

## 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 the Department of Energy (DOE) used 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 the project team developed for the standards-setting process are presented and open for stakeholder review.

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

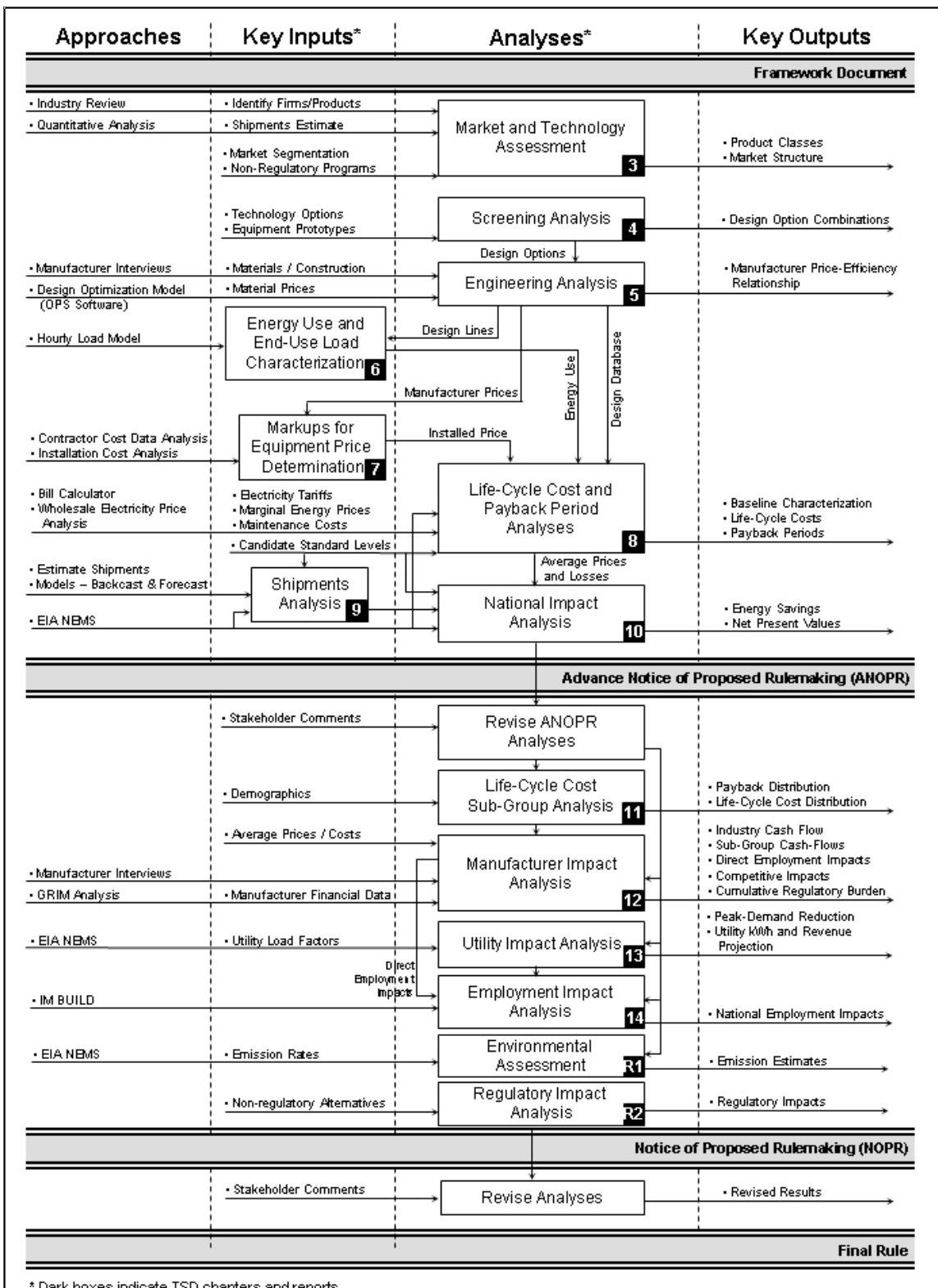
- a market and technology assessment to characterize the distribution transformer market and review techniques and approaches used to produce more efficient transformers;
- a screening analysis to identify design options that improve distribution transformer efficiency and to determine which ones DOE should evaluate and which it should screen 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. In parallel, 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 impact analysis to assess the aggregate impacts at the national level of consumer payback, net present value (NPV) of total consumer LCC, national energy savings (NES), and national employment.

