

CHAPTER 2. ANALYTIC FRAMEWORK

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CHAPTER 2. ANALYTIC FRAMEWORK

2.1 INTRODUCTION

This chapter provides a description of the general analytic framework used by the Department in developing standards and assessing the impacts for distribution transformers. The description addresses the methodology, the analytic tools, and the relationship between the various analyses conducted in the rulemaking. The objective of the rulemaking process is to determine minimum efficiency standards for distribution transformers that are technologically feasible and economically justified. In this context, economic justification includes consideration of the economic impact on manufacturers and consumers, the national benefits, the impacts on utilities, and the impacts from any lessening of competition.

Figure 2.1.1 summarizes the analytic components of the standard-setting process. The focus of this figure is the third column, identified as “Analyses.” The columns labeled “Key Inputs” and “Key Outputs” indicate how the analyses fit into the rulemaking process, and how the analyses relate to each other. Key outputs are analytical results that feed directly into the standard-setting process. Key inputs are the types of data and information that the analyses require. Some key inputs exist in public databases; DOE also collects inputs from stakeholders or others with special knowledge. Inputs developed by the project team for the standards-setting process are presented and open for stakeholder review.

The analyses that the Department performed for the advance notice of proposed rulemaking (ANOPR) include:

- a market and technology assessment to characterize the distribution transformer market and review techniques and approaches used to produce more efficient transformers;
- a screening analysis to identify design options that improve distribution transformer efficiency and to determine which should be evaluated and which should be screened out;
- an engineering analysis to estimate the relationship between the manufacturer’s selling price of a transformer and its efficiency level;
- an energy use and end-use load characterization to generate energy use estimates and end-use load profiles of distribution transformers;
- a markup process to convert manufacturer sales prices to customer installed prices;
- a life-cycle cost (LCC) analysis to calculate, at the consumer level, the discounted savings in operating costs throughout the estimated average life of the distribution transformer, compared to any increase in the installed costs likely to result directly from the imposition of the standard. As a supporting or parallel analysis, DOE performed a payback period (PBP) analysis to calculate the amount of time it takes consumers to recover the assumed higher purchase expense of more-efficient equipment through lower operating costs;

- a shipments analysis to estimate shipments of distribution transformers over the time period examined in the analysis; and
- a national impacts analysis to assess the aggregate impacts at the national level of consumer payback, net present value (NPV) of total consumer LCC, national energy savings, and national employment.

After the Department published the ANOPR on July 29, 2004 and received comments from stakeholders, the Department revised the ANOPR analyses in the manner described in the notice of proposed rulemaking (NOPR) Federal Register Notice that accompanies this technical support document (TSD).

The Department also conducted several new analyses for the NOPR, including:

- an LCC subgroup analysis to evaluate impacts on identifiable groups of customers of distribution transformers, including various types of electric utilities or various types of commercial or industrial transformer purchasers or owners, who may be disproportionately affected by a national energy-efficiency standard;
- a manufacturer impact analysis (MIA) to estimate the financial impact of standards on distribution transformer manufacturers and to calculate impacts on competition, employment at the manufacturing plant, and manufacturing capacity;
- a utility impact analysis to estimate the effects of proposed standards on the installed capacity and generating base of electric utilities;
- an employment impact analysis to estimate the impacts of standards on net jobs eliminated or created in the general economy as a consequence of increased spending on the purchase price of transformers and reduced customer spending on energy;
- an environmental assessment to assess the impacts of proposed standards on certain environmental indicators; and
- a regulatory impact analysis to present major alternatives to proposed standards that could achieve comparable energy savings at a reasonable cost.

In response to comments it receives on the NOPR, the Department may revise some of its analyses before publishing the Final Rule.

