DOE/EA-1565

ENVIRONMENTAL ASSESSMENT FOR ADOPTED ENERGY CONSERVATION STANDARDS FOR DISTRIBUTION TRANSFORMERS

July 2007

U.S. Department of Energy
Assistant Secretary
Office of Energy Efficiency & Renewable Energy
Building Technologies Program
Appliances and Commercial Equipment Standards
Washington, DC 20585

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) prepared this distribution transformers environmental assessment (EA) pursuant to the National Environmental Policy Act of 1969 (NEPA)(42 U.S.C. 4321 *et seq.*), the regulations of the Council on Environmental Quality (40 CFR parts 1500–1508), and the DOE's regulations for compliance with NEPA (10 CFR part 1021).

Title III of the Energy Policy and Conservation Act (EPCA) (42 U.S.C. 6291 *et seq.*) sets forth a variety of provisions designed to improve energy efficiency. Part C of title III (42 U.S.C. 6311–6317) establishes an energy-conservation program for "Certain Industrial Equipment" and includes distribution transformers, the subject of this EA. EPCA states that the Secretary of Energy shall prescribe testing requirements for those distribution transformers for which the Secretary makes a determination that energy conservation standards would be technologically feasible and economically justified, and would result in significant energy savings. Furthermore, the Secretary shall prescribe, by rule, energy conservation standards for those distribution transformers for which the Secretary prescribed testing requirements under the first statement. (42 U.S.C. 6317) There are no current mandatory national standards for distribution transformers in the United States.

On October 22, 1997, the Secretary of Energy issued a determination that "based on its analysis of the information now available, DOE 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 Department of Energy's Oak Ridge National Laboratory (ORNL). In July 1996, ORNL published a report entitled *Determination Analysis of Energy Conservation Standards for Distribution Transformers*, ORNL-6847,[1] 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.[2] 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*,[3] along with the efficiency levels previously considered by DOE in the determination study. 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/dist_transformers.html

On July 29, 2004, DOE published the advance notice of proposed rulemaking (ANOPR) and its associated technical support document (TSD).[4] At the ANOPR public meeting on September 28, 2004, as well as during the formal comment period, DOE invited stakeholders to comment on the following issues: definition and coverage, product classes (PCs), engineering analysis inputs, design option combinations, the 0.75 scaling rule, modeling of transformer load profiles, distribution chain markups, discount rate selection and use, baseline determination through purchase evaluation formulae, electricity prices, load growth over time, life-cycle cost (LCC) subgroups, and utility deregulation impacts.

On August 5, 2005, DOE posted its draft NOPR analysis for the liquid-immersed and medium-voltage, dry-type distribution transformers on its website for early public review, along with spreadsheets for several of these analyses. This early publication of the draft NOPR analysis included the draft engineering analysis, LCC analysis, national impact analysis, and manufacturer impact analysis (MIA), and the draft TSD chapters associated with each of these analyses. The purpose of publishing these four draft analyses was to give stakeholders an opportunity to review the analyses and prepare recommendations for DOE as to the appropriate standard levels.

On August 4, 2006, DOE published the distribution transformer energy conservation standards NOPR. 71 FR 44355. In conjunction with the NOPR, DOE also published on its website the complete TSD for the proposed rule, which incorporated the final analyses DOE conducted and technical documentation for each analysis.

On February 9, 2007, DOE issued a notice of data availability and request for comments (NODA). 72 FR 6186. DOE published this notice in response to stakeholders who had commented in the NOPR that DOE's proposed standards might prevent or render impractical the replacement of distribution transformers in certain space-constrained (e.g., vault) installations. In the NODA, DOE sought comment on whether it should include in the LCC analysis potential costs related to size constraints of transformers installed in vaults. DOE also requested comment on an additional option of selecting final efficiency levels for liquid-immersed distribution transformers by design line. As discussed in the Engineering Analysis (see TSD Chapter 5), DOE created separate engineering design lines for small and large kVA liquid-immersed distribution transformers in both the single-phase and the three-phase product classes. In the NODA, DOE asked stakeholders whether it should select the final efficiency level for liquid-immersed distribution transformers by looking at its liquid-immersed analytical results in their most disaggregated form - by design line. Stakeholder comment from the NODA were considered in formulating the final rule for the energy conservation standard.

2.0 PURPOSE

Energy-efficiency standards for distribution transformers are expected to result in savings in electrical energy. The metric used to measure the efficiency of distribution transformers is percent efficiency, which is calculated by taking into account no-load losses (which are constant) and load losses (which vary by the square of the load) at a specified design load. An increase in the percent efficiency as measured above indicates that the distribution transformer is more energy-efficient. Details on the technical analysis of increased efficiency levels are provided in the TSD that accompanies DOE's adopted energy conservation standard standard.

