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 analysis of the impacts of energy-efficiency standards can greatly aid in the regulation or negotiation of those standards. Key decisions for the analyst include the products to be analyzed, the analysis method to be used, and the criteria to be used for evaluating energy performance. It is essential to document all assumptions, methods, and results, and it is extremely beneficial to include an open process of review and consultation with stakeholders.

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

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

Policy makers interested in implementing minimum energy-performance standards (MEPS) generally require analyses performed by disinterested parties to assess the impacts of alternative policies. The stakeholders (all interested parties) in a standards proceeding also look to third-party analyses to focus their supportive or critical comments.

This chapter describes some of the methods 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 or equipment.

For any analysis approach, the level of detail can range from simple estimates to detailed probabilistic analysis. Simple analysis is almost always a useful first step. The subsequent level of analytical detail depends upon availability of data and the needs of the program. If the existing products in the market are relatively inefficient, simple analysis may be sufficient to justify efficiency increases. If the market is already relatively efficient or the market or policy atmosphere is sufficiently complex and the resources are available, additional analysis may be warranted or even necessary to set standards.

One caution noted in Chapter 2 is especially important when designing mandatory standards: poorly designed or executed standards can actually harm consumers, manufacturers, other stakeholders, and the overall economy and the environment. Inattention to detail in the development and implementation of a standard 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 note of caution is worth remembering when applying the material that follows.

6.1.1 Types of Efficiency Standards

This section describes three types of energy-efficiency standards:

- prescriptive standards
- MEPS
- 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, the U.S. government required that new gas-fired clothes dryers not use standing pilot lights from January 1987 on. Determining compliance is simplest for prescriptive standards because it requires only inspection of the product.

Performance standards prescribe minimum efficiencies (or maximum energy consumption) in all products manufactured after a certain date. For example, some refrigerator standards require that each unit use no more than a maximum amount of energy per year (kWh/a) under test conditions. These standards specify the energy performance but not the technology or design specifications of the energy-efficient product. Generally, a technical analysis supports the cost effectiveness of achieving prescribed efficiency levels. In the case of a statistical analysis, required levels are usually met by models already on the market. In the case of an engineering / economic analysis, efficiency levels are generally set that are shown to be achievable using available designs known to be cost effective, but these options are not the only possibilities for achieving an efficiency goal. Performance standards therefore permit innovation and competing designs. Assessing compliance with performance standards requires establishment of a well-defined test procedure and verification process (see Chapter 4).

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. A sales-weighted average takes into account the market share of models of varying efficiency to achieve a targeted gain in overall energy savings rather than specifying the efficiency of each unit. The sales-weighted approach can be particularly useful to promote a leap in technology (e.g., from electric-resistance storage water heaters to heat-pump water heaters) because sales of a very efficient product can dramatically reduce the sales-weighted average energy use. Class-average standards require more record keeping than other approaches, however, and verifying compliance is more difficult. Nonetheless, this type of standard allows manufacturers more flexibility 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: *Performance or Class-Average Standards?* on next page.)

Performance or Class-Average Standards?

Heat-pump electric storage water heaters, CFLs, and condensing furnaces are three examples whose energy efficiencies are far higher than those of conventional products. U.S. DOE's 1994 proposal of an electric storage water heater MEPS initially required use of a new technology, the heat-pump water heater (U.S. DOE 1994). What ensued illustrates the limitations of performance standards and the usefulness of class-average standards.

There were two problems with a step transition to the heat-pump water-heater MEPS. First, 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 reality 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 put in place rapidly. The second problem was that 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. After hearing all the arguments, U.S. DOE set a performance standard that did not require heat-pump water heaters and instead set the standard at the efficiency of the best conventional units.

One solution in this case would have been to recommend set class-average standards. Class-average standards could have required a sales-weighted average efficiency higher than that of the then-current conventional technology but lower than that of the heat-pump technology, instead of requiring all models to meet the same MEPS. The sales-weighted average would have to have been met by a set date. This alternative approach would have encouraged a more rapid phase-in because a fixed fraction of production capacity would have been required to meet the new standards. This approach would have offered the opportunity for consumer acceptance of the new technology to build gradually but steadily.

The appliance efficiency standards of most of North America and many other nations (e.g., China, Australia) are in the form of mandatory MEPS. Some countries (e.g., Japan, Germany, and Switzerland) have instituted voluntary or target levels rather than mandatory efficiency standards. Voluntary agreements are usually worked as a consensus between the government and manufacturers. In some cases, (e.g., Switzerland), manufacturers are given a set time period to reach the voluntary standard, and, if they do not comply, the regulatory agency can substitute mandatory standards.

6.1.2 The Process of Analyzing and Setting Standards

The steps in analyzing and negotiating standards are shown in Figure 6-1 and discussed in sections 6.2 through 6.8.

Table 6-1 on pages 139–140 outlines the analytical elements of the standards development process. The elements of priority setting, initial-product (design-option) screening, engineering review, and economic

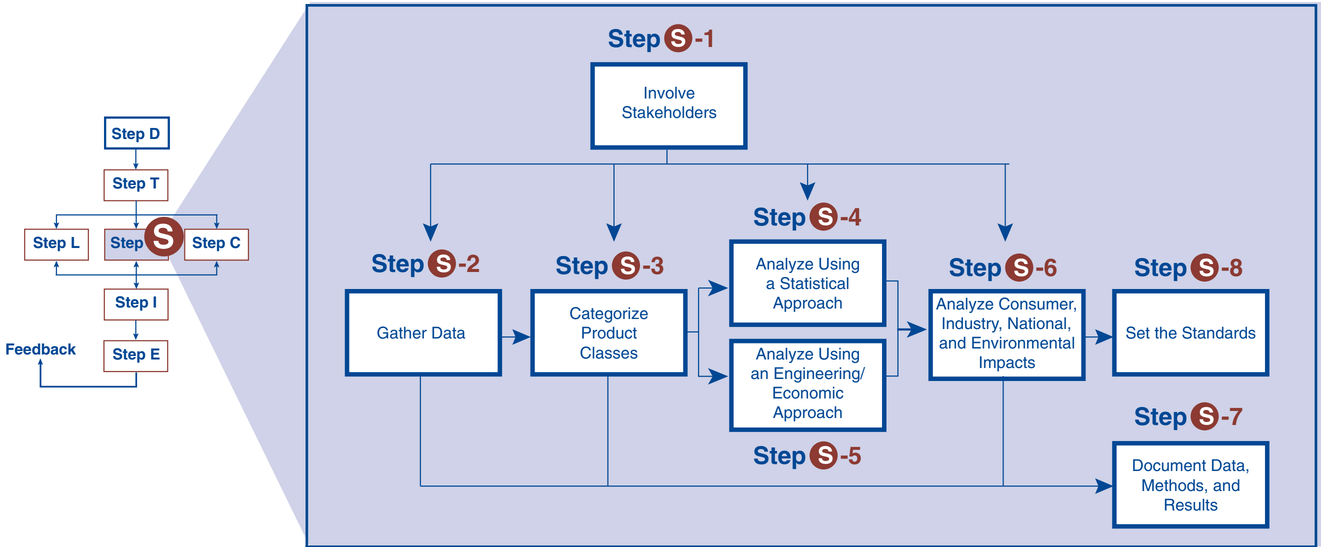

Figure 6-1 Major steps in analyzing and setting standards

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 and economic trends. Thus, the priority-setting step may be undertaken frequently, i.e., every year or two. The other 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 and have time to adjust.