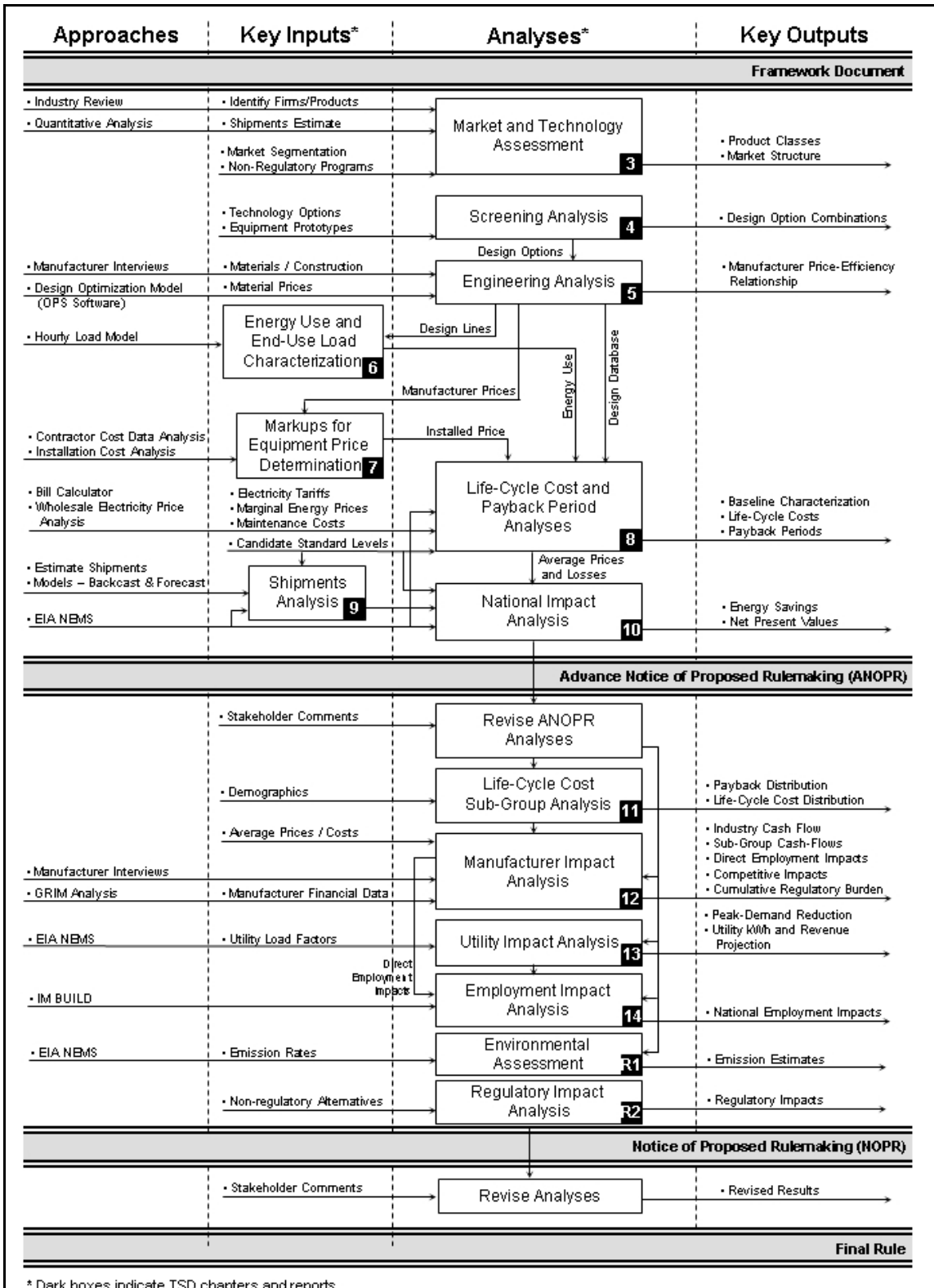


Figure 2.1.1 Analyses for Distribution Transformer Energy-Efficiency Standards

2.2 BACKGROUND

As described in Chapter 1 of the TSD, in September 1995, the Department announced a formal effort to consider further improvements to the process used to develop appliance efficiency standards. The Department called on energy-efficiency groups, manufacturers, trade associations, state agencies, utilities, and other interested parties to provide input to this effort. As a result of this combined effort, the Department published *Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products* (the “Process Rule”), 10 CFR 430, Subpart C, Appendix A. The Process Rule outlined the procedural improvements identified by the interested parties, and included a review of the: 1) economic models, 2) analytic tools, 3) methodologies, 4) non-regulatory approaches, and 5) prioritization of future rules. The Process Rule recommended that the Department take into account uncertainty and variability by carrying out scenario or probability analysis. The following sections provide a general description of the analytic components of the improved rulemaking framework.

2.3 MARKET AND TECHNOLOGY ASSESSMENT

The market and technology assessment (Chapter 3) characterizes the distribution transformer markets and existing technology options for making a transformer more efficient.

2.3.1 Market Assessment

When initiating a standards rulemaking, the Department develops information on the present and past industry structure and market characteristics of the product(s) concerned. The market assessment consists of both quantitative and qualitative efforts to assess the industry and products based on publicly available information. Issues addressed in this market assessment included: 1) national transformer shipments; 2) identification of largest players in the transformer industry; 3) discussion of existing non-regulatory efficiency improvement initiatives; 4) developments around standards in States and neighboring countries; and 5) trends in product characteristics and retail markets. The information collected serves as resource material to be used throughout the rulemaking.

2.3.2 Technology Assessment

The technology assessment provided information about existing technology options and designs to construct more energy-efficient distribution transformers. In consultation with interested parties, the Department developed several technology options and designs for consideration. Some examples of these design options are: 1) higher-grade electrical core steels, 2) use of different conductor types and materials, and 3) adjustments to core and coil configurations.

As described in Chapter 4, the Department reviewed and analyzed some emerging technologies for distribution transformers (e.g., superconducting materials). Although these technologies are not generally considered commercially available, the Department discusses their potential impact on the distribution transformer industry.

