, where 345,000 CFLs were distributed in just a few months. The two programs resulted in 7 MW of peak demand savings on each island plus 29-33 GWh of annual electricity savings.

*Source: Results Center.*

**Performance contracting**—Performance contracting (or third-party financing) has been widely used to finance energy-efficiency projects in the U.S. and Europe. In performance contracting, an end user obtains efficient equipment or other facility upgrades from an ESCO. The ESCO pays for the improvements and receives a share of the savings as a performance-based incentive fee. Performance contracting through an ESCO transfers some technology and management risks from the end user to the ESCO. It also minimizes or eliminates the requirement for an initial cash outlay by the customer and reduces other transaction costs and demands on staff.

**Vendor financing**—Vendor financing often targets energy-efficient products that are newly introduced or at least new to a market segment in a country or region. Vendor financing is typically used for sales of common equipment with large numbers of end users (e.g., industrial motors, commercial lighting).

There may be only a weak link between financing programs and labels and standards. As with incentive programs, labels and standards can be used to establish and communicate a reliable baseline for setting efficiency criteria and determining loan repayments that correspond to projected savings in energy costs. Likewise, the presence of readily available financing may allow regulators to justify more stringent standards that impose higher initial costs on either manufacturers or consumers.

**Utility financing programs**—A utility can assume three roles in financing energy efficiency—facilitator, collection agent, or direct provider of financial services. In all cases, the utility's role needs to be approved by the applicable regulatory authority or governing body or else spun off to an unregulated subsidiary in countries where deregulation or utility restructuring are under way.

- *Facilitator.* As a facilitator of loan financing, the utility acts as a broker to help bring together end users (its customers), energy-efficiency businesses, and lenders. Utilities are often well positioned to help market the program, pool or aggregate projects, and achieve the economies of scale that attract commercial lenders to the energy-efficiency market.
- *Collection agent.* If a utility collects customer loan payments through its regular monthly bills, this can help reduce transaction costs (especially for smaller projects) and also lower credit risk. The utility can then aggregate individual loan payments into a single monthly payment to the lender.
- *Direct provider.* Utilities can also be direct providers of financial services (e.g., direct loans, equipment leases), using the market advantages of their customer relationships, access to capital, and existing billing systems. Alternatively, utilities can offer finance programs marketed by qualified equipment vendors or installation contractors. As a lender, the utility may be allowed to earn fees and/or recover a return on its capital investment.

In a few cases, utilities have also played a useful role as direct retailers of efficient appliances and equipment (including warranty maintenance services) even without special financing provisions other than allowing the use of credit cards. For example, Scottish Hydro-Electric offers its customers easy

access to direct purchasing of efficient home appliances rated A, B, or C, the top categories on the EU appliance label, as well as useful consumer information such as energy-related operating costs.

The links between utility financing programs and labels and standards tend to be stronger than with financing offered by other institutions. This is because utilities generally have a more direct interest in the outcome: cost-effective energy savings and, in some cases, improved customer relations and customer retention in an increasingly competitive market.

### 9.3.3 Regulatory Programs

Four main types of regulatory programs can influence appliance and equipment energy efficiency:

- mandatory energy labels (or manufacturer “declarations” of energy performance even without a physical label on the product),
- efficiency standards for appliances and equipment (either at a minimum required level or as a “fleet average” for all products sold),
- energy-efficiency requirements in building codes, and
- government requirements that private utilities offer energy-efficiency programs.

The first two of these programs are the subjects of previous chapters in this guidebook. The third, energy-efficient building codes, is an important means of assuring efficiency in both new construction and major renovation. Building energy codes, common in the U.S., Europe, Southeast Asia, and several other countries, usually specify performance levels for the building envelope and heating and cooling equipment, and specify overall lighting levels. Codes generally do not set standards for plug-in appliances or for replacement equipment in existing buildings. Code requirements are typically expressed either in energy performance terms (e.g., maximum lighting power, in W/m<sup>2</sup>, to deliver a specified level of illumination) or as prescriptive requirements (e.g., ceiling and wall insulation of a certain thickness or R-value). Efficiency labels on heating and cooling equipment and performance labels for windows can make it much easier for building inspectors to check for compliance with energy codes.

Some countries, including the U.S., have both mandatory equipment efficiency standards and mandatory building energy codes that cover some of the same products. In this situation, the credibility and effectiveness of both programs depend on effective coordination between those responsible for equipment standards and those responsible for the building code.

The fourth type of regulatory program, prominent in the U.S. in the 1980s, required private electric and natural gas utility companies to conduct programs to help their customers use energy more efficiently and to better manage peak loads. Many government-run public utilities also undertook DSM programs. As will be discussed in Section 9.4, utility DSM programs in the U.S. are now being replaced by more comprehensive market-transformation programs.

### 9.3.4 Voluntary Programs

Voluntary programs, led by both government and industry, encourage manufacturers, distributors, installers, and customers to produce, promote, or purchase energy-efficient products and services. These programs may include:

- quality marks or labels that distinguish products based on superior energy and environmental performance (see Chapter 5),
- voluntary targets that set guidelines for an industry to strive for, and
- marketing and promotional campaigns.

These programs are the most closely aligned to the labeling and standards-setting activities that are the primary focus of this guidebook. They often have exactly the same objectives as efficiency standards and labels—communicating information to consumers and setting performance goals—and rely upon similar information and analyses.