To analyze improvements in the efficiency of distribution transformers, DOE created six trial standard levels (TSLs) during the NOPR using the following criteria for determining the efficiencies:

TSL 1: The NEMA TP 1 standard level
TSL 2: 1/3 of difference between TP 1 and minimum LCC
TSL 3: 2/3 of difference between TP 1 and minimum LCC
TSL 4: Minimum LCC
TSL 5: Maximum energy savings with no change in LCC
TSL 6: Maximum energy savings (or maximum technologically feasible level)

In response to comments received in response to the NOPR and the NODA, DOE formulated four recombined standard levels that it evaluated for the final rule for liquid-immersed transformers. For liquid-immersed transformers, the efficiencies selected using the minimum LCC produced inconsistencies in the stringency of the single-phase and three-phase efficiency requirements. Appendix 8I of the TSD provides a detailed discussion of the three-phase to singe-phase inconsistencies in the NOPR standard levels and DOE's response to thies issue. To resolve the issue of inconsistencies between single-phase and three-phase efficiency levels, DOE formulated four recombined efficiency levels to evaluate for the final rule. The recombined levels maintain exact consistency between the single-phase and three-phase efficiency levels for TSL A, B, and C and approximate single-phase and three-phase consistence for TSL D.

TSL A: Combination of a DL1 TSL5, and a DL3 TSL4
TSL B: Combination of a DL4 TSL2, and a DL5 TSL4
TSL C: Combination of a DL4 TSL2, and a DL5 TSL3
TSL D: Combination of a DL1 TSL4, a DL4 TSL2, a DL3 TSL2, and a DL5 TSL3

Tables EA.3 through EA.10 provide the precise definitions of the efficiency levels for each product class.

For medium-voltage dry-type transformers, DOE selected TSL 2 while for liquid-immersed transformers DOE selected TSL C. Tables EA.1 and EA.2 summarize the adopted standard levels for the liquid-immersed and medium-voltage, dry-type transformers.

Table EA.1 Adopted Standard Levels for Liquid-Immersed Distribution Transformers

Single-Phase Adopted Efficiency Level TSLC		**Three-Phase Adopted Efficiency Level TSLC**	
kVA	PC 1 Efficiency (%)	kVA	PC 2 Efficiency (%)
10	98.62	15	98.36
15	98.76	30	98.62
25	98.91	45	98.76
37.5	99.01	75	98.91
50	99.08	112.5	99.01
75	99.17	150	99.08
100	99.23	225	99.17
167	99.23	300	99.23
250	99.31	500	99.27
333	99.36	750	99.31
500	99.42	1000	99.36
667	99.46	1500	99.42
833	99.49	2000	99.46
		2500	99.49

Note: All efficiency values are at 50% of nameplate rated load, determined according to the DOE test procedure.

Table EA.2 Adopted Standard Levels for Medium-Voltage, Dry-Type Distribution Transformers

Single-Phase Adopted Efficiency Level TSL2				Three-Phase Adopted Efficiency Level TSL2			
kVA	PC5 20-45kV BIL (%)	PC7 46-95kV BIL (%)	PC9 ≥96kV BIL (%)	kVA	PC6 20-45kV BIL (%)	PC8 46-95kV BIL (%)	PC10 ≥96kV BIL (%)
15	98.10	97.86	-	15	97.50	97.19	-
25	98.33	98.12	-	30	97.90	97.63	-
37.5	98.49	98.30	-	45	98.10	97.86	-
50	98.60	98.42	-	75	98.33	98.12	-
75	98.73	98.57	98.53	112.5	98.49	98.30	-
100	98.82	98.67	98.63	150	98.60	98.42	-
167	98.96	98.83	98.80	225	98.73	98.57	98.53
250	99.07	98.95	98.91	300	98.82	98.67	98.63
333	99.14	99.03	98.99	500	98.96	98.83	98.80
500	99.22	99.12	99.09	750	99.07	98.95	98.91
667	99.27	99.18	99.15	1000	99.14	99.03	98.99
833	99.31	99.23	99.20	1500	99.22	99.12	99.09
				2000	99.27	99.18	99.15
				2500	99.31	99.23	99.20

Note: All efficiency values are at 50% of nameplate rated load, determined according to the DOE test procedure.