Another key part of the technology assessment is the determination of the product classes that will be used in the rulemaking. Distribution transformers are divided into classes using the following criteria: a) the type of energy used, b) capacity, and c) performance-related features that affect consumer utility or efficiency. Different efficiency standards apply to different product classes. The Department developed its product classes using information obtained from manufacturers, trade associations, and other interested parties.

2.4 SCREENING ANALYSIS

The screening analysis (Chapter 4) reviews various technologies with regard to whether they: 1) are technologically feasible, 2) are practicable to manufacture, install, and service, 3) do not have an adverse impact on product utility or product availability, and 4) do not adversely impact health and safety.

2.4.1 Technology Screening

The Department developed an initial list of efficiency enhancement design options from the technologies identified in the technology assessment. Then the Department reviewed the list to determine if the design options are practicable to manufacture, install, and service, would adversely affect product utility or product availability, or would have adverse impacts on health and safety. In the engineering analysis, the Department used efficiency enhancement design options that passed the four screening criteria. It did not consider those options that failed one or more of the screening criteria in the analysis. Chapter 4 of this TSD discusses which design options DOE considered in the distribution transformer engineering analysis. The chapter also includes a list of emerging technologies that could impact future distribution transformer manufacturing costs.

2.4.2 Baseline Equipment

To analyze design options for energy-efficiency improvements, the Department typically defines a baseline unit against which to compare more-efficient units. For products with existing standards, the baseline unit is usually a unit designed at the existing standard level. However, since distribution transformers do not have an existing efficiency standard, the Department developed an approach based on a consumer choice model, involving a distribution of efficiencies in the baseline. The consumer choice model is part of the LCC analysis, and is discussed in Chapter 8 of this TSD.

2.5 ENGINEERING ANALYSIS

The engineering analysis (Chapter 5) develops cost-efficiency relationships for distribution transformers, estimating manufacturer costs of achieving increased efficiency levels. The Department uses manufacturing costs to determine retail prices in the LCC analysis, and also uses them in the MIA. The engineering analysis also determines the maximum technologically feasible energy-efficiency level.

In general, the engineering analysis estimates the efficiency improvement potential of the individual or combinations of design options that pass the four criteria in the screening analysis. This cost-efficiency relationship developed in the engineering analysis is used in the LCC analysis.

As described in Chapter 1, the Department considers those distribution transformers that are designed to achieve the maximum improvement in energy efficiency that the Secretary determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Therefore, an important role of the engineering analysis is to identify the maximum technologically feasible level. The maximum technologically feasible level is one that can be reached by adding efficiency improvements and/or design options, both commercially feasible and in prototypes, to the baseline units. The Department believes that the design options comprising the maximum technologically feasible level must have been physically demonstrated in at least a prototype form to be considered technologically feasible.

In general, three methodologies can be used to generate the manufacturing costs needed for the engineering analysis. These methods are:

1. the design-option approach – reporting the incremental costs of adding design options to a baseline model;
2. the efficiency-level approach – reporting relative costs of achieving improvements in energy efficiency; and
3. the reverse engineering or cost-assessment approach – involving a "bottom-up" manufacturing cost assessment based on a detailed bill of materials derived from transformer tear-downs.

The Department considers public comments in determining the best approach for each rulemaking.

2.5.1 Design-Option Approach

The design-option approach identifies individual or combinations of design options that increase efficiency. These increases in efficiency are typically based either on manufacturer or component supplier estimates or on engineering computer simulation models. The Department then determines the incremental manufacturing costs of adding design options to a baseline

model. It adds individual or combinations of design options to the baseline model in ascending order of cost effectiveness. Typically, DOE uses the payback period—determined by the ratio of the change in total consumer cost to the change in operating cost—to establish a design option’s cost effectiveness.

The primary advantage of the design-option approach is its ability to analyze individual technologies. The approach is transparent in that the impact of any single technology on cost and efficiency is explicit. An additional advantage is its ability to incorporate designs that have been demonstrated to perform in prototypes but have yet to be utilized in equipment currently available on the market. Thus, maximum technologically feasible designs are more easily established than in the efficiency-level approach.

A drawback to the design-option approach is its imperfect compatibility with the MIA. The Department recognizes that the manufacturer selling price information derived in a component-based analysis does not reflect the variability in baseline units, design strategies, and cost structures that can exist among manufacturers. Therefore, in the MIA (see Chapter 12), the Department may need to derive additional manufacturing cost estimates, using other approaches developed in consultation with interested parties.

2.5.2 Efficiency-Level Approach

The efficiency-level approach establishes the relationship between manufacturer sales price and increased efficiency at incremental increases in efficiency levels. Manufacturers provide incremental manufacturer cost data for incremental increases in efficiency. Cost-efficiency curves can be easily constructed to clearly identify at what point manufacturers are incurring significant costs to raise efficiency. Additionally, the efficiency-level approach gives manufacturers the ability to supply detailed cost data without revealing their unique design strategies for achieving increased efficiency levels.