Voluntary programs often enlist private firms as partners with the sponsoring government agency. The private firm may want to participate in a voluntary program either to realize energy and cost savings or to get credit and recognition for reducing pollution or GHG emissions. An individual firm's commitment may include agreeing to upgrade energy-using equipment within its facilities. For example, when the U.S. EPA enlists public- and private-sector partners for the Green Lights and ENERGY STAR® Buildings programs, the partners agree to voluntarily survey their facilities and perform cost-effective energy upgrades. In return, EPA offers a range of tools to help participants evaluate the expected energy and cost savings. EPA also provides public recognition to its partners for contributing to environmental stewardship.

The Green Lights program, launched by EPA in the early 1990s as its flagship voluntary “green” program, has made considerable progress in promoting cost-effective lighting energy savings. The original Green Lights program has now been merged with a broader effort called ENERGY STAR® Buildings, which provides tools and recognition for a more comprehensive approach to retrofitting heating and cooling systems and building envelopes as well as lighting. As of September 1999, a total of 3,037 partners were listed as participants in either the Green Lights or ENERGY STAR® Buildings programs, with voluntary commitments to energy-saving actions that should reduce energy bills by about US\$1.4 billion (U.S. EPA 1999). Participants in these programs can also agree to purchase energy-efficient products that qualify for the ENERGY STAR® label (see Insert Box: *Transforming the Office Equipment Market with ENERGY STAR® and Energie-2000 Labels*).

An entire industry sector may also establish voluntary targets for energy-using products or processes—to promote best practices and increase competitiveness and profitability within the industry, to gain public relations benefits, or to anticipate regulatory pressures and thus minimize the likelihood of

## Transforming the Office Equipment Market with ENERGY STAR® and Energie-2000 Labels

In most offices, PCs, monitors, printers, and copy machines are left on all day (and sometimes even at night), consuming substantial energy when not actually in use. To address this problem, the U.S. EPA worked with equipment manufacturers to develop the ENERGY STAR® label for equipment that automatically shifts to a low-power mode (e.g., 30 Watts or fewer for a PC) when not in active use. Manufacturers found that they could use very inexpensive power management controls to switch equipment to low-power standby. Industry interest in the ENERGY STAR® label, limited at first, grew rapidly following an executive order requiring federal government agencies to purchase PCs and other office equipment that qualify for the label. At the same time, utility programs helped raise customer awareness of energy wasted by office equipment in standby mode. As a result, by 1995 about 74% of PCs, 93% of computer monitors, and 97% of printers sold in the U.S. qualified for the ENERGY STAR® label (Fanara 1997).

These exceptionally high market shares were achieved because of the rapid rates of technical innovation and product replacement in the electronics industry, the very low cost of building in power management when designing a new microchip, and other marketable advantages of power management, such as quieter PCs, reduced internal heat build-up, and lower air conditioning loads in equipment-intensive offices. As a result, it was relatively easy to convince manufacturers to make power management a standard feature on most or all models. EPA attributes its success to its focus on creating a well-recognized national brand for energy efficiency, that combines the voluntary participation of a wide range of organizations with EPA's endorsement and extensive information disseminated to participating organizations and the public. However, despite high market penetration, continued efforts have been needed to make sure that manufacturers ship their products with the power management features enabled, to educate consumers on the proper use of power management, and to update the ENERGY STAR® criteria to keep pace with new technical developments.

The Swiss Federal Office of Energy (SFOE) has also combined voluntary standards, labeling, and government purchasing to promote energy-efficient office equipment. First, SFOE developed fleet-average targets for low-standby-power office equipment (and consumer electronics) designed to influence manufacturers' choices about which products would be manufactured for sale in Switzerland. If the industry failed to meet these target values by a specified date, SFOE had the statutory right to set mandatory minimum efficiency standards. In addition to establishing target values, SFOE developed the Energie-2000 label to help consumers identify models from among the 25% on the market that are most efficient. SFOE also publishes a list of the qualified models each year and encourages large government and private-sector purchasers to buy Energie-2000 labeled products. See Chapter 5, pages 93-95 for sample ENERGY STAR® and Energie-2000 labels.



future regulation. Such voluntary targets can be based on either a single target value for efficiency that everyone must meet or a fleet-average efficiency for all products sold by each firm or by the industry as a whole. The success of a voluntary program for office equipment and consumer electronics in Switzerland shows the importance of both government leadership and active involvement from manufacturers (see Insert Box: *Transforming the Office Equipment Market with ENERGY STAR® and Energie-2000 Labels*, on previous page).

## Technology Procurement: A Tool to Speed Introduction of New Technology

A number of countries have used “technology procurement” to speed the introduction of new energy-efficient technologies into their markets. Technology procurement uses the aggregated buying power of several large-volume purchasers to establish market demand for new products and to clearly communicate this demand to potential suppliers. Technology procurement for energy-efficient products was pioneered and refined by Sweden’s NUTEK (the Swedish National Board for Industrial and Technical Development, now the Swedish National Energy Administration, STEM) and subsequently used by a number of countries, including the Netherlands, Finland, and the U.S. It was part of a general market-transformation program that was established to coordinate the demand side of the energy market.

Although there is no set formula for a technology procurement project, it typically involves organizing a group of large-volume buyers who, with the assistance of a technical organization, define technical performance and cost specifications for a new product they would like to see made available. Their interest in the new product is communicated to potential suppliers via an open solicitation for proposals. The suppliers then compete for the opportunity to supply the product to the initial buyer group as well as others. This process helps reduce the risk to suppliers of introducing a new product and allows consumers to specify exactly what they are willing to buy without being limited to products already on the market.