3.0 ALTERNATIVES, INCLUDING THE ACTION

DOE analyzed 11 alternative standards levels for liquid-immersed transformers and seven for medium-voltage, dry-type transformers. For the liquid-immersed transformers the alternatives consisted of the six TSLs identified in the NOPR, four recombinations and a no-action alternative. As discussed above, DOE's adopted action is to propose TSL 2 for medium-voltage, dry-type transformers and TSL C for liquid-immersed transformers. The following sections discuss the 11 liquid-immersed alternatives and the seven medium-voltage dry-type transformers alternatives.

3.1 No-Action Alternative

Under a no-action alternative, DOE would not publish new minimum energy-efficiency standards for distribution transformers. DOE addresses the no-action alternative in the TSD, including the regulatory impact analysis (RIA), along with other non-regulatory policy cases and voluntary incentive programs. The RIA found that the no-action alternative would result in insufficient reductions in energy consumption as compared to other alternatives, including DOE's adopted action.

3.2 Adopted Action

DOE's action is to adopt TSL C for liquid-immersed transformers and TSL 2 for medium-voltage, dry-type transformers (as identified in Tables EA.1 and EA.2), which would result in national energy savings, reduced average LCC for consumers, a net national benefit (i.e., monetary savings to the Nation exceed increased equipment costs to the Nation), and air-borne emissions reductions. The adopted action would also result in a reduction in industry net present value, but DOE believes the amount is not significant. In this final rule, DOE determined that the benefits of the adopted action outweighed its burdens and that the action is economically justified. DOE concluded that the adopted action would save a significant amount of energy and is technologically feasible. The adopted action goes into effect in the year 2010. Additional details on estimated impacts resulting from the adopted action and other TSLs are provided in the TSD.

3.3 Alternative Standards

This EA also presents the results of the environmental impacts from five other distribution transformer TSLs for medium-voltage, dry-type transformers and nine other TSLs for liquid-immersed transformers—besides those from DOE's adopted action (TSL 2 and TSL C respectively). Each TSL is an alternative action, which DOE compared with the no-action alternative. (In the no-action alternative, also referred to as the base case, no new amended standards are adopted.) Each TSL has a unique combination of efficiency levels associated with it. Tables EA.3 through EA.10 show each TSL, including DOE's adopted action, by product class. Each of the tables also indicate the specific engineering design lines (DL) associated with that particular product class at the transformer capacity associated with the particular design lines. DOE performed a detailed engineering and economic analysis for each design line and then extrapolated the results to the product class to estimate the economic and engineering impacts of alternative standards for the entire population of transformers. Chapter 5 of the TSD presents the engineering analysis for each of the transformers design lines, while Chapter 8 of the TSD presents the consumer economic impacts for each engineering design line.

Table EA.3 Trial Standard Levels for PC 1 Liquid-Immersed, Medium-Voltage, Single-Phase Distribution Transformers

Product Class 1		**Trial Standard Level**											
		0		**1**	**2**	**3**	**4**	**5**	**6**	**A**	**B**	**C**	**D**
Design Line	kVA	Ave. Base Case Eff.	Min. Base Case Eff.	TP 1					Max Tech.				
	10	98.42	97.77	98.4	98.40	98.44	98.48	98.69	99.32	98.79	98.62	98.62	98.48
	15	98.57	97.99	98.6	98.56	98.59	98.63	98.82	99.39	98.91	98.76	98.76	98.63
DL2	25	98.74	98.23	98.7	98.73	98.76	98.79	98.96	99.46	99.04	98.91	98.91	98.79
	37.5	98.86	98.40	98.8	98.85	98.88	98.91	99.06	99.51	99.13	99.01	99.01	98.91
DL1	50	98.97	98.56	98.9	98.90	98.90	99.04	99.19	99.59	99.19	99.08	99.08	99.04
	75	99.04	98.66	99.0	99.04	99.06	99.08	99.21	99.59	99.27	99.17	99.17	99.08
	100	99.11	98.75	99.0	99.10	99.12	99.14	99.26	99.62	99.32	99.23	99.23	99.14
	167	99.22	98.90	99.1	99.21	99.23	99.25	99.35	99.66	99.40	99.32	99.32	99.25
	250	99.24	98.89	99.2	99.26	99.36	99.45	99.69	99.70	99.45	99.37	99.31	99.26
	333	99.29	98.97	99.2	99.31	99.40	99.49	99.71	99.72	99.49	99.41	99.36	99.31
DL3	500	99.36	99.07	99.3	99.38	99.46	99.54	99.74	99.75	99.54	99.47	99.42	99.38
	667	99.40	99.13	99.4	99.42	99.50	99.57	99.76	99.77	99.57	99.51	99.46	99.42
	833	99.44	99.18	99.4	99.45	99.52	99.60	99.77	99.78	99.60	99.53	99.49	99.45