The simplicity of the efficiency-level approach is also its primary drawback. Namely, since technological details are not provided, it can be difficult to verify whether the costs provided for each specific efficiency level are representative of the costs for that level. In addition, prototypical designs become difficult to evaluate and maximum technologically feasible designs are then difficult to ascertain. As a result, some supplementary analysis is often necessary to verify the accuracy of the costs supplied through the efficiency-level approach.

2.5.3 Cost-Assessment Approach

The cost-assessment approach, also called the ‘reverse engineering approach,’ is a component-based technology-costing of the various technological paths manufacturers typically use to achieve increased product energy efficiency. To carry out this type of analysis, DOE physically analyzes (i.e., dismantles) actual pieces of equipment on the market, component-by-component, to determine what technologies and designs manufacturers employ to increase efficiency. The Department then uses independent costing methods and manufacturer and component supplier data to estimate the costs of the components. This approach has the distinct

advantage of using “real” market equipment to establish the technologies that are used by manufacturers and to establish the manufacturing cost to produce more-efficient units.

The primary disadvantage of reverse engineering is the time and effort required to analyze “real” equipment. Several models from a diverse range of manufacturers may have to be assessed to ensure an accurate representation of technological paths for increasing efficiency. In addition, since only equipment in the market is analyzed, prototypical designs may not be captured by the analysis, thus making it difficult to establish maximum technologically feasible designs.

2.5.4 Other Regulatory Impacts on the Engineering Analysis

In conducting an engineering analysis, DOE must recognize that regulatory changes occurring outside of the standards-setting process can affect product manufacturing. Some of these changes can also affect the efficiency of the product. The Department attempts to identify all “outside” issues that can impact the engineering analysis. For distribution transformers, this included consideration of a core steel type that is only available from Japan, whose core steel exports to the U.S. are subject to an anti-dumping duty.

2.6 ENERGY USE AND END-USE LOAD CHARACTERIZATION

The energy use and end-use load characterization analysis (Chapter 6) produces energy use estimates and end-use load shapes for distribution transformers. The energy use estimates enable evaluation of energy savings from the operation of distribution transformer equipment at various efficiency levels, while the end-use load characterization allows evaluation of the impact on monthly and peak demand for electricity from the operation of transformers. The analysis produces a distribution of results for a variety of transformer types and uses, to represent the diversity of use and performance of distribution transformer equipment.

2.7 MARKUPS FOR EQUIPMENT PRICE DETERMINATION

Chapter 7 describes the process used to determine the installed price of distribution transformers. The Department derives this installed price by applying markups to the manufacturer selling price from the engineering analysis (Chapter 5). Markups, shipping costs, sales tax, and installation costs are the costs associated with bringing a manufactured transformer into service as an installed piece of electrical equipment. Electric utilities typically purchase liquid-immersed transformers from manufacturer representatives, so the sales price includes a relatively small handling markup applied to the manufacturer selling price. Dry-type transformers are subject to both distributor and contractor markups. Both liquid-immersed and dry-type distribution transformers are subject to shipping, sales tax, and installation markups.

2.8 LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSES

Chapter 8 describes the LCC analysis, which calculates the discounted savings in operating costs throughout the estimated average life of the covered product compared to any increase in the installed cost for the product likely to result directly from the imposition of a standard. In determining economic justification, the Energy Policy and Conservation Act (EPCA) directs the Department to consider a number of different factors, including the economic impact of potential standards on consumers. (42 U.S.C. 6295 (o)(2)(B)(i))

To consider these factors, the Department calculated changes in LCC that are likely to result from the candidate standard level, as well as a simple payback period. The Department calculated both the LCC and the PBP using a Monte Carlo framework, so results are represented by distributions. The effect of standards on individual consumers includes a change in operating expense (usually decreased) and a change in purchase price (usually increased). The Department analyzed the net effect by calculating the change in LCC as compared to the base case. Inputs to the LCC calculation include the installed consumer cost (purchase price plus shipping, sales tax, and installation cost), operating expenses (energy and maintenance costs), lifetime of the equipment, and a discount rate.

Chapter 8 also describes the PBP analysis, which calculates the amount of time needed to recover the additional cost that consumers pay for increased efficiency. Numerically, the simple payback period is the ratio of the increase in purchase price to the decrease in annual energy costs.

2.8.1 Life-Cycle Cost Spreadsheet Model

The Department developed an LCC Spreadsheet Model to calculate the economic impacts of more-efficient distribution transformers. The LCC spreadsheet estimates the economic impacts on the consumer (i.e., the owner or purchaser) of a transformer by calculating the difference between pairs of transformers. In these pairs, one transformer is a baseline model representing a typical transformer that would be purchased in the current environment (i.e., without an efficiency standard). The Department selects the other transformer model in two ways:

- For those purchasers conducting total owning cost (TOC) evaluations, the transformer corresponds to the lowest TOC design meeting a particular energy-efficiency standard.
- For those purchasers not basing purchase decisions on TOC evaluation, the second transformer in the pair is the one with minimum first cost meeting the specific energy-efficiency standard that the Department decides to evaluate.

