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 Advance Notice of Proposed Rulemaking (ANOPR) for distribution transformers. 69 FR 45376, July 29, 2004 This ANOPR TSD also complements the engineering, life-cycle cost (LCC) and payback period (PBP) spreadsheets that are posted on the Department of Energy's web site at: http://www.eere.energy.gov/buildings/appliance_standards/commercial/dist_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. (42 U.S.C. 6317(a))

Before the Department determines whether to adopt a proposed energy conservation standard, it will first solicit comments on the proposed standard. The Department intends to design any new or amended standard to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295 (o)(2)(A) and 42 U.S.C. 6317(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 will state the reasons for this in the proposed rule. To determine whether economic justification exists, the Department will review comments on the proposal and determine 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 by the Department in the determination study. The latest downloadable version of TP 1 is available at the NEMA website: http://www.nema.org/index_nema.cfm/1427/47168E11-AA56-4B4E-9F329B339C23F115/. In its supplemental assessment, ORNL used a more accurate analytical model and better transformer market and loading data developed following the publication of ORNL-6827. Downloadable versions of both ORNL reports are available on the DOE website at: http://www.eere.energy.gov/buildings/appliance_standards/commercial/dist_transformers.html

As a result of this positive determination, in 2000, 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 on the aforementioned DOE website. On November 1, 2000, the Department held a public workshop on the framework document to discuss the proposed analytical framework. Manufacturers, trade associations, electric utilities, environmental

advocates, regulators, and other interested parties attended the framework document workshop, actively participating in discussions and showing their willingness to work with DOE on the process of 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 sub-groups; 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 upon 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 and net present value analyses; the analysis of the effects of a potential standard on employment; the manufacturer impact assessment; 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 workshop.

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 into its engineering analysis, which is described in more detail in the engineering analysis section (Chapter 5). Following the publication of the ANOPR and the ANOPR public meeting, the Department intends to hold additional meetings with manufacturers as part of the consultative process for the manufacturer impact analysis (Chapter 12).

As part of its pre-ANOPR analysis process, the Department posted several draft reports on its website and solicited stakeholder input. These reports are:

- The Department's initial engineering analysis for design line 1 (*Distribution Transformer Rulemaking, Engineering Analysis Update*, posted December 17, 2001). This document contains preliminary results of the engineering analysis for design line 1.

- The Department's initial screening analysis (*Screening Analysis*, posted March 5, 2002). This document discusses various design options for improving the energy efficiency of distribution transformers and describes the reasons for eliminating certain design options from consideration.

- The Department's draft LCC analysis for design line 1 (*Distribution Transformer Rulemaking, Life Cycle Cost Analysis, Design Line 1*, posted June 6, 2002). This document discusses the methodology and structure of the LCC analysis used for liquid-immersed transformers, along with the basis for various input values and assumptions. It also presents example results from the LCC analysis on a 50 kVA unit.

- The Department's revised engineering analysis for design line 1 (posted June 6, 2002, as Appendix B to the LCC report listed above). This appendix presents a revision of the engineering analysis that the Department originally circulated in December 2001.

- The Department's engineering analysis for medium-voltage dry-type distribution transformers (*Distribution Transformer Standards Rulemaking, Draft Report for Review, Engineering Analysis for Dry-type Distribution Transformers and Results on Design Line 9*, posted August 23, 2002). This document contains preliminary results of the engineering analysis for design line 9.

- The Department's draft LCC analysis for design line 9 (*Distribution Transformer Standards Rulemaking, Draft Report for Review, Dry-type Distribution Transformers, Life Cycle Cost Analysis on Design Line 9*, posted October 4, 2002). This document discusses the methodology and structure of the LCC analysis for dry-type transformers, along with the basis for various input values and assumptions. It also presents example results from the LCC analysis on a 50 kVA unit.

The Department also posted several spreadsheets while preparing for the ANOPR for early stakeholder review and comment:

- ANOPR engineering analysis results spreadsheets for all 13 design lines (posted April 4, 2003). These spreadsheets summarize the cost and performance of all the designs in the Department's engineering database. One spreadsheet contains the engineering analysis results of the liquid-immersed design lines, and the other contains the dry-type design lines.

- ANOPR LCC spreadsheets for all 13 design lines (posted May 14, 2003). These spreadsheets are used by the Department to calculate the LCC and PBP. The Department conducted a webcast on October 17, 2002, presenting and explaining the basic LCC spreadsheet to stakeholders.

The Department developed two spreadsheet tools for this rulemaking. The first spreadsheet tool calculates LCC and payback periods. Thirteen different LCC and payback period spreadsheets were developed to capture variations in the distribution transformer market. The second spreadsheet tool calculates impacts of candidate standards at various levels on 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 ANOPR.

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 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 it intends to conduct in its evaluation of standards for distribution transformers.

Table 1.3.1 Distribution Transformers Analyses in Accordance with the Process Rule

ANOPR	NOPR	Final Rule
Market and technology assessment	Revised ANOPR analyses	Revised analyses
Screening analysis	Life-cycle cost sub-group 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 ANOPR uses the full range of consumer marginal energy rates which are the energy rates that correspond to incremental changes in energy use. The LCC analysis also defines a range of energy price forecasts for each fuel used in the economic analyses, and defines a range of

primary energy conversion factors and associated emission reductions based on the generation displaced by energy efficiency standards. If timely new data, models, or tools that enhance the development of standards become available, they will be incorporated into this rulemaking.

1.4 STRUCTURE OF THE DOCUMENT

This TSD consists of fourteen chapters, two reports, and six 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 Analytical Framework: describes the rulemaking process.

Chapter 3 Market and Technology Assessment: provides the Department's definition of a distribution transformer, 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.

Chapter 4 Screening Analysis: identifies all the design options that improve transformer efficiency, and determines which of these will be evaluated and which will be 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: provides a shipments estimate for 2001 and 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 Sub-Group Analysis: evaluates impacts on any identifiable groups or customers who may be disproportionately affected by any proposed national energy efficiency standard level (NOPR stage).

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 (NOPR stage).

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 (NOPR stage).

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 (NOPR stage).

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

Regulatory Impact Analysis Report: evaluates major alternatives to standards to achieve customer product energy efficiency (NOPR stage).

Appendix 5-A Supplementary Engineering Analysis Results: presents scatter plots for each of the 13 design lines, illustrating no-load losses vs. selling price; load-losses vs. selling price and transformer weight vs. selling price.

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

Appendix 8-A LCC and PBP Results: presents LCC and PBP results for all 13 design lines.

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

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

Appendix 8-D	LCC Sensitivity Results: presents the findings for the sensitivity analysis of design lines one and nine that result from changing key variables.
Appendix 10-A	National Energy Savings and Net National Present Value Results: presents national energy savings net present value results for all ten product classes.