Table EA.4 Trial Standard Levels for PC 2 Liquid-Immersed, Medium-Voltage, Three-Phase Distribution Transformers

Product Class 2		**Trial Standard Level**											
		0		**1**	**2**	**3**	**4**	**5**	**6**	**A**	**B**	**C**	**D**
Design Line	kVA	Ave. Base Case Eff.	Min. Base Case Eff,	TP 1					Max Tech.				
	15	98.06	97.19	98.1	98.36	98.68	98.68	99.25	99.31	98.56	98.36	98.36	98.36
	30	98.37	97.64	98.4	98.62	98.89	98.89	99.37	99.42	98.79	98.62	98.62	98.62
	45	98.53	97.87	98.6	98.76	99.00	99.00	99.43	99.47	98.91	98.76	98.76	98.76
	75	98.70	98.12	98.7	98.91	99.12	99.12	99.50	99.54	99.04	98.91	98.91	98.91
	112.5	98.83	98.30	98.8	99.01	99.20	99.20	99.55	99.58	99.13	99.01	99.01	99.01
DL4	150	98.91	98.42	98.9	99.08	99.26	99.26	99.58	99.61	99.19	99.08	99.08	99.08
	225	99.02	98.57	99.0	99.17	99.33	99.33	99.62	99.65	99.27	99.17	99.17	99.17
	300	99.08	98.67	99.0	99.23	99.38	99.38	99.65	99.67	99.32	99.23	99.23	99.23
	500	99.19	98.83	99.1	99.32	99.45	99.45	99.69	99.71	99.40	99.32	99.32	99.32
	750	99.24	98.97	99.2	99.24	99.31	99.37	99.66	99.66	99.45	99.37	99.31	99.31
	1000	99.29	99.04	99.2	99.29	99.36	99.41	99.68	99.68	99.49	99.41	99.36	99.36
DL5	1500	99.36	99.13	99.3	99.36	99.42	99.47	99.71	99.71	99.54	99.47	99.42	99.42
	2000	99.40	99.19	99.4	99.40	99.46	99.51	99.73	99.73	99.57	99.51	99.46	99.46
	2500	99.44	99.23	99.4	99.44	99.49	99.53	99.74	99.74	99.60	99.53	99.49	99.49

Table EA.5 Trial Standard Levels for PC 5 Dry-Type, Medium-Voltage, Single-Phase Distribution Transformers (20-45 kV BIL)

Product Class 5		**Trial Standard Level**							
		0		**1**	**2**	**3**	**4**	**5**	**6**
Design Line	kVA	Ave. Base Case Eff.	Min. Base Case Eff.	TP 1					Max Tech.
	15	98.02	97.45	97.6	98.10	98.46	98.81	99.05	99.05
	25	98.26	97.75	97.9	98.33	98.64	98.95	99.17	99.17
	37.5	98.43	97.97	98.1	98.49	98.77	99.05	99.25	99.25
	50	98.54	98.11	98.2	98.60	98.86	99.12	99.30	99.30
	75	98.68	98.29	98.4	98.73	98.97	99.20	99.37	99.37
DL9	100	98.77	98.41	98.5	98.82	99.04	99.26	99.41	99.41
	167	98.92	98.60	98.8	98.96	99.16	99.35	99.48	99.48
	250	99.01	98.56	98.9	99.05	99.17	99.27	99.42	99.42
	333	99.08	98.66	99.0	99.11	99.23	99.32	99.46	99.46
DL10	500	99.17	98.79	99.1	99.20	99.30	99.39	99.51	99.51
	667	99.23	98.87	99.2	99.26	99.35	99.43	99.54	99.54
	833	99.27	98.93	99.2	99.30	99.38	99.46	99.57	99.57

Table EA.6 Trial Standard Levels for PC 6 Dry-Type, Medium-Voltage, Three-Phase Distribution Transformers (20-45 kV BIL)

Product Class 6		**Trial Standard Level**							
		0		**1**	**2**	**3**	**4**	**5**	**6**
Design Line	kVA	Ave. Base Case Eff.	Min. Base Case Eff.	TP 1					Max Tech.
	15	97.40	96.64	96.8	97.50	97.97	98.44	98.75	98.75
	30	97.81	97.17	97.3	97.90	98.29	98.68	98.95	98.95
	45	98.02	97.45	97.6	98.10	98.46	98.81	99.05	99.05
	75	98.26	97.75	97.9	98.33	98.64	98.95	99.17	99.17
	112.5	98.43	97.97	98.1	98.49	98.77	99.05	99.25	99.25
	150	98.54	98.11	98.2	98.60	98.86	99.12	99.30	99.30
	225	98.68	98.29	98.4	98.73	98.97	99.20	99.37	99.37
DL9	300	98.77	98.41	98.6	98.82	99.04	99.26	99.41	99.41
	500	98.92	98.60	98.8	98.96	99.16	99.35	99.48	99.48
	750	99.01	98.56	98.9	99.05	99.17	99.27	99.42	99.42
	1000	99.08	98.66	99.0	99.11	99.23	99.32	99.46	99.46
DL10	1500	99.17	98.79	99.1	99.20	99.30	99.39	99.51	99.51
	2000	99.23	98.87	99.2	99.26	99.35	99.43	99.54	99.54
	2500	99.27	98.94	99.2	99.30	99.38	99.46	99.57	99.57