The LCC spreadsheet compares the life-cycle costs for a representative unit from the baseline scenario with life-cycle costs for more efficient units. Baseline units are those designs that customers would choose in the absence of a new efficiency standard. Identifying a specific

baseline for transformers is complicated for two reasons: 1) the lack of existing mandatory efficiency standards, and 2) the wide variability in designs available to potential purchasers at any given efficiency level. To address these issues, the Department developed an LCC model that uses distributions of inputs to produce a representative range of transformer costs and efficiencies. That representative distribution of costs and efficiencies determines the baseline LCC scenario.

The Department used the LCC spreadsheet to determine the effects of more-efficient units on operating expenses (usually decreased) and purchase prices (usually increased) of distribution transformers. The LCC spreadsheet focuses on a distribution of potential transformer designs for selected efficiency levels (see Chapter 5, *Engineering Analysis*, for a discussion of the potential designs). These designs differ in cost, no-load losses, and load losses. Using the LCC spreadsheet, the Department calculated operating costs, taking into account distributions in loading and marginal electricity prices, and compared several potential candidate standard levels.

The spreadsheet model DOE used was developed in Microsoft Excel combined with Crystal Ball (a commercially available software program for conducting a Monte Carlo analysis). The model uses a Monte Carlo simulation (described in Appendix 8B) to perform the analysis, considering uncertainty and variability. The LCC spreadsheet is organized so that users can enter ranges (or probability distributions) for each input variable needed to perform the calculations.

The Department calculated the PBP based on the same inputs used for the LCC analysis (with the difference that it based the values only on the first year the standard takes effect). The output is a probability distribution of payback periods, including the mean and median payback periods as well as the minimum and maximum payback periods. Additional information is available in Chapter 8 and the LCC spreadsheets are available on the DOE website: http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html

2.9 SHIPMENTS ANALYSIS

One of the more important components of any estimate of future impacts from energy-efficiency standards is transformer shipments (Chapter 9). Forecasts of shipments for the base case and each potential standards case need to be obtained as an input to the national energy savings (NES) model. The Department chose an accounting model method to prepare shipment scenarios for the base case and the candidate standard levels. The model keeps track of the aging and replacement of transformer capacity given a projection of future transformer sales growth. New transformer capacity demand is created by growth in electrical demand. Transformer shipments, a retirement function, and the initial number of transformers in service influence how transformers in service and supply of transformer capacity change over time.

Shipments are organized into two categories: replacements and new capacity. Replacements occur when old transformers break down, corrode, are struck by lightning, or otherwise need to be replaced. New capacity purchases occur due to increases in electricity use that may be driven by increasing population, increasing commercial and industrial activity, or

growth in electricity distribution systems. The model starts with an estimate of the overall growth in transformer capacity and then estimates shipments for particular design lines and transformer sizes using estimates of the relative market share for different design and size categories. Chapter 9 provides a detailed description of how DOE conducted its shipments forecasts.

2.10 NATIONAL IMPACT ANALYSIS

The NES and NPV impacts are the cumulative energy and economic effects of a transformer energy conservation standard (Chapter 10). The Department projected the impacts from the year the standard would take effect through a selected number of years in the future. The Department analyzed energy savings, energy cost savings, equipment costs, and NPV of savings (or costs) for each candidate standard level. The national energy and cost savings (or increases) that would result from energy conservation standards depend on the projected energy savings per transformer and the anticipated numbers of transformers sold. The Department created base case transformer shipments projections that include units at various efficiency levels. It based the projections on historical information plus forecasts of market influences, national economic growth, and electricity consumption. The Department then derived energy savings for various candidate standard levels from the cost-efficiency schedules.

To make the analysis more accessible and transparent to all stakeholders, DOE used a Microsoft Excel spreadsheet model to calculate the NES and the NPV (i.e., national economic costs and savings from new standards). Users can change input quantities within the spreadsheet to test the impact of alternative input assumptions. Unlike the LCC analysis, the NES spreadsheet does not use distributions for inputs or outputs. Users can demonstrate sensitivities by running different scenarios using the spreadsheet. The NES spreadsheet model is available on the DOE website:

http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html

As discussed in Chapter 10, the national impact analysis assesses the NPV of total consumer LCC, energy savings, and direct and indirect employment impacts. The Department conducted an assessment of the aggregate impacts at the national level for the NOPR. Analyzing impacts of Federal energy-efficiency standards requires a comparison of projected U.S. energy consumption with and without standards. The base case, which is the projected U.S. energy consumption without standards, includes the mix of efficiencies being sold at the time the standard becomes effective.

