CHAPTER 1. INTRODUCTION

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1.1 PURPOSE OF DOCUMENT

This technical support document (TSD) is a "stand-alone" report that provides the technical analyses and results in support of the information presented in the notice of proposed rulemaking (NOPR) for distribution transformers. ## FR #####. This NOPR TSD also complements the engineering, life-cycle cost (LCC) and payback period (PBP), national impacts, and manufacturer impact analysis spreadsheets that are posted on the Department of Energy's web site at:
http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html

1.2 OVERVIEW OF APPLIANCE STANDARDS

Part C of Title III of the Energy Policy and Conservation Act (EPCA) provides for an energy conservation program for certain commercial and industrial equipment. (42 U.S.C. 6311-6317) In particular, section 346 of EPCA states that the Secretary of Energy must prescribe testing requirements and energy conservation standards for those distribution transformers for which the Secretary determines that standards would be technologically feasible and economically justified, and would result in significant energy savings, although section 325(v) of EPCA in effect modifies this provision by specifying standards for low voltage dry-type distribution transformers. (42 U.S.C. 6295(v) and 6317(a))

The Department designs any new or amended standard to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (See 42 U.S.C. 6295 (o)(2)(A), 6313(a), and 42 U.S.C. 6317(a) and (c)) If a proposed standard is not designed to achieve the maximum improvement in energy efficiency or the maximum reduction in energy use that is technologically feasible, the Secretary states the reasons for this in the proposed rule. To determine whether economic justification exists, the Department reviews comments that it has solicited on the proposed rule and determines that the benefits of the proposed standard exceed its burdens to the greatest extent practicable, weighing the following seven factors (42 U.S.C. 6295 (o)(2)(B)):

1. The economic impact of the standard on manufacturers and consumers of products subject to the standard;

2. The savings in operating costs throughout the estimated average life of the covered products in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered products that are likely to result from the imposition of the standard;

3. The total projected amount of energy savings likely to result directly from the imposition of the standard;

4. Any lessening of the utility or the performance of the covered products likely to result from the imposition of the standard;

5. The impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the imposition of the standard;

6. The need for national energy conservation; and

7. Other factors the Secretary considers relevant.

1.3 OVERVIEW OF DISTRIBUTION TRANSFORMER STANDARDS

On October 22, 1997, the Secretary of Energy issued a determination that "based on its analysis of the information now available, the Department has determined that energy conservation standards for transformers appear to be technologically feasible and economically justified, and are likely to result in significant savings." 62 FR 54809.

The Secretary's determination was based, in part, on analyses conducted by the Oak Ridge National Laboratory (ORNL). In July 1996, ORNL published a report entitled *Determination Analysis of Energy Conservation Standards for Distribution Transformers*, ORNL-6847, which assessed options for setting energy conservation standards. That report was based on information from annual sales data, average load data, and surveys of existing and potential transformer efficiencies obtained from several organizations.

In September 1997, ORNL published a second report entitled *Supplement to the 'Determination Analysis' (ORNL-6847) and Analysis of the NEMA Efficiency Standard for Distribution Transformers*, ORNL-6925. This report assessed the suggested efficiency levels contained in the then-newly published National Electrical Manufacturers Association (NEMA) Standards Publication No. TP 1-1996, *Guide for Determining Energy Efficiency for Distribution Transformers*, along with the efficiency levels previously considered in ORNL-6847. The latest downloadable version of TP 1 is available at the NEMA website: http://www.nema.org/stds/tp1.cfm#download. In its supplemental assessment, ORNL used a more accurate analytical model and better transformer market and loading data developed following the publication of ORNL-6847. Downloadable versions of both ORNL reports are available on the DOE website at: http://www.eere.energy.gov/buildings/appliance_standards/commercial/disttrans_support.html

In the year 2000, as a result of the Secretary's positive determination, the Department developed a *Framework Document for Distribution Transformer Energy Conservation Standards Rulemaking*, describing the procedural and analytic approaches that the Department

anticipated using to evaluate the establishment of energy conservation standards for distribution transformers. This document is also available at http://www.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/trans_framework.pdf. On November 1, 2000, the Department held a public meeting to discuss the proposed analytic framework. Manufacturers, trade associations, electric utilities, environmental advocates, regulators, and other interested parties attended the Framework Document public meeting, actively participating in discussions and showing their willingness to work with DOE in analyzing possible efficiency standards. The major issues discussed were: definition of covered transformer products; definition of product classes; possible proprietary (patent) issues regarding amorphous metal; ties between efficiency improvements and installation costs; baseline and possible efficiency levels; base case trends under deregulation; transformer costs versus transformer prices; appropriate LCC subgroups; LCC methods, e.g., total owning cost (TOC); loading levels; utility impact analysis vis-a-vis deregulation; scope of environmental analysis; and harmonization of standards with other countries.