6.1.3 Types of Analysis

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

- statistical analysis of current products
- engineering/economic analysis of potential technologies

These approaches can be used in combination and are not mutually exclusive. They can also be used with other approaches; one example of a third approach, used in Japan, is to establish standards according to recommendations of 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 method is best 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

Table 6-1 **Analytical Elements of U.S. Standards-Setting Process, as Revised in 1996**

Stages, Primary Inputs (•), and Outputs (≅)	Factors Considered
PRIORITY SETTING • Preliminary Analysis • Stakeholder Consultation on Draft Agenda ≅ Regulatory Agenda—annual publication of rule-making priorities and accompanying analysis and schedules for all priority rule makings anticipated within the upcoming two years	• Potential energy savings • Potential economic benefits and costs • Potential environmental and energy security benefits • Applicable rule-making deadlines • Incremental government resources required to complete the rule making • Other regulatory actions affecting products • Stakeholder recommendations • Evidence of energy-efficiency gains in the market in the absence of new or revised standards • Status of required changes to test procedures • Other relevant factors
DESIGN-OPTION SCREENING • Expert and Stakeholder Consultation ≅ Identification of product categories and design options to be analyzed further or to be eliminated from further consideration ≅ Identification of key issues and expertise necessary to conduct further analysis ≅ Identification of any needed modifications to test procedures	• Technological feasibility • Practicability of manufacture, installation, and service • Adverse impacts on product utility or availability • Adverse impacts on health or safety (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.)

continued on next page

statistical analysis of the energy efficiencies of currently available products to engineering analysis of possible future designs. Key outputs from the analysis include many factors representing costs and benefits that must be considered; projected energy savings and associated environmental consequences; economic costs and savings to subsets of consumers; and investment and employment impacts on manufacturers, energy suppliers, and the general economy. Economic indicators can include cost of conserved energy (CCE), average payback period, consumer life-cycle costs (LCCs), manufacturer or industry cash flow, and national expenditures.

Different standards-setting methods have been successful in achieving their objectives—new or revised efficiency standards—in different settings and at different times. Analyses have been used to forecast the impact of efficiency standards on consumers, manufacturers, utilities, and the environment. These projections have been used to compare options and to quantify uncertainties. In most cases, decision makers have used these data to implement effective policies.

Statistical Analysis of Currently Available Products

The statistical approach is most appropriate where products with a wide range of efficiencies are already available, and the goal is eliminating the least efficient products. The statistical approach

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.

requires data that may be easier to obtain than the engineering/economic approach, but it typically results in standards that are restricted to efficiency levels within the range of already available products. The data required are those that characterize the current marketplace for the products of interest, in terms of the number of models available in each efficiency range. Data can be collected for the national market only or can include products available on the international market. The impact of possible efficiency standards is expressed in terms of the percentage of available models that would be eliminated by requiring a particular efficiency and the number of manufacturers producing these models. The energy savings can be estimated from the change in average efficiency before and after standards.

The statistical approach avoids the need for cost data from appliance manufacturers or suppliers (these data are often very difficult to obtain for reasons of confidentiality) and for a representative survey of retail prices, which may be difficult or costly to obtain. The statistical approach also has political advantages because it avoids explicitly disclosing the cost of compliance. On the other hand, by masking the costs, it prevents economic optimization of the program and therefore may result in either an overly costly investment in efficiency or a lost opportunity to achieve more cost-effective efficiency improvements through standards.

Statistical analysis of current products is discussed in more detail in Section 6.5. The statistical approach has been utilized in the European Union (EU) (Group for Efficient Appliances 1993) and in Australia (Wilkenfeld 1993). In Japan, the Ministry of International Trade and Industry (MITI) has 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 Potential Technologies

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 the significant advantage of determining the energy savings and cost effectiveness of a wide range of designs even if the technologies are not yet available in mass production. Because it requires estimates of the efficiency and costs of new designs not yet widely marketed, this adds some uncertainty and may be subject to challenge by stakeholders opposed to stringent standards.

The engineering/economic approach allows for a great deal of policy flexibility. For instance, policy makers can choose an option that minimizes overall consumer costs or an option that maximizes energy savings but is still cost effective. 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. In general, however, this type of analysis is more expensive and time-consuming than a statistical analysis. If resources are limited, there is a recently developed spreadsheet tool that can estimate potential energy savings and financial impacts based either on user-supplied or default engineering and market parameters built into the model. The more country-specific data that are used, the more accurate the results, but estimates are possible with very limited data (see insert: *The Policy Analysis Modeling System for Simplified Engineering Analysis*). Section 6.6 describes engineering/economic analysis in more detail.

6.2 Step S-1: Involve Stakeholders

Experience from many countries has shown that effective standards programs are difficult to establish without stakeholder involvement. At a minimum, the principal stakeholders—manufacturers, consumers, utilities, local governments, and environmental or energy-efficiency interest groups—should

The Policy Analysis Modeling System for Simplified Engineering Analysis

The Policy Analysis Modeling System (PAMS) is a spreadsheet tool developed by LBNL for CLASP. PAMS estimates the following potential energy savings and financial impacts resulting from government energy labeling or minimum efficiency standards, based on user-supplied or default engineering and market parameters:

- Life Cycle Cost Savings—Financial savings to each consumer (household or commercial enterprise) for each product purchased, calculated over the product's lifetime (described in Section 6.7.1),
- National Energy Savings—Primary (source) energy savings (described in Section 6.7.3),
- Net Present Value—National financial impacts (described in Section 6.7.3), and
- Greenhouse Gas Emissions Reduction—Based on source energy savings and forecast of electricity generation mix (described in Section 6.7.5).

The model is sophisticated in that it allows either for input of relevant detailed data or, when obtaining these data is difficult or prohibitively expensive, for an estimate based on data from other countries. Macro-economic forecasting is built into the model using engineering data from countries other than the target country; market trends are forecast based on well-established econometric methods coupled with publicly available economic data.

The tool also provides the user with the option to manually input country-specific field data to take into account the particular characteristics of product markets and economic scenarios. Inputting the country-specific data listed in Table 6-2 can greatly increase confidence in the model's results, increasing the usefulness of the tool for determining the direction of labeling or standards policy. Collecting the data listed as "recommended" requires moderate effort and significantly improves the accuracy of the model. Providing "suggested" data increases confidence in the results, but these data may require significant effort to collect.

PAMS generates forecasts for one country and one appliance at a time. The model is capable of creating a general picture of impacts with a minimum investment of local resources.

be represented. Including representatives from importers and international organizations, where applicable, is useful to ensure that programs are feasible internationally. To avoid the perception of favoritism, the government must ensure that all stakeholder interests are fairly represented.