The Department estimated national energy consumption for each year beginning with the expected effective date of the standard. The Department calculated national annual energy savings as the difference between two projections: a base case and a standards case. Analysis included estimated energy savings by fuel type used for generating electricity. The Department estimated energy consumption and savings based on site energy (kilowatt-hours (kWh) of electricity), and then converted the electricity consumption and savings to primary energy consumption.

2.11 LIFE-CYCLE COST SUBGROUP ANALYSIS

The Department conducted the LCC subgroup analysis after the ANOPR was published and reported the results in the NOPR and in Chapter 11 of this TSD.

While DOE expects distribution transformer energy conservation standards to reduce overall costs to the economy and consumers, there may be groups of consumers who see some increase in life-cycle cost. In the NOPR phase of the rulemaking, DOE examined the results from the LCC analysis to evaluate the cost impacts on consumer subgroups, such as different types of utilities, to see if they are differentially affected by potential energy conservation standards in a significant manner.

The analysis of these subgroups of transformer owners depended on identifying characteristics related to transformer use or economics that sets the subgroup apart from other transformer owners. The Department analyzed the effects on these groups by comparing the transformer owners' capital and operating costs with and without an energy conservation standard. The Department used LCC analysis methods for the consumer subgroup analysis by modifying cost assumptions to reflect the situations of the subgroups. Factors that could result in differential impacts to subgroups include differences in purchase price, energy price, and transformer loading.

The Department evaluated variations in regional energy prices, variations in energy use, and variations in installation costs that might affect the NPV of a standard to consumer sub-populations. To the extent possible, DOE obtained estimates of the variability in each input quantity and considered this variability in its calculation of consumer impacts. The Department discussed the variability in each input quantity and likely sources of information with the interested parties.

2.12 MANUFACTURER IMPACT ANALYSIS

The Department conducted the MIA (see Chapter 12) to estimate the financial impact of efficiency standards on manufacturers of distribution transformers and to assess the impact of such standards on employment and manufacturing capacity. The MIA has both quantitative and qualitative components. The quantitative part of the MIA primarily relies on the Government Regulatory Impact Model (GRIM), an industry-cash-flow model adapted for this rulemaking. The key GRIM inputs relate to industry cost structure, shipments, and pricing strategies. The GRIM's key output is the industry net present value (INPV). The model estimates the financial impact of higher efficiency standards by comparing changes in INPV between the base case and the various trial standard levels. The qualitative part of the MIA addresses factors such as the material supply chain, manufacturing techniques and equipment, and market and product trends, and includes a subgroup assessment of the impacts on small manufacturers.

In the Department's Framework Document published on November 1, 2000, DOE outlined the procedural and analytical approaches for the MIA. As outlined, the Department

conducted the MIA in three phases. Phase 1, “Industry Profile,” consisted of the preparation of an industry characterization, including data on market share, sales volumes and trends, pricing, employment, and financial structure. Phase 2, “Industry Cash Flow,” focused on the industry as a whole. In this phase, DOE used the GRIM to prepare an industry cash flow analysis. Using publicly available information developed in Phase 1, the Department adapted the GRIM’s generic structure to perform an analysis of distribution transformer energy conservation standards. In Phase 3, the “Sub-Group Impact Analysis,” DOE conducted interviews with several manufacturers. The group of manufacturers included small, medium, and large manufacturers providing a representative cross-section of the U.S. distribution transformer industry. During these interviews, the Department discussed engineering, manufacturing, procurement, and financial topics specific to each company and also obtained each manufacturer’s view of the industry as a whole under standards. The interviews provided valuable information that the Department used to evaluate the impacts of a standard on manufacturers’ cash flows, manufacturing capacities, and employment levels.

2.12.1 Industry Characterization

In Phase 1 of the MIA, the Department prepared a profile of the distribution transformer industry that built on the market and technology assessments prepared for the ANOPR analysis. DOE collected additional information about the present and past industry structure and market characteristics for distribution transformers, including information on national shipments, market leaders, and cost structure for a range of manufacturers. In characterizing the industry, the Department gathered information about product construction, product characteristics, manufacturing techniques, trends in the number of firms, and market characteristics.

The industry profile included a topdown cost analysis of the distribution transformer industry that DOE used to derive initial cost and financial inputs for the GRIM, e.g., revenues; material; labor; overhead; depreciation; selling, general and administrative (SG&A) expenses; and research and development (R&D) expenses. The Department used public sources of information to calibrate its initial characterization of the industry, including Securities and Exchange Commission (SEC) 10-K reports, corporate annual reports, the U.S. Census Bureau’s Economic Census, Dun & Bradstreet reports, and industry analysis from Ibbotson Associates.

2.12.2 Industry Cash Flow

Phase 2 of the MIA focused on the industry-wide financial impacts of standards. Energy conservation standards can affect distribution transformer manufacturers in three distinct ways. They can: 1) require additional investment, 2) raise production costs, and 3) affect revenues through higher prices and, possibly, lower shipments. The analytical tool DOE uses for calculating the financial impacts of standards on manufacturers is the GRIM. To quantify these impacts in Phase 2 of the MIA, the Department performed a distribution transformer industry cash flow analysis using the GRIM.