Stakeholder comments submitted during the Framework Document comment period elaborated on the issues raised at the meeting and also addressed the following issues: options for the screening analysis; approaches for the engineering analysis; discount rates; electricity prices; the number and basis for the efficiency levels to be analyzed; the national energy savings (NES) and net present value (NPV) analyses; the analysis of the effects of a potential standard on employment; the manufacturer impact analysis; and the timing of the analyses. The Department worked with its contractors to address these issues as well as those raised during the Framework Document meeting.

As part of the information gathering and sharing process, the Department organized and held visits with manufacturers of liquid-immersed and dry-type distribution transformers during the first quarter of 2002. The Department selected companies that represented production of all types of distribution transformers, ranged from small to large manufacturers, and included both NEMA and non-NEMA members. The Department had four objectives for these meetings: (1) solicit feedback on the methodology and findings presented in the draft engineering analysis update report that the Department posted on its website December 17, 2001; (2) get information and comments on production costs and manufacturing processes presented in the December 17, 2001, draft engineering analysis update report; (3) provide an opportunity, early in the rulemaking process, to express specific concerns to the Department; and (4) foster cooperation between the manufacturers and the Department.

There were five general issues discussed at each of these manufacturer site meetings: (1) company overview and product offerings; (2) the structure of the engineering analysis, including the engineering design lines, which represent groupings of similarly built distribution transformers; (3) design option combinations for each of the representative transformers from the engineering design lines; (4) use of Optimized Program Services (OPS) distribution transformer design software; and (5) the 0.75 scaling rule, used to scale the costs and efficiencies of the representative units within each of the engineering design lines.

The Department incorporated the information gathered at the meetings in its engineering analysis. Following the publication of the advance notice of proposed rulemaking (ANOPR) on July 19, 2004 and the ANOPR public meeting on September 28, 2004, the Department held additional meetings with manufacturers as part of the consultative process for the manufacturer impact analysis (Chapter 12). During this period, the Department received numerous comments regarding the ANOPR analysis.

The Department developed two types of spreadsheet tools for this rulemaking. The first spreadsheet tool calculates LCC and payback periods. The Department developed 10 different LCC and payback period spreadsheets to capture variations in the distribution transformer market. The second spreadsheet tool calculates impacts of candidate standards at various levels on transformer shipments, and calculates the NES and NPV at various standard levels. These spreadsheets are posted on the Department's website along with the complete TSD documenting the analyses supporting this NOPR.

The Energy Policy Act of 2005 (EPACT 2005), enacted in August 2005, amended EPCA to prescribe standards for low-voltage, dry-type distribution transformers. EPACT 2005 specifies that the efficiency of any such transformer "manufactured on or after January 1, 2007, shall be the Class I Efficiency Levels for distribution transformers specified in table 4-2 of the 'Guide for Determining Energy Efficiency for Distribution Transformers' published by the National Electrical Manufacturers Association (NEMA TP-1-2002)."

Because EPACT 2005 established energy-efficiency standards for low-voltage, dry-type distribution transformers, the Department has removed from this NOPR TSD its analysis of design lines 6, 7, and 8, which comprise product class 3 (low-voltage, dry-type, single-phase) and product class 4 (low-voltage, dry-type, three-phase).

1.3.1 Process Improvement

Although the *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, applies to consumer (residential) products, in its Notice of Determination for Distribution Transformers, the Department stated its intent to adhere in this rulemaking to the provisions of the Process Rule, where applicable. 62 FR 54817. In Table 1.3.1, the Department presents the analyses conducted in its evaluation of standards for distribution transformers.

Table 1.3.1 Distribution Transformers Analyses in Accordance with the Process Rule

ANOPR	NOPR[a]	Final Rule
Market and technology assessment	Revised ANOPR analyses	Revised NOPR analyses
Screening analysis	Life-cycle cost subgroup analysis	
Engineering analysis	Manufacturer impact analysis	
Energy use and end-use load characterization	Utility impact analysis	
Markups for equipment price determination	Employment impact analysis	
Life-cycle cost and payback period analyses	Environmental assessment	
Shipments analysis	Regulatory impact analysis	
National impact analysis		

The analyses in Table 1.3.1 reflect methodological improvements made in accordance with the Process Rule, including the development of economic models and analytical tools. For example, this NOPR uses the full range of consumer marginal electricity costs, which are the energy costs that correspond to incremental changes in energy use. The LCC analysis also defines a range of electricity price forecasts used in the economic analyses, and defines a range of primary energy conversion factors and associated emissions reductions based on the generation displaced by energy-efficiency standards.

1.4 STRUCTURE OF THE DOCUMENT

This TSD consists of 14 chapters, 2 reports, and 16 appendices.

Chapter 1 Introduction: provides an overview of the appliance standards program and how it applies to the distribution transformer rulemaking, provides a history of the Department's actions to date, and outlines the structure of this document.