Table EA.7 Trial Standard Levels for PC 7 Dry-Type, Medium-Voltage, Single-Phase Distribution Transformers (46-95 kV BIL)

Product Class 7		**Trial Standard Level**							
		0		**1**	**2**	**3**	**4**	**5**	**6**
Design Line	kVA	Ave. Base Case Eff.	Min. Base Case Eff.	TP 1					Max Tech.
	15	97.46	96.87	97.6	97.86	98.14	98.41	98.54	98.54
	25	97.77	97.24	97.9	98.12	98.36	98.60	98.71	98.71
	37.5	97.98	97.51	98.1	98.30	98.52	98.73	98.84	98.84
	50	98.12	97.68	98.2	98.42	98.62	98.82	98.92	98.92
	75	98.30	97.90	98.4	98.57	98.75	98.94	99.02	99.02
DL11	100	98.42	98.05	98.5	98.67	98.84	99.01	99.09	99.09
	167	98.61	98.28	98.8	98.83	98.98	99.13	99.20	99.20
	250	99.02	98.58	98.9	98.95	99.08	99.23	99.42	99.42
	333	99.09	98.68	99.0	99.03	99.15	99.28	99.46	99.46
DL12	500	99.18	98.81	99.1	99.12	99.23	99.35	99.51	99.51
	667	99.24	98.89	99.2	99.18	99.28	99.40	99.54	99.54
	833	99.28	98.95	99.2	99.23	99.32	99.43	99.57	99.57

Note: Because the representative units for both of the underlying DLs for PC 7 (DL 11 and DL 12) were 95 kV BIL, for kVA ratings from 167 through 833, the value in the “TP 1” column is the NEMA TP 1 value for >60 kV BIL.

Table EA.8 Dry-Type, Medium-Voltage, Three-Phase Distribution Transformers (46-95 kV BIL)

Product Class 8		**Trial Standard Level**							
		0		**1**	**2**	**3**	**4**	**5**	**6**
Design Line	kVA	Ave. Base Case Eff.	Min. Base Case Eff.	TP 1					Max Tech.
	15	96.66	95.88	96.8	97.19	97.55	97.91	98.08	98.08
	30	97.19	96.53	97.3	97.63	97.94	98.24	98.38	98.38
	45	97.46	96.87	97.6	97.86	98.14	98.41	98.54	98.54
	75	97.77	97.24	97.9	98.12	98.36	98.60	98.71	98.71
	112.5	97.98	97.51	98.1	98.30	98.52	98.73	98.84	98.84
	150	98.12	97.68	98.2	98.42	98.62	98.82	98.92	98.92
	225	98.30	97.90	98.4	98.57	98.75	98.94	99.02	99.02
DL11	300	98.42	98.05	98.5	98.67	98.84	99.01	99.09	99.09
	500	98.61	98.28	98.8	98.83	98.98	99.13	99.20	99.20
	750	99.02	98.58	98.9	98.95	99.08	99.23	99.42	99.42
	1000	99.09	98.68	99.0	99.03	99.15	99.28	99.46	99.46
DL12	1500	99.18	98.81	99.0	99.12	99.23	99.35	99.51	99.51
	2000	99.24	98.89	99.2	99.18	99.28	99.40	99.54	99.54
	2500	99.28	98.95	99.2	99.23	99.32	99.43	99.57	99.57

Note: Because the representative units for both of the underlying DLs for PC 8 (DL 11 and DL 12) were 95 kV BIL, for kVA ratings from 300 through 2500, the value in the “TP 1”column is the NEMA TP 1 value for >60 kV BIL.