Examples:

1. In 1992 NUTEK recruited a number of Swedish social housing cooperatives for a technology procurement effort to introduce highly efficient windows that would save 60% more energy than standard triple-glazed Swedish windows.
2. Starting in 1995, the New York Power Authority cooperated with the New York City Housing Authority and other public housing authorities to create a technology procurement project for new refrigerators that would use 30% less electricity than those already on the market. The aggregated demand of several public housing authorities convinced Maytag Corporation, the winning bidder, to invest in new refrigerator manufacturing capacity for their high-efficiency models.
3. The IEA’s Annex III on Demand-Side Management has sponsored a number of other technology procurement projects for electric motors, heat-pump dryers, light-emitting diode (LED) traffic signals, and digital multifunction office copiers.

Sources: Ledbetter et al. 1999, Westling 1996.

### 9.3.5 Government Purchasing

In their day-to-day activities, public agencies purchase large quantities of energy-using equipment and appliances for use in facilities such as government offices, public schools, universities, hospitals, and state-owned enterprises. Harnessing the power of routine purchasing by government and other institutional buyers can be a powerful way to stimulate the market for energy-efficient products while setting an example for corporate buyers and individual consumers. This strategy also bypasses much of the need to raise new capital for energy-efficiency investments, making use of budgeted funds that would be spent anyway to purchase or replace equipment but redirecting this spending toward more energy-efficient products.

Although a few countries have recently instituted energy-efficient purchasing programs (see Insert Box: *Technology Procurement: A Tool to Speed Introduction of New Technology*), up to now this potential has been largely ignored as an element of energy-efficiency policy (Borg et al. 1997). One notable exception is in the U.S., where programs led by DOE and EPA promote energy-efficient purchasing at all three levels of government: federal, state, and local. The U.S. federal government by itself is the world's largest single buyer of energy-using products, spending more than US\$10 billion on such purchases each year (McKane and Harris 1996). Including purchases by state and local government agencies, the public sector represents at least one

#### U.S. Government Requirements for Purchasing of Energy-Efficient Products

(Excerpt from Executive Order 13123,  
June 8, 1999)

*ENERGY STAR® and Other Energy-Efficient Products.*

(1) Agencies shall select, where life-cycle cost-effective, ENERGY STAR® and other energy efficient products when acquiring energy-using products. For product groups where ENERGY STAR® labels are not yet available, agencies shall select products that are in the upper 25 percent of energy efficiency as designated by FEMP...

(2) GSA and the Defense Logistics Agency (DLA), with assistance from EPA and DOE, shall create clear catalogue listings that designate these products in both print and electronic formats. In addition, GSA and DLA shall undertake pilot projects from selected energy-using products to show a "second price tag," which means an accounting of the operating and purchase costs of the item, in both printed and electronic catalogues and assess the impact of providing this information on Federal purchasing decisions.

(3) Agencies shall incorporate energy efficient criteria consistent with ENERGY STAR® and other FEMP-designated energy efficiency levels into all guide specifications and project specifications developed for new construction and renovation, as well as into product specification language developed for...all other purchasing procedures.

*Note: FEMP is the Federal Energy Management Program for making the government's energy use more efficient. GSA is the Government Service Agency responsible for government purchasing.*

of every 10 dollars spent in the U.S. on energy-using products. In many developing countries, public-sector purchasing represents an even larger share of the economy.

Within the U.S. federal government, an executive order (see Insert Box: *U.S. Government Requirements for Purchasing of Energy-Efficient Products*, on previous page) directs all agencies to buy products that qualify for the ENERGY STAR® label or (where there is no label) products that are among the most efficient 25% on the market. These procurement programs have the potential to save government agencies—and thus taxpayers—hundreds of millions of dollars in annual energy costs.

A new program in Denmark, sponsored by the Danish Electricity Savings Trust (DEST), further illustrates how government purchasing policies can be built around an energy-efficiency labeling scheme. DEST has organized a group of large institutional buyers, including social housing companies and local governments, to jointly procure—at a very favorable bulk-purchase price—up to 10,000 energy-efficient refrigerators that qualify for the top efficiency rating (A) on the EU appliance label. In the future, DEST plans other volume purchases for high-efficiency appliances, consumer electronics, office equipment, and CFLs (Karbo 1999).

The Swiss federal government and several Swiss cantons also promote purchases of energy-efficient computers, office equipment, TVs, and videocassette recorders (VCRs) based on the Swiss Energie-2000 efficiency label. The Mexican government energy-efficiency agency (CONAE) is also starting a program to specify energy-efficiency levels for lighting and other equipment purchased for use in government buildings.

Government policies on energy-efficient purchasing can also cover “indirect purchasing” by contractors who provide design, construction, or maintenance services that include specifying and procuring equipment. For example, the U.S. Navy recently changed its guide specifications for non-residential lighting, exit signs, and distribution transformers to match DOE efficiency criteria. Based on the volume of military construction in one year alone (1998), these Navy guide specifications should save an estimated \$1.2 million/year by reducing electricity used by 500,000 efficient (T-8) fluorescent lamps, 200,000 electronic ballasts, and 20,000 LED exit signs. Most recently, DOE criteria for efficient chillers to cool large buildings are being incorporated in a new guide specification widely used by private architecture and engineering firms outside the government.

By adopting energy-efficiency criteria to guide their own purchasing, government agencies save energy and money, set an example for other buyers to follow, and provide a strong market signal to product suppliers and manufacturers. Energy testing and rating systems already in place to support efficiency labels and standards provide a baseline for establishing these energy-efficient purchasing criteria.