For the industry cash flow analysis, DOE prepared a set of financial parameters for use in the GRIM. The Department originally based these financial parameters on the its topdown

financial analysis but, in response to discussions with transformer manufacturers, subsequently adjusted them to be more representative of the industry. The Department used a similar process during the ANOPR phase of the analysis (i.e., public financial reports and manufacturer discussions) to derive the manufacturer markups used to establish manufacturer selling prices in its engineering analysis. The MIA production costs and manufacturer selling prices are consistent with both the LCC analysis and the engineering analysis, upon which DOE based the LCC pricing. The Department established this consistency by using the mean values for production costs and selling prices in the GRIM, as selected by the LCC's Monte Carlo algorithm. Finally, the Department's shipments analysis (Chapter 9) provided the basis for the shipments projection under each of the trial standard levels in the GRIM.

2.12.3 Manufacturer Subgroup Analysis

Using average cost and financial assumptions to develop an industry cash flow model is not adequate for assessing differential impacts among subgroups of manufacturers. Smaller manufacturers, niche players, or manufacturers exhibiting a cost structure that differs largely from the industry average could be more negatively impacted. The Department used the results of the industry characterization to group manufacturers exhibiting similar characteristics. As discussed in the ANOPR, the Department established two distinct subgroups of distribution transformer manufacturers that could be affected by efficiency standards: liquid-immersed, and medium-voltage (MV) dry-type. A discussion of these superclasses appears in Chapter 12.

Within each superclass, the Department contacted companies from its database of manufacturers who provided representation of firms operating in that superclass. The Department interviewed small and large companies, subsidiaries and independent firms, public and private corporations, and a mix of National Electrical Manufacturers Association (NEMA) and non-NEMA members. The Department also made an effort to interview companies who had been interviewed for the engineering analysis in 2002, as well as those who had previously participated in the rulemaking process. The purpose of the meetings was to enhance the Department's understanding of how manufacturer impacts change with each of the trial standard levels.

The Department also evaluated the impact of the energy conservation standards on small businesses. Small businesses, as defined by the Small Business Administration (SBA) for the distribution transformer manufacturing industry, are manufacturing enterprises with 750 or fewer employees. The Department conducted telephone interviews with nine small businesses, to determine if there are differential impacts on these companies that may result from the standard.

The Department contacted material and equipment suppliers to the distribution transformer industry to enhance its understanding of the context in which transformer manufacturers operate and to assist in quantifying conversion costs. The Department conducted interviews with the two domestic suppliers of electrical core steel and with two core steel distributors. The domestic suppliers of core steel are large corporations that have a broad range of steel products, of which electrical core steel is one product offering. The core steel distributors offer manufacturers a varying degree of processing, ranging from basic slit-to-width rolls to prefabricated cores (both stacked and wound-core configurations). The Department also spoke

with four equipment suppliers, including manufacturers of both distributed gap and mitered core processing machines, and two manufacturers of annealing furnaces. The information from these discussions was helpful in understanding comments and concerns expressed by manufacturers as well as in estimating the conversion capital expenditures used in the GRIM. To prepare the liquid-immersed industry conversion costs for switching to amorphous material at trial standard levels 5 and 6, the Department spoke with the only domestic supplier of amorphous ribbon and several transformer manufacturers who had experience working with amorphous material. Through this dialogue, the Department gained a better understanding of manufacturing amorphous core transformers, including core processing equipment, annealing furnaces, and material handling issues.

2.13 UTILITY IMPACT ANALYSIS

The Department conducted the utility impact analysis after the ANOPR and reported the results in the NOPR. In addition to the economic impacts on electric utilities as consumers of distribution transformers, standards could affect utilities through the reduction in net generation resulting from the increased transformer efficiency of their electricity customers who purchase their own transformers. To perform the utility impacts analysis, the Department used the BT (Building Technologies) version of the Energy Information Administration (EIA)'s National Energy Modeling System (NEMS).¹ NEMS is a large, general-equilibrium energy-economy model of the United States that EIA has developed over several years, primarily for the purpose of preparing the *Annual Energy Outlook (AEO)*.²

NEMS produces a widely recognized baseline forecast for the U.S. through 2020 and is available in the public domain. Typical NEMS output includes forecasts of electricity sales and prices. The Department conducted the utility analysis by comparing NEMS-BT output for various distribution transformer standard levels with the latest *AEO* forecasts. The comparison between NEMS-BT and the *AEO* forecasts incorporated time-differentiated load impacts of transformer standards. The time-differentiated load impact estimate used load shape information from the LCC analysis, and national energy use impact forecasts from the NES analysis. Other assumptions used in the *AEO* also served as the basic assumptions applied to the analysis of the impacts of energy conservation standards on utilities.