Furthermore, there must be an open and transparent process through all steps of the standards-setting process for these stakeholders to contribute information and raise concerns and for the implementing agency to receive and process these contributions. By this means, the implementing agency can obtain technical support in the form of data and review of analytical methods and results. Generally, stakeholder contributions are incorporated through public meetings or invitations to provide written comments. Including stakeholders in the analytical stages of the standards development process can engender a spirit of trust among stakeholders, thus increasing the likelihood of the program's success. Responding to stakeholder comments and adapting proposed standards to reflect the most relevant stakeholder input helps accomplish this trust and can even lead to negotiated consensus standards. Negotiations among

Process for 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.

The U.S. process rule is Title 10. United States Code. Section 430.34. The rule with a brief description can be found at: www.eere.energy.gov/buildings/appliance_standards/get_involved.html

The process has led to several consensus rules. To show the complexity of such consensus building, here is the list of the signatories to the recent consensus rule for commercial air conditioners and heat pumps:

Air-Conditioning and Refrigeration Institute, Arlington, VA
American Council for an Energy-Efficient Economy, Washington, DC
Aaon Heating and Cooling Products Tulsa, OK
Alliance to Save Energy, Washington, DC
Appliance Standards Awareness Project, Boston, MA
Armstrong Air Conditioning Inc., Bellevue, OH
California Energy Commission, Sacramento, CA
Carrier, Farmington, CT
Daikin, New York, NY
Lennox International Inc., Dallas, TX
Mammoth, Inc., Chaska, MN
McQuay International, Minneapolis, MN
Natural Resources Defense Council, San Francisco, CA
Nordyne Inc., O'Fallon, MO
Northeast Energy Efficiency Partnerships, Lexington, MA
Rheem Manufacturing Company, Fort Smith, AR
Sanyo Fisher (USA) Corp., Chatsworth, CA
Trane/American Standard, Tyler, TX
York International, York, PA

stakeholders are a standard element of Japan's and Australia's standards-setting processes and led to consensus standards for refrigerators, clothes washers, and fluorescent lamp ballasts in the U.S.'s sometimes adversarial regulatory environment. Once trust is established, it is easier to conduct good-faith negotiations, concentrating on issues of legitimate disagreement (Thompson 2003) (see insert: *Process for Stakeholder Involvement*).

The purpose of analysis is to create a sound basis for the government's policy choices, to detail the technical information and assumptions underlying those choices, and to quantify the likely impacts of policies. Analysis gives the regulating agency the necessary basis for decision making, informs regulated parties (appliance manufacturers and importers) about the government's understanding of the factors related to regulation, and advises all stakeholders (including regulated parties, environmental advocates, energy providers, and consumers) of the likely impacts of proposed regulations. The analysis process focuses attention on a limited range of policy options and creates a transparent, public basis for discussion and debate.

Typically, most of the research on the impacts of standards is conducted under the sponsorship of the government agency that is responsible for setting the standards. Frequently, however, the technical team performing the analysis is independent of the implementing agency, e.g., a private contractor or academic institution.

The implementing agency has a fundamental interest in the quality of the analysis as high-quality analysis will ensure a well-informed decision leading to economically optimum standards levels. The analysis may also have a role to fill in satisfying specific statutory requirements, e.g., requirements that standards do not unduly burden consumers or that they provide at least minimum benefits. Regulators overseeing the standards process must insure that the technical analysis is robust and thorough enough to avoid unintended negative consequences, without exceeding budgets and deadlines and thereby reducing the effectiveness of the program. The analysis should also be clear and definitive, to allow for open and fair resolution of disputes that arise among stakeholders. As with any policy, it is difficult to totally eliminate uncertainty and arrive at a unique, scientifically defensible conclusion. However, demonstrating that the likely impacts are favorable and politically supportable for a range of plausible future scenarios is generally sufficient.

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

6.2.1 Appliance Manufacturers and Importers

Energy-efficiency regulations limit the set of products that may legally be produced or imported. Manufacturers and importers are directly impacted by these regulations that can increase the costs of doing business. 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 have a practical attitude about the authority of governments to impose standards if the standards are perceived to be fair.

Depending on 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 impacting some manufacturers more than others. Policies must be applied uniformly without favoritism and the implementation schedule must allow manufacturers 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
- considers the effects of competition on regulated parties

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

Stakeholder involvement is also 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 simultaneously 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. Manufacturers' and importers' interests may be partially served by scheduling that:

- recognizes the need for sufficient lead time between deciding on a new standard and the effective date (typically 3 to 5 years)
- takes into consideration the cumulative regulatory burden affecting manufacturers from other non-related regulations (e.g., refrigerant phase-out)

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 as a result of regulatory actions.

6.2.2 Consumers

Consumer groups may generally be interested in ensuring that government regulations are not overly burdensome to those who purchase energy-consuming products. They may also be concerned about overly strong standards that raise the price of appliances or about overly weak standards that don't result in sufficient savings on utility bills. Analysis of payback periods (included in LCC analyses) illustrates these tradeoffs and helps identify policies that will have net benefit for consumers. Other elements of the analysis that may be important to consumers include: consideration of different impacts among consumers based on the energy prices they pay and their actual appliance usage (which may differ from laboratory or test procedure conditions), possible impacts on the service provided (the utility to the consumer) by a product as a result of design changes, and possible shifts to competing technologies (e.g., switching between electricity- and gas-fueled storage water heaters).

6.2.3 Energy Providers

Energy-efficiency standards reduce energy consumption, which may reduce the need for new energy supply or make more new supply available for other applications. 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 heating or water heating) may be an important concern to energy suppliers. The analysis of impacts can address likely market shares by fuel type. Private energy providers may be affected by reduced demand among regulated end uses. The analyses that accompany energy-efficiency regulations typically benefit both utility planners and private energy providers by reducing uncertainty about future demand.

6.2.4 Environmental Advocates

When energy-efficiency standards reduce combustion of fossil fuels, they not only reduce energy consumption but also associated environmental emissions such as CO_2, oxides of sulfur and nitrogen, mercury, and particulates. Environmental advocates will be especially interested in the magnitude of these impacts. Other environmental factors subject to analysis include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and other alternative refrigerants or insulation blowing agents. There may be tradeoffs between reducing ozone-depleting chemicals and reducing global warming potential; 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 simultaneously improve energy efficiency (e.g., choosing alternative insulation for refrigerators in consideration of the 1993 U.S. standards).

6.3 Step S-2: Gather Data and Forecast Input Parameters

The information needed to perform an analysis of standards depends on the method used to establish standards, or, for governments with limited resources, on the information that is readily available. To select products for analysis, it is necessary to understand the market structure, including the manufacturers, importers, and distributors.

6.3.1 Effect of Data Availability on Selection of Analytical Method

Figure 6-2 is a schematic diagram showing the decision logic for analyzing standards depending on what data are available. We have already briefly described the statistical and engineering analysis methods. More data are needed for the engineering analysis than for the statistical analysis. In some developing countries, there will not be enough available information to utilize either of these methods, so a simplified method will be needed.