### 9.3.6 Energy Auditing Programs

Many end users do not have the time or expertise to identify what they can do to improve energy efficiency. Free or subsidized energy audits can help them identify and prioritize energy-saving opportu-

nities. Energy audits have been a central element of efficiency programs in many countries, in the industrial sector and also for homes, commercial buildings, and public facilities. Often, audits have been provided through utility DSM programs at little or no cost to the end user. Some countries, such as Thailand, have made energy audits mandatory for large energy users.

Audits typically identify generic energy-saving options, including operation and maintenance (O&M) improvements, as well as site-specific options for capital investments in better equipment and systems. Some programs offer in-depth energy audits conducted by experts skilled in a particular industrial process or building type and may address industrial waste reduction or other environmental measures as well as energy efficiency.

Experience shows that it does little good to provide energy audit recommendations without some way to assure that the customer will implement the recommended measures. Increasingly, audits have been combined with project financing, as in the Technology Transfer for Energy Management (TTEM) program in the Philippines (Rumsey and Flanigan 1995). This program, sponsored by a grant from USAID, addressed two major constraints: a lack of reliable information on energy-efficient technologies and reluctance on the part of industrial managers and lenders to fund efficiency upgrades. Through a Demonstration Loan Fund, accredited banks made five-year loans for energy-efficiency upgrades at below-market rates. Loan financing for 16 demonstration projects produced energy savings with an average 41% internal rate of return. TTEM also provided free technical assistance to more than 120 companies, seminars for 1,100 attendees from private firms and financial institutions, and technical training for the staff of the Philippines Office of Energy Affairs (OEA). Program staff believed that technical assistance, even more than financing, was the key to the program's success.

Energy audit programs have a relatively weak linkage to labels and standards. Labels and standards can make audits a little easier to perform by providing information about the energy performance of appliances, equipment, and lighting products; audit recommendations may include upgrading or replacing equipment to meet or surpass current efficiency standards.

### **9.3.7 Consumer Education and Information**

In the long run, developing and maintaining an energy-efficient economy requires that private citizens, corporate managers, government officials, and professionals and tradespeople all share at least a basic understanding of how energy is used, the economic and other costs (environmental, social) of energy production and use, and the main opportunities to improve energy efficiency. This basic “energy literacy” must begin with elementary and secondary schooling and continue as part of professional and technical training for those whose jobs will involve energy-related decisions. Finally, consumers need access to information about how their homes or businesses use energy, what energy-saving opportunities are open to them, and which products represent energy-efficient and cost-effective choices.

Energy-efficiency labels can play an important role in this consumer education. As described in Chapter 5, surveys and focus groups to help design energy-efficiency labels provide important information about

## Market Transformation Improves Product Design: China's CFC-Free Energy-Efficient Refrigerator Project

The CFC-Free Energy-Efficient Refrigerator Project is China's first comprehensive market-transformation project to focus on improving the efficiency of a common consumer product with a huge domestic market: nearly 10 million units/year. The project originated in 1989 as a joint effort by the U.S. EPA and China's National Environmental Protection Agency (NEPA—now SEPA, the State Environmental Protection Administration). The intent was to take advantage of the planned phase-out of CFC refrigerants to also increase the energy efficiency of Chinese refrigerators, thus achieving both environmental goals with a single retooling of manufacturing plants. The participating agencies worked with industry to develop a prototype CFC-free refrigerator that used 45% less energy and, most important for China, incorporated non-proprietary technologies and design features that allow for wide application in China (Fine et al. 1997).

The next step was to focus on distribution and sales, to ensure that dealers would stock and promote the new, efficient refrigerator models and that consumers would buy them. GEF sponsored research on consumer attitudes, market trends, efficiency standards, sales channels, pricing, compressor efficiency, and other topics in order to develop a comprehensive approach to market barriers. This analysis found that a 20% market penetration of the energy-efficient refrigerators after 10 years would reduce China's CO<sub>2</sub> emissions by more than 100 million tons over the life of these refrigerators. Actual market penetration and savings are expected to be even higher.

In 1999, GEF funded the first \$9.8 million of a planned \$40 million market-transformation project, to include revised efficiency standards, a mandatory appliance energy label, dealer training and consumer education, manufacturer training in refrigerator design and modeling, and a manufacturer incentive program based on the U.S. "Golden Carrot" program. The incentive program stimulates the incorporation of the prototype technology by providing graduated payments to the top 10 manufacturers based on their individual gains in fleet-average efficiency for models sold each year compared with a 1998 base year. These incentives help offset manufacturer retooling costs, estimated at about \$2 million per factory. Additional "market pull" is planned through a volume-purchasing program and a pilot program to recover and recycle CFCs by retiring older, less-efficient refrigerators.

This project exemplifies a multi-staged approach to a comprehensive market-transformation project, incorporating an array of both "technology push" and "demand pull" elements of limited duration. If successful, it will provide China with a substantial increase in refrigerator efficiency, save money for consumers, ease power loads on an already strained electricity grid, and significantly reduce emissions of CFCs, CO<sub>2</sub>, and other air pollutants.

consumer motivation. Subsequent training and educational campaigns to support the energy labels target not only the final consumer but also those who have direct contact with customers, including retail sales staff, contractors/installers, and maintenance/service personnel, all of whom should understand the benefits of efficient products and can personally profit from promoting these products to end users.