2.14 EMPLOYMENT IMPACT ANALYSIS

The Department conducted the employment impact analysis after the ANOPR and reported the results in the NOPR. The Process Rule directs DOE to consider employment impacts in selecting a proposed standard. The Department estimated the impacts of standards on employment in the transformer manufacturing industry, relevant service industries, energy suppliers, and the economy in general. The Department separates employment impacts into direct and indirect impacts. Direct employment impacts would result if standards led to a change in the number of employees at transformer manufacturing plants and related supply and service firms. The MIA discusses direct impacts. Indirect impacts are impacts on the national economy other

than in the manufacturing sector DOE is regulating. Indirect impacts may result from both expenditures shifting among goods (substitution effect), and income changing, which will lead to a change in overall expenditure levels (income effect).

The Department defines indirect employment impacts from standards as net jobs eliminated or created in the general economy as a consequence of increased spending to purchase distribution transformers and reduced spending to pay utility costs. An important indirect employment effect may arise from shifting investment from the energy sector into more (or less) labor-intensive industries. The Department expects new equipment standards to increase a transformer's purchase price, which includes retail price, sales tax, and installation. The Department expects the same standards to decrease energy consumption, and therefore reduce expenditures for energy. Over time, the increased purchase price may be paid back through energy savings. Consumers may spend the savings in energy expenditures on other items. Using an input/output model of the U.S. economy, the Department estimated national impacts for major sectors of the U.S. economy and the net impact on jobs. The Department used public and commercially available data sources and software to estimate employment impacts. It analyzed at least three scenarios to bound the range of uncertainty in future energy prices. All methods and documentation are available for review in the employment impact analysis in the NOPR.

2.15 ENVIRONMENTAL ASSESSMENT

The Department conducted the environmental assessment after the ANOPR and reported the results in the NOPR. The Environmental Assessment is required under the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321 et seq.), regulations of the Council on Environmental Quality (49 CFR parts 1500-1508), the Department regulations for compliance with NEPA (10 CFR part 1021), and the Secretarial Policy on the National Environmental Policy Act (June 1994).

The main environmental concern addressed is emissions from fossil-fuel-fired electricity generation. Power plant emissions include oxides of nitrogen (NO_x) and sulfur (SO₂), as well as carbon dioxide (CO₂). The first two are major causes of acid precipitation, which can affect humans by reducing the productivity of farms, forests, and fisheries, decreasing recreational opportunities, and degrading susceptible buildings and monuments. Nitrogen oxides are also precursor gases to urban smog and are particularly detrimental to air quality during hot, still weather. Carbon dioxide emissions are believed to contribute to raising the global temperature via the "greenhouse effect."

The major environmental effects of transformer energy conservation standards would result from reduced electrical energy consumption, and would take the form of reduced emissions from the operation of power plants. Analyses for previous standards have reported reductions in energy-related emissions of SO₂, NO_x, and CO₂. The Department estimated the emission impacts at the national level. Details of this analysis are in the *Environmental Assessment*, published as a separate report within this TSD.

2.16 REGULATORY IMPACT ANALYSIS

The Department conducted the regulatory impact analysis after the ANOPR, and reported the results in the NOPR. The Department prepared a draft regulatory impact analysis pursuant to E.O. 12866, *Regulatory Planning and Review*, which will be subject to review under the Executive Order by the Office of Information and Regulatory Affairs (OIRA) 58 FR 51735 (October 4, 1993). The Department identified seven major alternatives as representing feasible policy options to achieve consumer product energy efficiency. It evaluated each alternative in terms of its ability to achieve significant energy savings at a reasonable cost, and compared these results to the effectiveness of the rule.

Under the Process Rule, the Department is committed to continually explore non-regulatory alternatives to standards. The list below indicates those alternatives the Department examined for this rulemaking. Through manufacturer interviews and literature searches, the Department compiled information on burdens on manufacturers from existing and impending regulations affecting distribution transformers. It also sought input from stakeholders regarding other regulations it should consider. The Department examined the following non-regulatory alternatives to standards:

- No new regulatory action
- Consumer rebates
- Consumer tax credits
- Manufacturer tax credits
- Voluntary energy-efficiency targets
- Early replacement
- Bulk government purchases

Details of the this analysis are in the *Regulatory Impact Analysis*, published as a separate report within this TSD.

REFERENCES

1. U.S. Department of Energy-Energy Information Administration. *National Energy Modeling System: An Overview 2003*. 2003. Report No. DOE/EIA-0581(2003). <<http://www.eia.doe.gov/oiaf/aeo/overview/index.html>>
2. U.S. Department of Energy - Energy Information Administration. *Annual Energy Outlook 2005: With Projections Through 2025*. January, 2005. Washington, DC. Report No. DOE/EIA-0383(2005). <<http://www.eia.doe.gov/oiaf/aeo/index.html>>