An example later in this section (in the sub-section on end-use metering) describes a situation in China in which a moderate amount of information was available but not enough to perform even 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 are also needed for a thorough engineering/economic analysis, to establish baseline models.

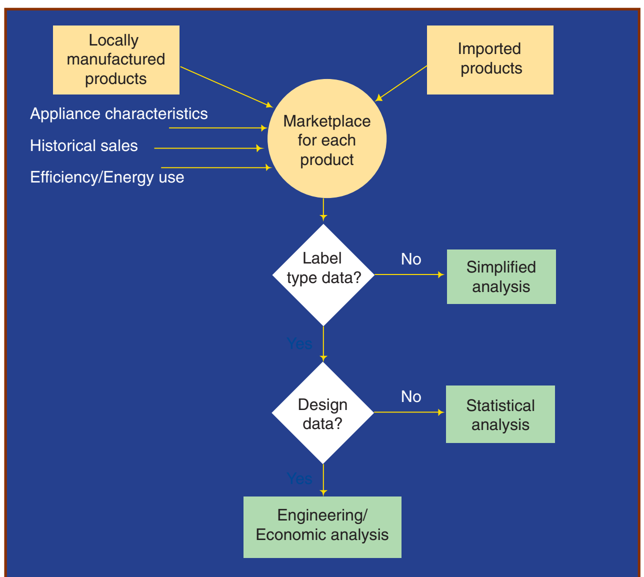

Figure 6-2 Decision tree for choosing appliance standards analysis method

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

6.3.2 Deciding What Data to Collect

Enough data should be collected to estimate roughly the percentage of sectoral (residential or commercial) energy use that is accounted for by each major end use. Examples of end uses are refrigerators, water heaters, air conditioners, lighting equipment, and televisions. An end-use analysis allows policy

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) or products that show high unit sales and are gaining in ownership.

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

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

Economic Data	Market Data	Engineering Data	Energy Sector Data
Recommended • Electricity (or natural gas) tariff schedule for residential or commercial customers (as applicable)* • Residential or commercial consumer discount rates (as applicable) • Societal discount rate	**Recommended** • Market Structure: manufacturers, importers, and distribution channels • Average retail price of appliance baseline model* • Percent of households or commercial buildings that have each major energy-using product* • Historical time series of annual shipments of each class of product* • Relative market share of product classes • Share of contribution of imports to total shipments **Suggested** • 10–to 20-year forecast of annual product shipments* • 10–to 20-year forecast of product price trends* • Share of product shipments by efficiency level • Manufacturer, distributor, and retailer price markups*	**Recommended** • Annual UEC for existing models of each class of product* • Annual UEC for more efficient models (or technologies) of each class of product* • Average product lifetime* • Retail price increase associated with higher efficiency **Suggested** • Relationship of manufacturer cost to design efficiency * • Energy consumption test data as collected by regulating agency or other certifying entity	**Recommended** • Conversion factor from site electricity to source energy • Electricity generation fuel mix* **Suggested** • 10–to 20-year electricity-generation carbon factor forecast • 10–to 20-year electricity-generation nitrogen oxide (NO_X) and sulfur oxide (SO_X) factor forecast

*In the absence of these data, PAMS provides a default value or an estimate based on macro-economic trends.

If information on the technologies available for improving 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 energy use, but their energy savings potential could be smaller than that of another, less efficient product. Section 6.1.3 describes a simplified method for estimating energy, economic, and greenhouse gas savings when sufficient data are unavailable for the more sophisticated analyses. Although that approach may be used with almost no country-specific data, the more data collected and used, the more accurate the results will be. The type of data that energy analysts would, ideally, like to have to thoroughly analyze appliance energy-efficiency standards are listed in Table 6-2, with the data requirements for the simplified tool indicated.

Although collecting data can be difficult, approximate information is often 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 or 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.

Energy Consumption Surveys

Performing a survey of energy-consuming appliances in households and commercial enterprises often provides a useful basis for characterizing market and use patterns. This survey may be done explicitly as part of the standards-setting process. If program resources do not allow for a survey, information may often be obtained from utilities or government statistics agencies, which perform related surveys for different purposes. The most obvious and readily obtainable information provided by an energy consumption survey is the current and historical ownership of each type of equipment. The relative market share of particular product classes (e.g., single vs. two-door refrigerators) and fuel types (e.g., electric vs. gas water heaters) can also be revealed by a survey. A detailed survey can give a rough estimate of the use patterns of certain appliances although this type of questioning can significantly lengthen the interview time and is dependent on the respondent's willingness and ability to accurately characterize energy consumption habits. Finally, survey data related to appliance brand and model can be correlated to manufacturer data to characterize the market in terms of appliance capacity and efficiency. However, this level of detailed information is often quite difficult to obtain.

The following prescriptions apply to the collection of survey data:

- The survey should focus on equipment that has a high ownership rate or rapid growth in ownership, and uses a significant amount of energy.
- Care should be taken to make sure the survey sample is representative of the country as a whole.
- The benefits of collecting as much data as possible should be balanced with the cost and burden to consumers of a lengthy interview.
- Surveyors should be adequately trained to collect data as accurately as possible, with minimum inconvenience to the interviewee.

The 1995 survey results presented in Figure 6-3 show that the largest electricity users in urban China were refrigerators and televisions. In order to decide which appliances to consider for standards analysis, it was necessary to evaluate possible technological efficiency improvements for each appliance type. Based on the extent of energy consumed and the potential efficiency improvements for each product known in 1995, China modified its efficiency standards for refrigerators and room air conditioners. Using updated survey data, China has since modified its standards for refrigerators a total of three times (effective in 2000, 2003, and 2007). Efficiency standards for room air conditioners were revised in 2001 and 2004. A revised efficiency standard for clothes washers took effect in 2004 as well. A new standard has also been proposed for televisions that will regulate both standby and active power consumption. For lighting products, efficiency standards were announced for compact fluorescent lamps (CFLs) and linear fluorescent lamps in 2003. Incandescent bulbs are still the dominant light source used in Chinese residences, so the greatest savings in residential lighting are likely to come from switching from incandescent lamps to CFLs.

Household surveys show relative use of different appliances.

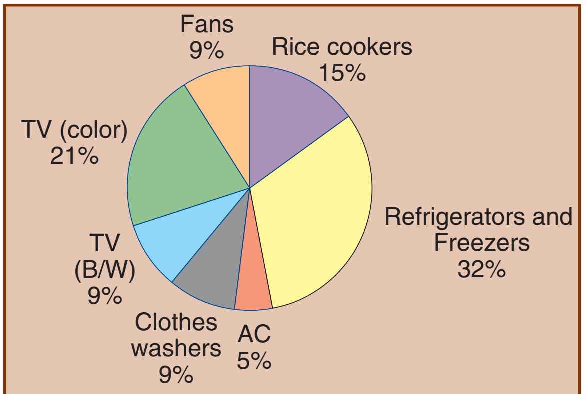

Figure 6-3 End-use electricity consumption (1995) in China households (lighting electricity consumption excluded)

Laboratory Measurements

Laboratory measurements for energy consumption of appliances are most useful if a well-defined test procedure has already been established for targeted appliances, and a significant number of test data have been gathered as part of a comparison or endorsement labeling program. Thoughtful design of a test procedure and certification process is critical to any standards and labeling program. Testing and certification are described in detail in Chapter 4. Testing data submitted by manufacturers participating in an existing program can give a good indication of actual consumer consumption.