## 9.4

### Comprehensive Strategies to Transform Markets

Governments can invite, coax, require, or directly sponsor any of the program and policy tools described in Section 9.3. As mentioned previously, in many parts of the world the design of energy-efficiency programs is changing—largely in response to electric utility industry deregulation—to focus more on lasting transformation of markets. Until recently, energy-efficiency programs and policies were conducted by government agencies, utility companies, private consultants, and large building owners or industrial firms themselves. But these programs typically targeted efficiency improvements at a specific site or for a given type of energy-using equipment. Market-transformation strategies focus more broadly on how products are manufactured and flow through markets to consumers. These approaches attempt to change the behavior of various market participants to increase the adoption of energy-efficient technologies and services (Suozzo and Nadel 1996, Suozzo and Thorne 1999).

A coordinated strategy for market transformation might focus on a single technology, energy end use, or well-defined market segment. Like any well-designed energy-efficiency program, this strategy should include a careful analysis of market conditions in order to identify specific barriers to development, introduction, purchase, and use of the energy-saving measure. The market-transformation strategy will use that information to prepare a clear statement of the specific objectives for each market segment and a practical plan for transitioning from intensive interventions toward a largely self-sustaining market process—i.e., an exit strategy. China's CFC-Free Energy-Efficient Refrigerator Project is a good example (see Insert Box: *Market Transformation Improves Product Design: China's CFC-Free Energy-Efficient Refrigerator Project*).

Market transformation typically includes activities designed to:

- stimulate the development and market introduction of new, energy-efficient models;
- raise consumer awareness of these new products;
- change consumer purchasing practices to increase market penetration so that the products become well established in the market;
- ensure that energy labels are in place to provide consumers with the information they need to make well-informed choices; and
- stimulate accelerated replacement and early retirement of existing products.

## Market Transformation Introduces a New Technology: Horizontal-Axis Clothes Washers

Clothes washers account for a substantial amount of energy and water use in U.S. homes; most of this energy is used to heat the wash water. Horizontal-axis clothes washers, familiar in Europe but only recently marketed widely in the U.S., use about half the water and one-third the energy of conventional U.S. models. Despite these impressive energy and water savings, a number of market barriers had limited the sale and use of high-efficiency washers to only about 1% of the U.S. market as of 1997. Barriers included limited product availability, high prices for the models that were available, and limited consumer and retailer awareness.

However, beginning in the early 1990s, a series of program initiatives helped motivate manufacturers to produce more-efficient washers. First, DOE announced its interest in horizontal-axis washer technology as the basis for possible new federal efficiency standards (DOE 1991, DOE 1994). Next, the utility-sponsored Consortium for Energy Efficiency (CEE) developed a common specification for utility incentive programs to promote efficient, water-saving clothes washers. The DOE/EPA ENERGY STAR<sup>®</sup> program followed suit by announcing new labeling criteria for clothes washers. Third, the Electric Power Research Institute (EPRI) joined forces with a U.S. manufacturer (Maytag) in an R&D project to develop an improved horizontal-axis design (EPRI 1995). And finally, The High-Efficiency Laundry Metering and Marketing Analysis project (THELMA) produced market research, performance testing, and field measurements that demonstrated substantial energy and water savings as well as superior cleaning performance (Pope 1995). In response, a number of domestic and overseas manufacturers have introduced new, horizontal-axis (and other low-energy, water-saving) clothes washer models to the U.S. market.

Today's efforts focus on building customer demand for these new products. Electric, gas, and water utilities in the U.S. are offering financial incentives, consumer education, and retailer training. The initial results are encouraging: as of January 2001, 63 high-efficiency washer models qualified for the ENERGY STAR<sup>®</sup> label (compared with 31 model lines in March 1999 and only one that would have qualified in 1991). Retailers are more knowledgeable about efficient clothes washers and are giving them floor space in showrooms. Consumers are increasingly aware of efficient clothes washers and highly satisfied with the products. A buyer study in the northwest U.S., where these products have been heavily promoted, found that 85% of a sample of recent buyers were highly satisfied with their efficient clothes washer. Market share in the northwest is increasing as well, averaging 13% in 1998 compared with less than 2% in May 1997. Even more important, this market share is holding steady after the phaseout of utility rebates. Nationally, market penetration is about 8%, and the early premium prices charged for high-efficiency washers are beginning to come down. All of these market changes make it more feasible to consider a minimum-efficiency standard based on horizontal-axis technology (or equivalent performance); this would represent a permanent transformation of the market.

*Sources: Suozzo and Thorne 1999, Gordon et al. 1998.*

The appropriate tools for market transformation depend in part on how mature a technology or practice is (Hinnells and McMahon 1997, Nadel and Suozzo 1996). For example, demonstration projects and technology procurement efforts may be employed in the early stages to stimulate the introduction of new, energy-efficient technologies. Rebates/loans and volume purchasing by large buyers, along with consumer education and other activities such as ENERGY STAR<sup>®</sup> labeling and marketing campaigns, may be used to increase market penetration. Where feasible, building codes and minimum efficiency standards are used to complete the transformation process by removing inefficient products and practices from the market. Market transformation also frequently benefits from having energy-efficiency standards in place that are periodically ratcheted upward to ensure continuing progress in saving energy (see Insert Box: *Market Transformation Introduces a New Technology: Horizontal-Axis Clothes Washers*).

In market transformation, several program and policy tools are combined to achieve permanent changes in the market. Labeling and standards-setting programs are an essential part of most market-transformation strategies and may be the only market interventions that need to be maintained in the long term.