Chapter 2 Analytic Framework: describes the rulemaking process.

Chapter 3 Market and Technology Assessment: provides the Department's definition of a distribution transformer, lists the proposed product classes, and names the major industry players. This chapter also provides an overview of distribution transformer technology, including techniques employed to improve transformer efficiency.

[a] Because EPACT 2005 established energy-efficiency standards for low-voltage, dry-type distribution transformers, the Department removed this type of transformer from the NOPR stage of its analysis.

Chapter 4 Screening Analysis: identifies all the design options that improve transformer efficiency, and determines which of these are evaluated and which are screened out.

Chapter 5 Engineering Analysis: presents detailed cost and efficiency information for the units of analysis. This chapter describes the Department's approach for determining manufacturer costs, including the markups used for converting material costs to manufacturer sales prices.

Chapter 6 Energy Use and End-Use Load Characterization: discusses the process used for generating energy use estimates and end-use load profiles for distribution transformers.

Chapter 7 Markups for Equipment Price Determination: discusses the methods used for establishing markups for converting manufacturer selling prices to installed customer equipment prices.

Chapter 8 Life-Cycle Cost and Payback Period Analyses: describes the impact of potential candidate standards on consumers of transformers. This chapter compares the life-cycle cost of transformers and other measures of consumer impact with and without candidate efficiency standards.

Chapter 9 Shipments Analysis: uses historical data to provide a shipments estimate for future years and describes the methods used for forecasting shipments with and without candidate efficiency standards.

Chapter 10 National Impact Analysis: describes the national forecast of energy consumption, efficiency of new units, and annual equipment sales in the absence (or presence) of new regulations. This chapter also evaluates indirect employment impacts.

Chapter 11 Life-Cycle Cost Subgroup Analysis: evaluates impacts on any identifiable groups or customers who may be disproportionately affected by any proposed national energy-efficiency standard level.

Chapter 12 Manufacturer Impact Analysis: assesses the impacts on transformer manufacturers of any proposed energy-efficiency standard. In addition to financial impacts, a wide range of quantitative and qualitative effects may occur following adoption of a standard that may require changes to the manufacturing practices for these products.

Chapter 13 Utility Impact Analysis: analyzes the effects of proposed distribution transformer standard levels on the electric utility industry. The utility impact analysis consists of a comparison between model results for the base case and for policy cases in which proposed standards are in place.

Chapter 14 Employment Impact Analysis: estimates national job creation or elimination (direct and indirect effects) resulting from possible standards, due to reallocation of the associated commercial expenditures for purchasing and operating equipment.

Environmental Assessment Report: assesses the impacts of proposed distribution transformer standard levels on certain environmental indicators.

Regulatory Impact Analysis Report: examines and evaluates major alternatives to standards, analyzing the costs and benefits of each. An appendix describes the use of implementation curves.

Appendix 3A Core Steel Market Analysis: presents the Department's research into the global core steel market and impacts on prices of core steel.

Appendix 5A Supplementary Engineering Analysis Results: presents scatter plots for each of the 10 design lines, illustrating no-load losses versus selling price; load losses versus selling price; and transformer weight versus efficiency.

Appendix 5B Scaling Relationships in Transformer Manufacturing: discusses the technical basis of the 0.75 scaling rule.

Appendix 5C Q1 2005 Material Pricing Analysis: presents the material prices developed by the Department for studying recent trends in material prices (first quarter of 2005). This includes the material prices themselves, the engineering analysis plots, and summary LCC analytical results on this pricing scenario.

Appendix 8-A Life-Cycle Cost and Payback Period Results: presents LCC and PBP results for all 10 design lines.

Appendix 8B Uncertainty and Variability: provides an overview of the treatment of uncertainty and variability in the analysis.

Appendix 8C Sample Utilities: details the specific electric utilities for which electricity tariffs were collected for use in the analysis.

Appendix 8D Life-Cycle Cost Sensitivity Results: presents the findings for the sensitivity analysis of design lines 1 and 12 that result from changing key variables.

Appendix 8E Average Transformer Design Properties from Life-Cycle Cost Model: provides the average manufacturer's selling price, the average installed cost (consumer equipment cost plus installation) and other important attributes for each of the thirteen distribution transformers analyzed.

Appendix 10A	User Instructions for Shipments and National Impacts Analysis Spreadsheet Model
Appendix 10B	National Energy Savings and Net National Present Value Results: presents NES and NPV results for all eight product classes.
Appendix 11A	Life-Cycle Cost Subgroup Results
Appendix 12A	Manufacturer Impact Analysis Interview Guides: Liquid-Immersed and Medium-Voltage, Dry-Type
Appendix 12B	Manufacturer Impact Analysis Small Business Interview Guide
Appendix 12C	Government Regulatory Impact Model (GRIM) Supporting Documentation
Appendix 13A	NEMS-BT Extension Modeling Beyond 2025