There are two caveats regarding the use of test data in designing standards, however. First, while test procedures are designed to emulate actual use patterns and environments, actual consumer use may vary considerably. For example, most refrigerator test procedures simulate household ambient air temperatures but do not include the opening and closing of doors that are a part of actual refrigerator use and which can significantly affect energy consumption. Second, the operation of some products, like heating and cooling equipment, is highly variable due to variations in climate. These variations cannot be accounted for with any single procedure. Therefore, test procedures give information only on relative consumption–actual savings from efficiency improvement can only be determined with additional characterization of use in the field. Test procedures may be best interpreted as providing an estimate of actual use that is inexact but sufficiently accurate for the purposes of designing standards.

End-Use Metering

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 may be substituted if necessary but are less accurate representations than metered end-use data of actual household energy consumption.

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 analyze standards using either of the two methods described above. This was the case in China during the late 1990s when official stock figures had not been publicly reported for more than five years, so current stock figures were derived from 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 performed 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 were 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, so rough estimates must be made until these data can be collected. For example, in the study on air conditioners in Ghana mentioned above, an estimated power demand was multiplied by estimated hours of operation to get the UEC. In the China example, end-use metering was used to obtain air-conditioner UECs. Refrigerators are a prime example of a product for which household surveys will not yield a UEC because occupants will not know how many hours a refrigerator compressor is in operation, and the power demand is also usually unknown.

6.3.3 Market Data

In order to project potential national energy savings (not just unit savings) from energy-efficiency standards over time, it is necessary to forecast shipments of the product for which a standard is being proposed. This forecast serves as an estimate of future sales and thus future ownership and use. Ideally, data are available regarding recent trends in appliance sales by product class. Examples are data collected by retailers or manufacturer/industry groups and/or import data collected by customs officials. Often, however, data of this type are not available. In their absence, some idea of future sales may be derived based on current ownership rates, assuming that currently installed equipment will be replaced at the end of its lifetime. These estimates can then be combined, as in the case of China, with projections of future saturation rates and population growth. One way to assess the configuration of the current market is through a retail survey, in which appliance dealers (including importers) are asked about market shares of product types (classes) and efficiency levels. Although retail surveys give only a partial picture of the market and responses may be somewhat subjective, they offer a relatively low-cost way of estimating the base-case configuration of products targeted for standards as well as an up-to-date picture of trends in consumer product preference. Section 6.7.3 discusses how to use these market data 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. Both the efficiency improvement and the ultimate cost increase that will be passed on to the consumer are based on experts' judgments of the effectiveness of particular efficiency-improving designs and the additional material and labor costs required to implement them. 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 model 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 for particular designs can also be very difficult because of the significant temporal and regional variations in consumer prices. In some cases, it may be possible to find two models of a product that only differ by the presence or absence of a particular design feature. The price difference between two matched models differing only in efficiency can be valuable information.

In addition to engineering data, energy price, appliance lifetime, and consumer discount rate are needed to calculate LCC. To calculate the payback period, only incremental cost, energy savings, and energy price are needed. Fuel or electricity price should 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.

6.3.5 Proprietary Information and Confidentiality

Publicly available information should be used as much as possible. In a competitive market, individual companies have good reasons for protecting the confidentiality of their proprietary information, particularly their costs and sales data, to keep it from falling into competitors' hands. It is useful to establish rules that permit policy makers to have access to proprietary information in exchange for strictly protecting it. The government must first identify the nature of the essential information, determine how it will be used, and ascertain that it is not already available from other sources. The government should request from manufacturers only specific information necessary for the analysis that is not otherwise available.

Confidentiality can be arranged either directly between regulators and the concerned industry or through an independent third party. Under third-party agreements, several companies often provide proprietary information essential to the analysis to an independent organization, which can be a trade association or a contractor to the government. Depending upon the details of the agreement, the third party gives the government either aggregated information (e.g., industry-wide totals or averages) or statistical information in which company identities are masked (e.g., information is attributed to Company A, Company B, and so on). The original proprietary information remains confidential as it is not shared directly with the government or the public.

In the early stages of a standards program, there is likely to be a problem with information asymmetry during discussions between government and stakeholders. The government, depending on the openness of the deliberations, may know more about the overall program plans while 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. If either of these parties refuses or otherwise doesn't share this information with all the other stakeholders, the resulting information imbalance can hamper the process of developing economically optimum standards. Such an 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.

6.4 Step S-3: Categorize Product Classes

Depending on the nature of the product being analyzed for 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 provided by the product. A reduction in service is undesirable because the intent of standards is 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 locations of freezer compartments (e.g., side by side or freezer on top of fresh food compartment) are typically distinguished by product class. In the E.U., 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 would models without those same features. Conversely, dividing a product into a large number of product classes can help stimulate the sale of higher-energy appliances and thus limit the potential overall energy savings.

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 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 them. 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 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 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 than standard electric water heaters in that HPWHs require more space, need sufficient air circulation, and must have a provision for condensate drainage. 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 (U.S. DOE 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 E.U. 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 (called the reference line), 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 impact of any proposed standard is calculated by assuming that manufacturers will react by replacing each model having energy efficiency below the standard with a model of higher efficiency. The number of models in the analysis stays constant. The energy savings for the improved-efficiency models are calculated, and energy savings are aggregated until the total savings 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. GEA studied four of the many possible ways to analytically 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.
- 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.
- 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 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 (GEA 1993).