## ACRONYMS

AC	Air conditioner	CEE	Consortium for Energy Efficiency
ACCC	Australian Competition and Consumer Commission	CEN	European Committee for Standardization
ACEEE	American Council for an Energy-Efficient Economy	CENELEC	European Committee for Electrotechnical Standardization
ADB	Asian Development Bank	CEO	chief executive officer
ADEME	Agence de l'Environnement et de la Maîtrise de l'Énergie (French Agency for the Environment and Energy Management)	CFC	chlorofluorocarbon
		CFL	compact fluorescent lamp
		CFR	Code of Federal Regulations
AEU	annual energy use	CLASP	Collaborative Labeling and Appliance Standards Program
AGO	Australian Greenhouse Office		
AHAM	Association of Home Appliance Manufacturers	CMS	Compliance Monitoring System
		CNIS	China National Institute of Standardization
AMI	Agra-Monenco International		
ANSI	American National Standards Institute	CO <sub>2</sub>	carbon dioxide
		CONAE	Comision Nacional para el Ahorro de Energia (Mexican government energy-efficiency agency)
ANOPR	advance notice of proposed rule making		
		COP	coefficient of performance
APEC	Asia-Pacific Economic Cooperation	CSA	Canadian Standards Association
		DEST	Danish Electricity Savings Trust
ARI	Air-Conditioning and Refrigeration Institute	DG TREN	European Commission Directorate General for Transport and Energy
ASEAN	Association of Southeast Asian Nations	DLA	Defense Logistics Agency
		DOE	Department of Energy
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers	DSM	demand-side management
		ECEEE	European Council for an Energy-Efficient Economy
AV	adjusted volume		
BRS	Building Research and Standards Office (U.S. DOE)	EDF	Electricité de France (the French electricity agency)
		EEA	European Economic Area
Btu	British thermal unit	EER	energy-efficiency ratio
CECED	European Committee of Domestic Equipment Manufacturers	EFTA	European Free Trade Association
		EF	energy factor
CECP	Center for the Certification of Energy Conservation Products (China)	EGAT	Electricity Generating Authority of Thailand

EIA	Energy Information Administration	IEEE	Institute of Electrical and Electronics Engineers, Inc.
EOTC	European Organization of Testing and Certification	IFC	International Finance Corporation
EPA	Environmental Protection Agency	IIEC	International Institute for Energy Conservation
EPACT	Energy Policy Act	ISO	International Standards Organization
EPCA	Energy Policy and Conservation Act	JIS	Japan Industrial Standards Committee
EPRI	Electric Power Research Institute	kCal/hr	kiloCalories per hour
ESCO	energy service company	kWh	kilowatt hour
EU	European Union	kWh/a	energy use per year
FEHA	Foreningen af Fabrikanter og Importorer af Elektriske Husholdningsapparater (Danish trade association)	LBC	lampe basse consommation (low-energy-consumption lamp)
FEMP	Federal Energy Management Program	LBNL	Lawrence Berkeley National Laboratory
FTC	Federal Trade Commission	LCC	life-cycle cost
GAO	General Accounting Office	LCIE	Le Laboratoire Central des Industries Electriques (Central Electricity Industry Laboratory)
GDP	gross domestic product	LED	light-emitting diode
GEA	Group for Efficient Appliances	LNE	Laboratoire National d'Essais (National Testing Laboratory)
GEF	Global Environmental Facility	MEES	minimum energy-efficiency standards
GHG	greenhouse gas	MEPS	minimum energy performance standards
GRIM	Government Regulatory Impact Model	MITI	Ministry of International Trade and Industry (Japan)
GSA	Government Service Agency	MRA	mutual recognition agreement
HCFC	hydrochlorofluorocarbon	NAECA	National Appliance Energy Conservation Act
HFC	hydrofluorocarbon	NEMA	National Electrical Manufacturers' Association
HPWH	heat-pump water heater	NEMS	National Energy Modeling System
HSPF	heating seasonal performance factor	NEPA	National Environmental Protection Agency (China)
IBRD	International Bank for Reconstruction and Development (also the World Bank)	NGO	non-government organization
IDB	Interamerican Development Bank	NOPR	notice of proposed rule making
IEA	International Energy Agency		
IEC	International Electrotechnical Commission		

NPV	net present value	UNDP	United Nations Development Program
NUTEK	Swedish National Board for Industrial and Technical Development	UNEP	United Nations Environmental Program
O&M	operation and maintenance	UNF	United Nations Foundation
OEA	Office of Energy Affairs (Philippines)	URL	universal resource locator
PC	personal computer	USAID	United States Agency for International Development
PELP	Poland Efficient Lighting Project	VCR	videocassette recorder
R&D	research and development	VICP	Voluntary Independent Certification Program
SBQTS	State Bureau of Quality and Technical Supervision (China)	WSSN	World Standards Services Network
SEER	seasonal energy-efficiency ratio	WTO	World Trade Organization
SEPA	State Environmental Protection Administration (China)		
SERP	Super-Efficient Refrigerator Program		
SETC	State Economic and Trade Commission (China)		
SFOE	Swiss Federal Office of Energy		
SI	Système Internationale d'Unités (International System of Units)		
STEM	Statens Energimyndighet (Swedish National Energy Administration)		
THELMA	The High-Efficiency Laundry Metering and Marketing Analysis project		
TSD	technical support document		
TTEM	Technology Transfer for Energy Management (Philippines)		
UEC	unit energy consumption		
UN/DESA	United Nations Department of Economic and Social Affairs		
UN/ECE	United Nations Economic Commission for Europe		
UN/ECLAC	United Nations Economic Commission for Latin America and the Caribbean		
UN/ESCAP	United Nations Economic and Social Commission for Asia and the Pacific		