After DOE published the ANOPR on July 29, 2004 and received comments from stakeholders, DOE revised the ANOPR analyses and published a notice of proposed rulemaking (NOPR) on August 4, 2006. 71 FR 44356. In addition to revising some of the ANOPR analyses, DOE 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 received on the NOPR, DOE revised some of its analyses before publishing its final rule and this accompanying technical support document (TSD).



**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, DOE announced a formal effort to consider further improvements to the process used to develop appliance efficiency standards. DOE 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, DOE 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 DOE’s: 1) economic models, 2) analytic tools, 3) methodologies, 4) non-regulatory approaches, and 5) prioritization of future rules. The Process Rule recommended that DOE 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, DOE 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 the largest players in the transformer industry; 3) 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 served as resource material that DOE 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, DOE identified 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, DOE reviewed and analyzed some emerging technologies for distribution transformers (e.g., superconducting materials). Although these technologies are not generally considered commercially available, DOE discusses their potential impact on the distribution transformer industry.

Another key part of the technology assessment is the determination of the product classes that DOE will use in the rulemaking. DOE divided distribution transformers 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. DOE 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**

DOE developed an initial list of efficiency enhancement design options from the technologies identified in the technology assessment. Then DOE 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, DOE considered those 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. 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, DOE 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, DOE 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 products that are the subject of a rulemaking, estimating manufacturer costs of achieving increased efficiency levels. DOE 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 individual design options or combinations of design options that pass the four criteria in the screening analysis. DOE uses this cost-efficiency relationship, developed in the engineering analysis, in the LCC analysis.

As described in Chapter 1, DOE considered 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 was to identify the maximum technologically feasible efficiency 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. DOE 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, DOE can use three methodologies 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 teardowns.

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

### **2.5.1 Design-Option Approach**

The design-option approach identifies individual design options, or combinations of design options, that increase efficiency. DOE typically bases these increases in efficiency either on manufacturer or component supplier estimates or on engineering computer simulation models. DOE 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 that it allows DOE 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 used in equipment currently available on the market. Thus, DOE can more easily establish maximum technologically feasible designs using the design-option approach than it can using the efficiency-level approach.

A drawback to the design-option approach is its imperfect compatibility with the MIA. DOE 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), DOE 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. DOE 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 manufacturers use 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. DOE may have to assess several models from a diverse range of manufacturers to ensure an accurate representation of technological paths for increasing efficiency. In addition, since DOE only analyzes equipment in the market, prototypical designs may not be captured by the analysis, 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 recognizes 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. DOE 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) produced energy use estimates and end-use load shapes for distribution transformers. The energy use estimates enabled evaluation of energy savings from the operation of distribution transformer equipment at various efficiency levels, while the end-use load characterization allowed evaluation of the impact on monthly and peak demand for electricity from the operation of transformers. The analysis produced 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 DOE used to determine the installed price of distribution transformers. DOE derived this installed price by applying markups to the manufacturer selling price it determined in 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 DOE 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 the economic impacts of standards, DOE calculated changes in LCC that are likely to result from the candidate standard level, as well as a simple payback period. DOE calculated both the LCC and the PBP using a Monte Carlo framework (described in Appendix 8B), 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). DOE 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**

DOE 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). DOE 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 DOE decided 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. As indicated above, 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, DOE 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.

DOE 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, DOE calculated operating costs, taking into account distributions in loading and marginal electricity prices, and compared several potential candidate standard levels.

DOE developed the spreadsheet model 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, to consider 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.

DOE calculated the PBP based on the same inputs it 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](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). DOE must obtain forecasts of shipments for the base case and each potential standards case as an input to the NES Model. For the distribution transformer rulemaking, DOE 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.

Distribution transformer 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). DOE projected the impacts from the year the standard would take effect through a selected number of years in the future. DOE 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. DOE 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. DOE 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](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. DOE 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.

DOE estimated national energy consumption for each year beginning with the expected effective date of the standard. DOE 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. DOE 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**

DOE conducted the LCC subgroup analysis after the ANOPR was published and reported the results in the NOPR. DOE provides the revised LCC subgroup analysis for the final rule 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 LCC. 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 would be 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. DOE analyzed the effects on these groups by comparing the transformer owners' capital and operating costs with and without an energy conservation standard. DOE 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, transformer loading, and the extra installation costs associated with replacing or expanding transformer vaults.

DOE 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. DOE discussed the variability in each input quantity and likely sources of information with the interested parties.