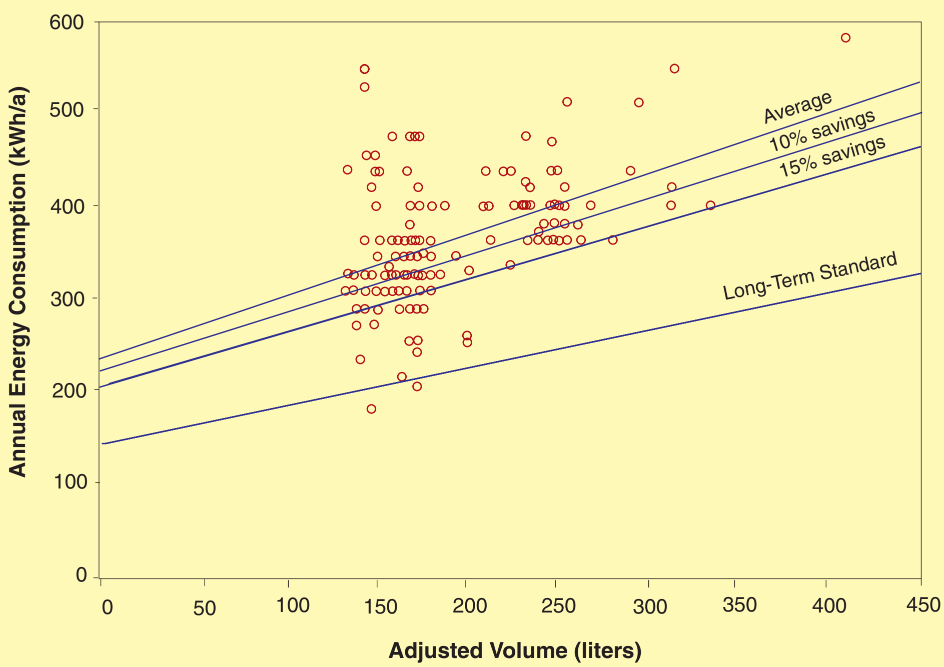

Figure 6-4 Statistical approach applied to E.U. refrigerator-freezers

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

The analyses described above are very simple compared to engineering/economic analyses, which require extensive time and resources 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%, 50% or more of products. If the standard level is revised frequently enough, 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 U.S. DOE since 1979 to analyze all U.S. standards. An engineering/economic approach has also been used to propose long-term refrigerator efficiency standards in the E.U. (Group for Efficient Appliances 1993). An engineering analysis is first carried out for each product class within a product type to estimate manufacturing costs or retail prices for improving efficiency compared to a baseline model. Installation and maintenance costs are also calculated. The engineering analysis can be described in seven steps shown in Table 6-3.

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

As with the statistical approach, the first step in the engineering analysis is the segregation of a product 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 in 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 from eliminating the least-efficient ones.

The third step is selecting design options for each product class. 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. Calculating the efficiency improvement from each design option is the fourth step in the analysis. Calculating the efficiency improvement from combinations of individual design options is the fifth step in the analysis. These calculations are usually performed with spreadsheets or engineering simulation models that account for the various energy-using components of a product.

In the sixth step, the expected costs of manufacturing, installing, and maintaining each design option are 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 as described in Section 6.3.4.

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

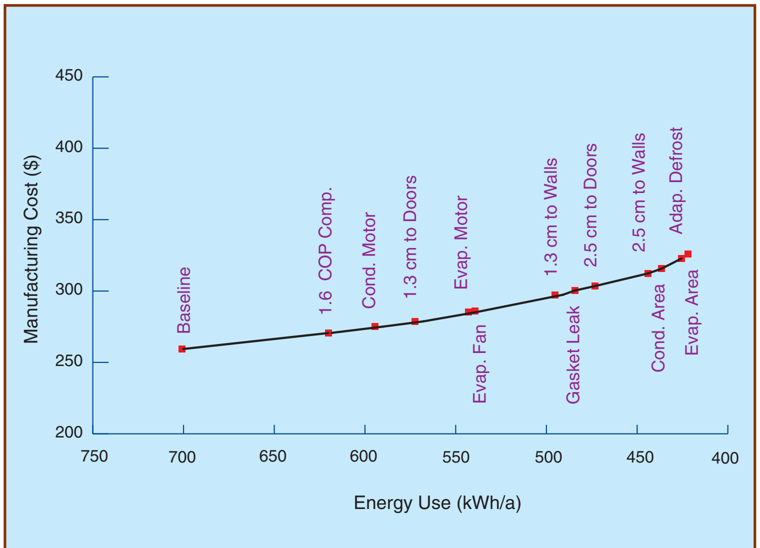

Figure 6-5 Example of fundamental data for engineering analysis: U.S. top-mount auto-defrost refrigerator-freezer

The seventh and final step in the analysis is to generate cost-efficiency curves. Figure 6-5 illustrates the results of an engineering/economic analysis for an 18.2-ft^3 (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 U.S. DOE in July 2001 (U. S. DOE 1995). Manufacturing 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 centimeters (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 9.1 Watts (W) and 12.0 W, respectively, to 4.5 W 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.

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^3, top-mount, auto-defrost refrigerator-freezer below 500 kWh/y at a time when no models with such a low energy use were commercially available. 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 is evidence of great design ingenuity among manufacturers.

6.7 Step S-6: Analyze Consumer, Manufacturer, National, and Environmental Impacts

There are separate methods for estimating consumer LCC and payback period, national energy savings and economic impact, manufacturer impact, energy supply impact, and environmental impact. Figure 6-6 shows the connection between the engineering analysis and the other analyses described below.

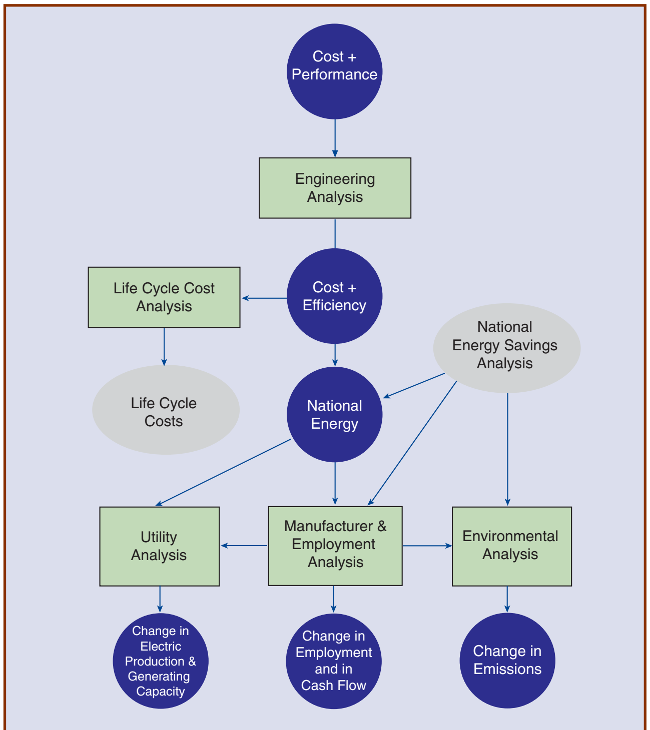

Figure 6-6 The relationship of engineering analysis to other impact analyses

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.

6.7.1 Consumer Payback Period and Life-Cycle Cost

Economic impacts of potential efficiency improvements are generally determined by analyzing consumer payback period and LCC. The ability to accurately determine consumer payback periods and LCCs depends greatly on the data collected during the previous stage of analysis. Generally, the statistical method can provide an adequate determination of energy impacts but relies on current retail prices to project the anticipated purchase prices of products that incorporate technology to enhance efficiency. These prices may be difficult to obtain and may shift under a standards scenario. In contrast, the detailed data necessary for an engineering/economic analysis generally permit an accurate projection of consumer payback periods and LCCs, using allegedly more accurate manufacturer costs and distributor markups to arrive at consumer equipment costs.

Retail Prices and Markups

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 directly determine retail prices. 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 survey approach may be the only available option, however, if the statistical method was used in the previous step of analysis.