## GLOSSARY

- Accreditation:** conformity certification process by which the government ensures that testing facilities correctly perform tests with properly calibrated equipment.
- Achievable potential:** practical sustainable energy-savings potential, given market barriers and competing policies.
- Adjusted volume:** accounts for the different temperatures in the fresh food and freezer compartments of refrigerators, refrigerator-freezers and freezers.
- Baseline:** represents the energy performance of a typical model for a given product; a description of what would have happened to energy use of a product if labels and/or standards had not been implemented.
- British thermal unit (Btu):** the standard measure of heat energy. It takes one Btu to raise the temperature of one pound of water by one degree Fahrenheit at sea level.
- Carbon dioxide (CO<sub>2</sub>):** colorless, odorless noncombustible gas with the formula CO<sub>2</sub> that is present in the atmosphere. It is formed by the combustion of carbon and carbon compounds (such as fossil fuels and biomass); by respiration, which is a slow combustion in animals and plants; and by the gradual oxidation of organic matter in the soil.
- Certification:** process intended to provide clear direction to participants about how to meet the labeling or standards requirements, to ensure consistency, and to add credibility to government and manufacturer claims about energy efficiency. Protects manufacturers by making willful non-compliance by cheaters unacceptable and unprofitable.
- Chlorofluorocarbons (CFCs):** family of chemicals composed primarily of carbon, hydrogen, chlorine, and fluorine whose principal applications are as refrigerants and industrial cleansers and whose principal drawback is the tendency to destroy the Earth's protective ozone layer. They include CFC-11, CFC-12, and CFC-113.
- Class-average standards:** standards that specify the average efficiency of a manufactured product over a specific time period, allowing each manufacturer to select the level of efficiency to design into each model in order to achieve the overall average.
- Compact fluorescent lamps (CFLs):** smaller version of standard fluorescent lamps, which can directly replace standard incandescent lights. These lights consist of a gas-filled tube and a magnetic or electronic ballast.
- Comparative labels:** labels that offer consumers information that allows them to compare performance among similar products, using either discrete categories of performance or a continuous scale.
- Compliance:** method to ensure that errors are found and corrected, violators of the requirements are made to, at least, return to the permitted range, or if necessary, punished for transgressions. Protects manufacturers by making willful non-compliance by cheaters unacceptable and unprofitable.
- Consumer analysis:** analysis that establishes the economic impacts on individual consumers of any standard being considered.
- “Declared” energy consumption:** measurements of energy performance for an entire production run of a given appliance.
- Demand-side management (DSM):** planning, implementation, and monitoring of energy consumption, generally designed to encourage customers to modify their pattern of electricity usage to optimize available and planned generation resources.

**Economic potential:** optimum economic energy savings from a product user's (consumer's) perspective.

**Endorsement labels:** "seals of approval" according to some specified set of criteria.

**Energy-efficiency labels:** informative labels affixed to manufactured products indicating a product's energy performance (usually in the form of energy use, efficiency, and/or energy cost) in order to provide consumers with the data necessary for making more informed purchases.

**Energy-efficiency ratio (EER):** measure of the instantaneous energy efficiency of room air conditioners; the cooling capacity in Btu/hr divided by the watts of power consumed at a specific outdoor temperature (usually 95 degrees Fahrenheit).

**Energy-efficiency standards:** set of procedures and regulations that prescribe the energy performance of manufactured products, sometimes prohibiting the sale of products less energy-efficient than the minimum standard. Also known as norms.

**Energy factor (EF):** a measure of efficiency. For U.S. clothes washers, EF is the basket capacity (cubic feet) per kilowatt-hour per cycle. For U.S. water heaters, EF is the useful energy output divided by the water heating energy consumption.

**Energy Policy Act of 1992 (EPACT):** comprehensive U.S. legislative package that mandates and encourages energy-efficiency standards, alternative fuel use, and the development of renewable energy technologies.

**Energy service company (ESCO):** company that specializes in undertaking energy-efficiency measures under a contractual arrangement whereby the ESCO shares the value of energy savings with its customer.

**Energy test procedure:** agreed-upon method of measuring the energy performance of an appliance. May be expressed as an efficiency, efficacy (for lighting products), annual energy use, or energy consumption for a specified cycle, depending on the appliance being tested. Used to rank similar products by their energy performance, to evaluate new technologies, and to forecast their energy performance. Also known as "test standard."

**Enforcement:** all activities used to deal with manufacturers, distributors and retailers that are not in compliance with the regulations.

**Engineering analysis:** analysis that assesses the energy performance of products currently being purchased in the country and establishes the technical feasibility and cost of each technology option that might improve the product's energy efficiency and its impact on overall product performance.

**Engineering data:** data gathered on technical and energy characteristics of individual product models available on the market.

**Greenhouse gas (GHG):** gases—such as water vapor, carbon dioxide, tropospheric ozone, methane, and low-level ozone—that are transparent to solar radiation but opaque to long wave radiation and that contribute to the greenhouse effect by absorbing infrared radiation in the atmosphere.

**Harmonization:** process by which policy makers rely on test facilities, test procedures, label design, and standards already established by international organizations or neighboring countries or in which countries jointly enact common test procedures, label design, and standards in order to reduce non-tariff trade barriers. Also called "alignment".