## **2.12 MANUFACTURER IMPACT ANALYSIS**

DOE 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 DOE's Framework Document published on November 1, 2000, DOE outlined the procedural and analytical approaches for the MIA. As outlined, DOE 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, DOE adapted the GRIM's generic structure to perform an analysis of distribution transformer energy conservation standards. In Phase 3, the "Subgroup Impact Analysis," DOE conducted interviews with several manufacturers. The group of manufacturers interviewed included small, medium, and large manufacturers providing a representative cross-section of the U.S. distribution transformer industry. During these interviews, DOE 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 DOE 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, DOE prepared a profile of the distribution transformer industry that built on the market and technology assessments it had 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, DOE 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. To calibrate its initial characterization of the industry, DOE used public sources of information, 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 this MIA, DOE used the GRIM to perform a distribution transformer industry cash-flow analysis.

For the industry cash-flow analysis, DOE prepared a set of financial parameters for use in the GRIM. DOE originally based these financial parameters on its topdown financial analysis but, in response to discussions with transformer manufacturers, subsequently adjusted them to be more representative of the industry. DOE used similar sources of information (i.e., public financial reports and manufacturer discussions) during the ANOPR phase of the analysis to derive the manufacturer markups it used to establish manufacturer selling prices in the 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. DOE ensured 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, DOE'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 by standards. DOE used the results of the industry characterization to group manufacturers exhibiting similar characteristics. As discussed

in the ANOPR, DOE established two distinct subgroups of distribution transformer manufacturers that could be affected by efficiency standards: liquid-immersed transformer manufacturers, and medium-voltage dry-type transformer manufacturers. A discussion of these superclasses appears in Chapter 12.

Within each superclass, DOE contacted companies from its database of manufacturers that represented firms operating in that superclass. DOE 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. DOE 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 DOE's understanding of how manufacturer impacts change with each of the trial standard levels.

DOE 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. DOE conducted telephone interviews with nine small businesses, to determine if there are differential impacts on these companies that may result from the standard.

DOE 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. DOE 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). DOE 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, DOE spoke with the only domestic supplier of amorphous ribbon and several transformer manufacturers who had experience working with amorphous material. Through this dialogue, DOE gained a better understanding of manufacturing amorphous core transformers, including issues related to core processing equipment, annealing furnaces, and material handling.

## 2.13 UTILITY IMPACT ANALYSIS

DOE 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 electricity generation resulting from the increased transformer efficiency of their electricity customers who purchase their own transformers. To perform the utility impact analysis, DOE used the BT (Building Technologies) version of the Energy Information Administration (EIA)'s National Energy Modeling System (NEMS).<sup>1</sup> 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)*.<sup>2</sup>

NEMS produces a widely recognized baseline forecast for the U.S. through 2030 and is available in the public domain. Typical NEMS output includes forecasts of electricity sales and prices. DOE 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. DOE also used other assumptions from the *AEO* as basic assumptions for analyzing the impacts of energy conservation standards on utilities.

## 2.14 EMPLOYMENT IMPACT ANALYSIS

DOE 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. DOE estimated the impacts of standards on employment in the transformer manufacturing industry and relevant service industries, among energy suppliers, and in the economy in general. DOE separates employment impacts into direct and indirect impacts. Direct employment impacts—discussed in the MIA—would result if standards led to a change in the number of employees at transformer manufacturing plants and related supply and service firms.

DOE defines indirect employment impacts from standards as net jobs eliminated or created in the general economy (other than in the manufacturing sector DOE is regulating). Indirect impacts may result both from expenditures shifting among goods (substitution effect), and from incomes changing, which will lead to a change in overall expenditure levels (income effect). An important indirect employment effect may arise from shifting investment from the energy sector into more (or less) labor-intensive industries. DOE expects new equipment standards to increase a transformer's purchase price, which includes retail price, sales tax, and installation. DOE 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, DOE estimated national impacts for major sectors of the U.S. economy and the net impact on jobs. It used public and commercially available data sources and software to estimate employment impacts. DOE 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 final rule TSD, Chapter 14.

## **2.15 ENVIRONMENTAL ASSESSMENT**

DOE 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), DOE 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<sub>x</sub>) and sulfur dioxide (SO<sub>2</sub>), as well as carbon dioxide (CO<sub>2</sub>). 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. NO<sub>x</sub> emissions are also precursor gases to urban smog and are particularly detrimental to air quality during hot, still weather. CO<sub>2</sub> 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. DOE 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**

DOE conducted the regulatory impact analysis after the ANOPR, and reported the results in the NOPR. DOE prepared a draft regulatory impact analysis pursuant to Executive Order 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). DOE 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, DOE is committed to continually explore non-regulatory alternatives to standards. The list below indicates those alternatives DOE examined for this rulemaking. Through manufacturer interviews and literature searches, DOE 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. DOE 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 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>>