Table EA.9 Dry-Type, Medium-Voltage, Single-Phase Distribution Transformers (≥ 96 kV BIL)

Product Class 9		Trial Standard Level							
		0		1	2	3	4	5	6
Design Line	kVA	Ave. Base Case Eff.	Min. Base Case Eff.	TP 1					Max Tech.
	75	98.72	98.22	98.4	98.53	98.79	99.05	99.22	99.22
	100	98.81	98.34	98.5	98.63	98.88	99.12	99.28	99.28
	167	98.95	98.54	98.7	98.80	99.01	99.22	99.36	99.36
	250	99.05	98.68	98.8	98.91	99.11	99.30	99.42	99.42
	333	99.12	98.77	98.9	98.99	99.17	99.35	99.46	99.46
	500	99.20	98.89	99.0	99.09	99.25	99.41	99.52	99.52
DL13	667	99.26	98.97	99.0	99.15	99.30	99.45	99.55	99.55
	833	99.30	99.03	99.1	99.20	99.34	99.48	99.57	99.57

Table EA.10 Dry-Type, Medium-Voltage, Three-Phase Distribution Transformers (≥96 kV BIL)

Product Class 10		**Trial Standard Level**							
		0		**1**	**2**	**3**	**4**	**5**	**6**
Design Line	kVA	Ave. Base Case Eff.	Min. Base Case Eff.	TP 1					Max Tech.
	225	98.72	98.22	98.4	98.53	98.79	99.05	99.22	99.22
	300	98.81	98.34	98.5	98.63	98.88	99.12	99.28	99.28
	500	98.95	98.54	98.7	98.80	99.01	99.22	99.36	99.36
	750	99.05	98.68	98.8	98.91	99.11	99.30	99.42	99.42
	1000	99.12	98.78	98.9	98.99	99.17	99.35	99.46	99.46
	1500	99.20	98.89	99.0	99.09	99.25	99.41	99.52	99.52
DL13	2000	99.26	98.97	99.0	99.15	99.30	99.45	99.55	99.55
	2500	99.30	99.03	99.1	99.20	99.34	99.48	99.57	99.57

4.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT

4.1 Geography

The distribution transformer standard that DOE has adopted–TSL 2 for medium-voltage, dry-type and TSL C for liquid-immersed–would apply to all 50 States and United States territories.

4.2 Air Resources

The primary focus of the EA is the effect of adopted efficiency standards on air resources. For this analysis, the EA used a variant of the DOE Energy Information Administration (EIA)'s National Energy Modeling System (NEMS), called NEMS-BT (BT is DOE's Building Technologies Program).[a] As described in section 4.2.1 below, the environmental analysis is similar to the utility impact analysis described in Chapter 13 of the TSD.[5] Outputs of the environmental analysis are in a format similar to the results of the EIA's *Annual Energy Outlook 2006 (AEO2006)*.[6]

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[a] The EIA approves use of the name NEMS to describe only an official version of the model without any modification to code or data. Because this analysis entails some minor code modifications and the model is run under various policy scenarios that are variations on DOE/EIA assumptions, DOE refers to it as NEMS-BT. NEMS-BT was previously called NEMS-BRS.

For each of the energy-efficiency standard levels, DOE calculated total power-sector emissions based on output from NEMS-BT. The EA considers one emission, carbon dioxide (CO_2). An air pollutant is any substance in the air that can cause harm to humans or the environment. Pollutants may be natural or man-made and may take the form of solid particles, liquid droplets, or gases. The Clean Air Act Amendments of 1990 list 188 toxic air pollutants that the U.S. Environmental Protection Agency (EPA) is required to control. The EPA has set national air-quality standards for six common pollutants (also referred to as "criteria" pollutants), two of which are SO_2 and NO_x. Also, the Clean Air Act Amendments of 1990 gave authority to EPA to control acidification and to require operators of electric power plants to reduce emissions of SO_2 and NO_x. In addressing SO_2 emissions, the Clean Air Act Amendments of 1990 set an SO_2 emissions cap on all power generation, but permitted flexibility among generators through the use of emissions allowances and tradable permits. This SO_2 trading implies that physical emissions effects of a standard is likely to be zero because emissions will always be at, or near, the allowed ceiling. Consequently, there is no direct SO_2 environmental benefit from electricity conservation, as long as there is enforcement of the emissions ceiling. But to the extent reduced power generation demand decreases the demand for and price of emissions allowance permits, there is potentially an environmentally related economic benefit from standards reducing SO_2 emissions allowance demand.

In March 2005, EPA legislated the Clean Air Interstate Rule (CAIR). This rule was designed to further reduce atmospheric releases of ozone and particulate matter and therefore targets NOx and SO_2 emissions. Applicable to 28 States and the District of Columbia, all fossil-fueled boilers and turbines greater than 25 MW including CHP units greater than 25 MW are required to reduce their NOx and SO_2 emissions in a two-phase program. Under CAIR, States are responsible for allocating emissions allowances, giving emitters the choice of participating in cap-and-trade programs or adopting control technologies to meet their requirements.