**Heat-pump water heater (HPWH):** water heater that uses electricity to move heat from one place to another instead of generating heat directly.

**Heating seasonal performance factor (HSPF):** measure of seasonal or annual efficiency of a heat pump operating in the heating mode. It takes into account the variations in temperature that can occur

within a season and is the average number of Btu of heat delivered for every watt-hour of electricity used by the heat pump over a heating season.

**Impact evaluation:** used to determine the energy and environmental impacts of a labeling program.

Can be used to determine cost-effectiveness and can also assist in stock modeling and end-use (bottom-up) forecasting of future trends. Impact elements include influence of the label on purchase decisions, tracking of sales-weighted efficiency trends, and energy and demand savings.

**Information-only labels:** labels that simply provide data on a product's performance.

**Intergovernmental MRAs:** agreements established between governments. Typically, they cover products that are regulated by the government sector, such as electrical, telecommunications, and food products. They can be either bilateral or multilateral MRAs.

**Kilowatt hour (kWh):** unit or measure of electricity supply or consumption; equal to 1,000 Watts over the period of one hour; equivalent to 3,412 Btu.

**Life-cycle cost (LCC):** the sum of the purchase cost and the annual operating cost discounted over the lifetime of the appliance. Includes consideration of lifetime of the appliance and consumer discount rate.

**Manufacturing analysis:** analysis that predicts the impact of any standard being considered on international and domestic manufacturers, their suppliers, and their importers. It assesses the resulting profitability, growth, and competitiveness of the industry and predicts changes in employment. Depending on the local situation, this analysis may be expanded to include distributors and retailers.

**Market penetration:** the level of ownership: the percentage of households that own and use the equipment in question.

**Market transformation:** specific interventions for a limited period leading to a permanent shift in the market toward greater energy efficiency.

**Market transformation perspective:** evaluation focus on whether sustainable changes in the marketplace have occurred as a result of labeling and standards programs.

**Minimum LCC:** the level at which the consumer receives the most benefit.

**Monitor compliance:** all activities that ensure that a manufacturer's products remain in compliance with a standard after it has been certified.

**Mutual recognition agreements (MRAs):** multilateral arrangements between two or more economies to mutually recognize or accept some or all aspects of another's conformity test procedures (e.g., test results and certification).

**National impact analysis:** analysis that assesses the societal costs and benefits of any proposed standard; the impacts on gas and electric utilities and future gas and electricity prices that would result from reduced energy consumption; and the environmental effects in terms of changes of emissions of pollutants such as carbon dioxide, sulfur oxides, and nitrogen oxides that would occur in both homes and power plants resulting from reduced energy consumption.

**Net present value (NPV):** value of a personal portfolio, product, or investment after depreciation and interest on debt capital are subtracted from operating income. It can also be thought of as the equivalent worth of all cash flows relative to a base point, called the present.

**Payback period:** measures the amount of time needed to recover the additional consumer investment through lower operating costs; the ratio of the increase in purchase price and installation cost to the decrease in annual operating expenses.

**Performance standards:** standards that prescribe minimum efficiencies (or maximum energy consumption) that manufacturers must achieve in each product, specifying the energy performance, but not the technology or design specifications, of that product.

**Prescriptions:** most essential features of a successful energy-efficiency labeling and standards-setting program.

**Prescriptive standards:** standards that require a particular feature or device to be installed in all new products.

**Process evaluation:** evaluation that measures how well the program is functioning. Process elements include assessing consumer priorities in purchasing an appliance, tracking consumer awareness levels, monitoring correct display of labels in retailers, measuring administrative efficiency, and maintaining program credibility.

**Qualitative primary research:** includes the focus group technique, where a small number of people with certain characteristics (e.g., recent buyers of refrigerators) are recruited to participate in a facilitated discussion about a particular topic in order to get the in-depth and subjective views of key audiences. Results cannot be statistically generalized to the greater population.

**Quantitative primary research:** uses survey approaches with randomly selected samples of a particular population. Results are then projected to the whole population from which the sample is drawn.

**Regulatory standard:** establishes a level of minimum energy efficiency. Typically references the appropriate test procedures.

**Resource acquisition perspective:** evaluation focus on the calculation of energy and demand savings and greenhouse gas emissions reductions from labeling programs and standards.

**Secondary research:** analyzes and applies the results of past market research to the current situation.

**Seasonal energy-efficiency ratio (SEER):** measure of seasonal or annual efficiency of a central air conditioner or air conditioning heat pump. It takes into account the variations in temperature that can occur within a season and is the average number of Btu of cooling delivered for every watt-hour of electricity used by the heat pump over a cooling season.

**Self-certification:** certification in which manufacturers formally test their own products and, in practice, also test each other's products and force compliance. Is currently practiced in the U.S., Japan, and most European countries.

**Stakeholder:** any party that may have an interest in the required data. This typically includes manufacturers, consumers, utilities, local governments and representatives of environmental or energy-efficiency interest groups; may also include representatives of importers and international organizations where applicable.

**Technical MRAs:** establish technical equivalency between bodies in different countries. They can cover laboratory accreditation agencies, inspection accreditation, and testing certification bodies. They facilitate testing by a manufacturer, since they can eliminate the need for retesting a product in a foreign country.

**Technical potential:** the maximum technically achievable energy savings.

**Test protocol:** specifications on testing.

**Theory evaluation:** approach which tests many hypotheses, such as “most/some/all consumers will use labels as part of their purchase decisions” or “labels will encourage manufacturers to improve the energy performance of their products.”



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