The alternative is to develop a markup, typically the ratio of the retail price of a baseline model to the manufacturer's cost. If market statistics are available, the markup is often developed from aggregate industry-wide data. The ratio of the average manufacturers' selling price to the average manufacturer's cost is usually assumed to remain constant in the standards case compared to the case with no standards. Actually, some distribution costs (e.g., labor by distributors and retailers) are unlikely to be changed when standards take effect, so a markup slightly lower than that before standards would maintain profits in the distribution channel at their former level.

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 plus 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 product means that the increased purchase price will be fully 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

Calculating Payback Period and Life-Cycle Cost

Payback period (PAY) is found by solving the equation

$$\mathrm{O}P + \sum_{1}^{PAY} \mathrm{O}O_t = 0$$

for PAY. 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, the equation has the simple solution

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

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

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

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

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

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

payback calculation (which is 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 minimum compliance with the standard under consideration. The second method tends to yield slightly longer payback periods (see insert: *Calculating Payback Period and Life-Cycle Cost*).

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

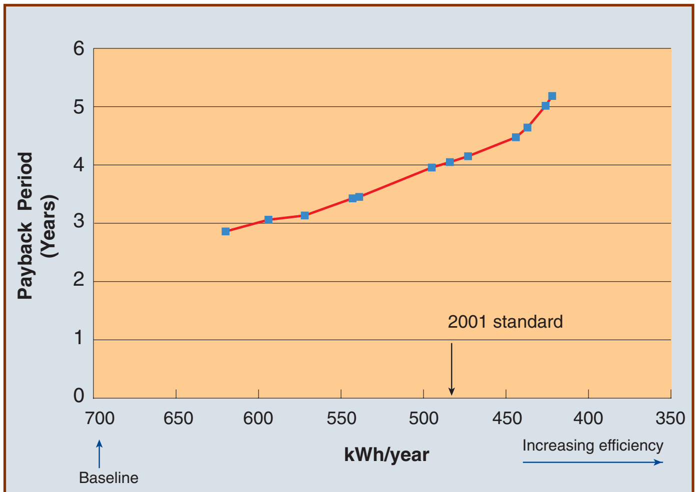

Figure 6-7 Payback periods for top-mount automatic-defrost refrigerator-freezers.

Figure 6-7 shows the payback periods obtained by the second method using the estimated base-case distribution of model efficiencies when calculating paybacks for the various design options. The left-hand axis shows the cumulative simple payback period. The consumer payback period for the reduced gasket heat leak design option, which has an energy use close to the consensus standard, 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 this approach has rarely been used.

Life-Cycle Cost

The LCC is the sum of the purchase and installation cost (P) and the annual operating and maintenance cost (O) discounted over the lifetime (N, in years) of the appliance. 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 in which standards are to become effective, using a discount rate, r, to determine the present value of future 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 on next page 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 U.S. DOE as part of the basis for setting standards that took effect in 1993. The later curve was used by negotiators to establish the consensus standards that took effect in 2001. In the latter case, the minimum LCC (where the consumer receives the most benefit) is around 450 kWh/a. At a lower discount rate, future savings in utility bills

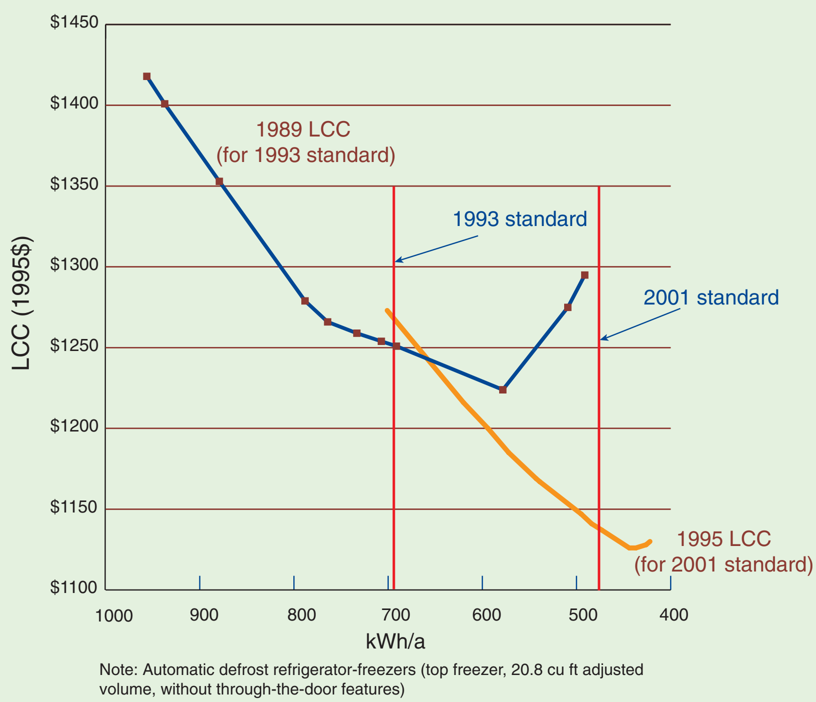

Figure 6-8 Life-cycle cost (LCC) vs. annual energy use (kWh/a)

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

become relatively more important, and 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 the 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 savings 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.

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 costs of water and detergent should also be considered if their consumption changes with energy efficiency.

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 of standards on manufacturers and their employees, distributors, retailers, and customers is an integral part of the 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 individually 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 U.S. (DOE 1999) and the E.U. (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. 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, manufacturer costs such as materials and labor, selling and administration costs, taxes, and capital expenditures to generate annual cash flows. The industry net present value (NPV) can be calculated by inflating the annual cash flows from the period 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., the Government Regulatory Impact Model (GRIM), a flexible, transparent tool, has been developed for analyzing the impact on manufacturers. This model uses readily obtainable financial information to consider the impact of government-imposed costs on profitability and cash flow, based on a variety of assumptions that can be varied to study 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 E.U.) energy savings from proposed energy-efficiency standards. These energy-savings estimates can be converted directly into economic savings and reduced emissions of carbon dioxide and other combustion products. Other impacts 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 first 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 determines 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
- time period of the analysis (usually the initial year is the effective date and the final year is considered sufficient if it accounts for at least one replacement of existing appliances)
- UEC with and without standard
- annual shipments forecast
- projected energy price trend
- discount rate

A probability function is often used to account for retiring appliances as their useful lifetimes are completed. 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, transmission and distribution losses, and continuing improvements in power-plant transmission and distribution technology.

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.

Electronic Standards for Units Sold from 2005 to 2030

Scenario	Low	Middle	High
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

*For energy savings only, Total Benefit and Net Present Value do not include heating, ventilation, and air conditioning (HVAC) savings.
**In billion 1997 dollars, discounted to 1997 at 7% real.

Table 6-4 shows an example of national energy savings and NPV results for fluorescent lamp ballasts. The range of cumulative energy savings (for the period 2005 to 2030), including net cooling energy savings, is from 1.27 to 5.17 EJ for the three shipment scenarios analyzed.

Although national energy savings and NPV are the major energy and economic effects of standards, an input/output model may be used, if sufficient data are available, to estimate other 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.