Carbon dioxide is of interest because of its classification as a greenhouse gas and its impact on global climate change. Greenhouse gases — which trap the sun's radiation inside the Earth's atmosphere — either occur naturally in the atmosphere or result from human activities. Naturally occuring greenhouse gases include water vapor, CO_2, methane (CH_4), nitrous oxide, and ozone. Human activities, however, add to the levels of most of these naturally occurring gases. For example, CO_2 is emitted to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), wood, and wood products are burned. During the past 20 years, about three-quarters of anthropogenic (i.e., human-made) CO_2 emissions resulted from burning fossil fuels. Concentrations of CO_2 in the atmosphere are naturally regulated by numerous processes, collectively known as the "carbon cycle." The movement of carbon between the atmosphere and the land and oceans is dominated by natural processes, such as plant photosynthesis. While these natural processes can absorb some of the anthropogenic CO_2 emissions produced each year, billions of metric tons are added to the atmosphere annually. The Earth's positive imbalance between emissions and absorption results in the continuing growth in greenhouse gases in the atmosphere, thereby causing surface air temperatures and sub-surface ocean temperatures to rise. The U.S. CO_2 emissions from both energy consumption and industrial processes account for 84.6 percent of total U.S. greenhouse gas emissions.[7]

4.2.1 Assumptions

In its forecasts of air resources impacts using NEMS-BT, DOE conducted the EA as a policy deviation from the typical meteorological year (TMY) System Load Reference Case, a modified *AEO2006 Reference Case*, using the same basic set of assumptions. The emissions characteristics of all electricity-generating plants are exactly as those used in *AEO2006*.[b] The TMY System Load Reference Case and alternative growth scenarios are as described in the utility impact analysis of the TSD (Chapter 13). DOE derived the environmental impacts of the adopted standard using the same higher decrement, double-decrement approach described in the utility impact analysis.

As in the utility impact analysis, DOE substituted the default NEMS system load with a system load that represents weather conditions for a TMY—here referred to as the TMY system load. As a result, the reference case used to judge the impacts from a adopted distribution transformer standard is no longer an exact replication of the *AEO2006* Reference Case and is therefore referred to as the TMY System Load Reference Case.

The EA also includes a sensitivity analysis for the adopted standard level, using the High and Low Economic Growth scenarios of NEMS-BT. As described in Chapter 13 of the TSD, these scenarios cover a range of macro-economic growth assumptions.

4.2.2 Methods

***CO_2*.** The NEMS-BT tracks CO_2 emissions using a detailed CO_2 module that features broad coverage of all sectors and includes interactive effects. Past experience with NEMS-generated CO_2 emissions suggests estimates are somewhat lower than estimates based on simple average factors. One of the reasons for this divergence is that NEMS tends to predict that conservation displaces more-efficient generating capacity in the later years of its forecast.

***Power Sector NO_x and Hg*.** The NEMS-BT reports the two airborne pollutant emissions that DOE has considered in past analyses, SO_2 and NO_x and now also reports Hg emissions. The NEMS-BT estimates NO_x and Hg emissions from power generation by assuming that the power sector conforms to all pre-2005 legislation and regulations with respect to monitoring power facility development, retrofitting, and dispatch, including potential installations of emissions-

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[b] While the *AEO2007* electricity price forecast data was available in time for preparation of this final rule, the full *AEO2007* forecast was not available at the time DOE performed the utility and environmental impact analysis. DOE therefore used *AEO2006* for the utility and environmental analysis. Following completion of the utility and environmental analysis and after the full *AEO 2007* became available, DOE compared the *AEO2006* and *AEO2007* and found the forecasts of electricity prices, the marginal generation mix and emissions factors in the AEO2007 and *AEO2006* forecasts were very similar. The two forecasts provide the same marginal fractions of coal and natural gas generation (within 3.5%), and have marginal CO2 emission factors that differ by less than 2%. DOE provides details of the *AEO2006* and *AEO2007* comparison in Chapter 13 of the TSD

reducing equipment (i.e., scrubbers). Three recent regulatory actions adopted by the EPA—regarding (1) regulations and guidelines for best-available retrofit technology determinations, (2) the reduction of interstate transport of fine particulate matter and ozone—are tending toward further NO_x reductions and has lead to an emissions cap on NO_x for the Eastern United States. 69 FR 25184 (May 5, 2004), 69 FR 32684 (June 10, 2004), and 70 FR 25162 (May 12, 2005), and (3) the recent promulgation of the mercury emissions rule has resulted in a cap on Hg emissions 70 FR 28606 (May 18, 2005). As with SO_2 emissions, a cap on NO_x and Hg emissions will likely result in no physical emissions effects from equipment efficiency standards. Because NO_x and Hg have been regulated with emissions caps, and no emissions reductions are reported from the NEMS-BT forecast model, DOE does not report NO_x and Hg results here.