Analysis of the effects of proposed standards on electric and natural gas utilities has historically focused on estimated fuel savings, capital cost savings, and the reduction in revenues that will result from 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 fluorescent lamp ballast energy-efficiency standards most recently enacted by U.S. DOE. The results are expressed as a change in electricity sales, generation, and installed generating capacity relative to the reference case.

Avoidance of power plant construction and reduction in the use of fuel for electricity generation are two major benefits from energy-efficiency standards.

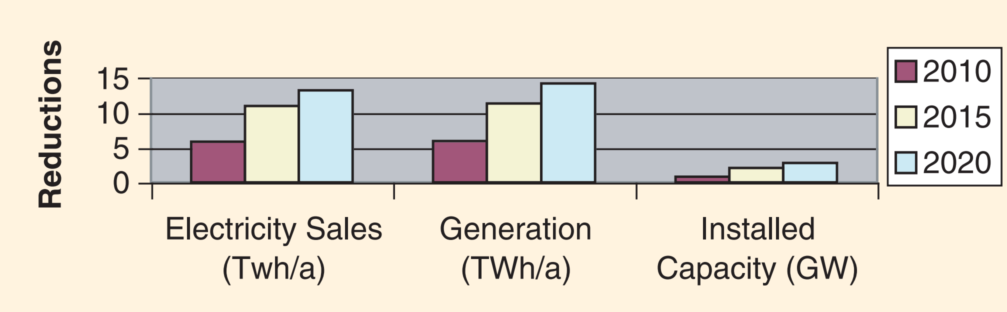

Figure 6-9 Example of utility impacts: new ballast standards effective in year 2005/2010.

6.7.4 Energy Supply Impacts

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-BT, together with some exogenous calculations (EIA 1998). NEMS is a large, multi-sector, partial-equilibrium model of the U.S. energy sector that produces the Annual Energy Outlook, a widely used baseline forecast for the U.S. through 2025, which is available in the public domain (www.eia.doe.gov/oiaf/aeo).

The comprehensiveness of NEMS-BT 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 major environmental impacts. Perhaps most importantly, because it explicitly simulates dispatch and capacity expansion of the industry, NEMS-BT can estimate marginal effects, which yield better indicators of actual effects than estimates based on industry wide average values.

6.7.5 Environmental Impacts

Environmental analysis provides information about the effect of new standards on greenhouse gas emissions (primarily CO_2) and regional pollutants (such as sulfur oxides and nitrogen oxides). Energy savings are typically converted to emissions 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).

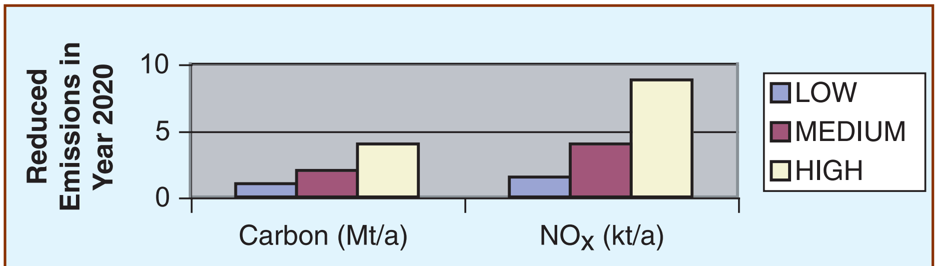

Figure 6-10 Example of environmental impacts: new ballast standards effective in year 2005/2010

Reductions of CO_2 and NO_x are major environmental benefits of energy-efficiency standards programs.

Figure 6-10 shows environmental analysis results for three fluorescent lamp ballast standards scenarios, representing a range of possible base-case shipments in the analysis of U.S. standards presented in Figure 6-9. The annual carbon emission reductions range up to 4 million metric tons and the nitrogen oxides emissions reductions up to 8.8 thousand metric tons in 2020.

6.7.6 Improving Analytical Methods

Analysis methods and standards-setting processes can be improved over time. In the international arena, discussions of harmonization or alignment of test procedures and appliance efficiency standards continue. In the long-running U.S. standards program, many significant changes have already taken place, including increased participation of manufacturers in the process and development of more transparent and robust analytical methods. Some enhancements to current methods may be needed to assess standards across countries or regions. One such method emphasizes uncertainty analysis, (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 offer means for comparing alternative policies and choosing among them with greater confidence in the outcome than would be possible otherwise (McMahon 2003).

6.8 Step S-7: Document Data, Methods, and Results

The subsections below describe the objectives, benefits, and practical mechanics of analysis documentation.

6.8.1 Documentation Objectives

The three primary objectives of documentation during the process of setting a standard for a particular product are to:

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

After the standards for a particular product are set, the documentation should meet two additional objectives:

4. enable staff to redo parts of the analysis if legal challenges are raised
5. find information or simulations that may be helpful for setting subsequent standards

Benefits

The benefits of documentation are significant but may not be realized immediately. 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 particular standards-setting project
- ability to respond to comments and defend work questioned by stakeholders or other interested parties or independent reviewers

- internal quality control
- transfer of work among staff
- peer review
- resumption of the analysis and rule-making process after delays
- consensus rule making

The immediate pressures of project deadlines, difficulties in obtaining data, and schedule changes all work against maintenance of thorough documentation. Nevertheless, neglecting documentation is risky because it leaves the work vulnerable whenever staff members leave the project or methods or data sources are questioned and 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

Documentation should be defined as a major task that is as close to continuous as possible and integral to each step in setting standards for a particular product. For example, for the data-collection stage that is part of any labeling or standards project, documentation should be conducted as the data are collected rather than 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 of 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 that sets a standard level for a particular appliance or equipment, the template should be stored in a separate, dedicated documentation subdirectory on a shared computer drive and should not be maintained in any other location. Only one documentation subdirectory should be created for use in any standards-setting project, but the template may be used many times over the course of the project. The project manager should review the documentation files periodically to ensure that they are kept up to date.

To the extent that it is practical, the same subdirectory structure should be used and maintained when setting standards for any other product. 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 is stored, especially information concerning interdependencies among files.

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 should be permitted to make entries at any given time within any particular project. 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, protocols for frequency and content, logs of activity, and databases are examples of approaches to structuring the documentation process. In the implementation of any structure, 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 insert *Contents of Documentation* on pages 169–171 lists what is necessary to keep track of the major types of work performed in efficiency labeling or standards. The major types of work anticipated are:

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

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 burdens and benefits of each alternative, deciding which standards levels to implement, and documenting the rationale for their deci-

CONTENTS OF DOCUMENTATION

Some of the documentation contents listed below 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.

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
- **C. At the response-to-comment stage include the following:**
  - 1) Name of the individual submitting the comment
  - 2) Page number of the individual's document on which the comment appears
  - 3) Organization, if applicable
  - 4) Date received
  - 5) 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:

continued on next page

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

sions. Following that decision, a public announcement should be made of the standards levels, the effective dates, and the procedure for compliance. In most countries, national law prescribes the announcement procedure. 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 in 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. Analysis 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. In parallel, those in charge of implementing standards and labeling programs should be preparing the outreach component of the program described in Chapter 7. The next step, maintaining and enforcing the standards-setting program described here, is described in Chapter 8.