Power Sector SO_2. As explained above, accurate simulation of SO_2 trading tends to imply that physical emissions effects will be zero, as long as emissions are at the allowed ceiling. Because SO_2 has been regulated with emissions caps for more than a decade, and no emissions reductions are reported from the NEMS-BT forecast model, DOE does not report SO_2 results here.

Fuel-Cycle Emissions. Fuel-cycle emissions refer to the emissions associated with the amount of energy used in the upstream production and downstream consumption of electricity, including energy used at the power plant. Upstream processes include the mining of coal or extraction of natural gas, physical preparatory and cleaning processes, and transportation to the power plant. he NEMS-BT does a thorough accounting of emissions at the power plant due to downstream energy consumption, but does not account for upstream emissions (i.e., emissions from energy losses during coal and natural gas production). Thus, this EA reports only power plant emissions.

Interpolation. Because the energy savings from distribution transformer standards are too small to produce stable power sector results in NEMS-BT, DOE estimated results for the TSLs using interpolation. To run a simulation in NEMS-BT, the system electricity load and commercial demand use are reduced annually according to the energy savings estimated by the national energy savings (NES) Spreadsheet Model (see Chapter 10 of the TSD) for each TSL. These energy savings increase over time. The magnitude of the energy decrement that would be required for NEMS-BT to produce stable results out of the range of numerical noise is greater than the highest standard level under consideration. Therefore, to estimate results for the TSLs considered here, DOE carried out a series of NEMS-BT runs using higher values for the input energy savings. These runs established the relationship between the NEMS-BT outputs (e.g., installed capacity reductions, emissions reductions) and the energy savings inputs. DOE then obtained results for energy savings corresponding to the TSLs using linear interpolation.

DOE then used the estimated reduction in total fuel generation at each TSL, as determined by interpolation, to determine emissions savings. First, it calculated annual marginal emissions rates for each of the simulations in each standard level, based on the actual output from NEMS-BT. Marginal emissions rates incorporate both effects of the standards—the emissions saved by the reduction in total generation, and the slight change in the emissions characteristics of the whole power sector that result from the slight change in dispatch and capacity expansion plan. The net effect on the entire system is very small and, typically, the overall effect on emissions can be fully attributed to the reduced generation capacity. DOE could then determine annual marginal emissions rates at the trial standard level from these rates (at multipliers of the TSL savings), by taking a simple average.

Extrapolation. The current time horizon of NEMS-BT is 2030 (modeling a 20-year period, 2010–2030); however, other parts of the distribution transformer rulemaking analysis extend to 2038. It is not feasible to extend the forecast period of NEMS-BT for the purposes of this analysis nor does DOE/EIA have an approved method for extrapolation of many outputs beyond 2030. While it might seem reasonable in general to make simple linear extrapolations of results, in practice this is not advisable because outputs could be contradictory. For example, changes in the fuel mix implied by extrapolations of those outputs could be inconsistent with the extrapolation of marginal emissions factors. An analysis of various trends sufficiently detailed to guarantee consistency is beyond the scope of this work, and, in any case, would involve a great deal of uncertainty. Therefore, all extrapolations beyond 2030 are simple replications of year 2030 results. While these may seem unreasonable in some instances, in this way results are guaranteed to be consistent. As with the AEO Reference Case in general, the implicit assumption is that the regulatory environment does not deviate from the current known situation during the extrapolation period. Only changes that have been announced with date-certain introduction are included in NEMS-BT. To emphasize the extrapolated results wherever they appear, they are shaded in grey to distinguish them from actual NEMS-BT results.

4.3 Socioeconomics

As part of the rulemaking process, DOE evaluated the socioeconomic effect on small businesses, especially small manufacturers, a subgroup that DOE identified as possibly being disproportionately affected by a national standard level. Converting from a company's current basic product line involves designing, prototyping, testing, and manufacturing a new product. These tasks have associated capital investments and product conversion expenses. Small businesses, because of their limited access to capital and their need to spread product conversion expenses over smaller production volumes, may be affected more negatively than major manufacturers by an energy-conservation standard. For these reasons, DOE specifically evaluated the impacts on small businesses from an energy-conservation standard. Chapter 12 of the TSD provides more details on the manufacturer subgroup analysis.

4.4 Environmental Justice

According to Executive Order 12898 of February 11, 1994, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," 59 FR 7629 (February 16, 1994), DOE is required to examine the effect of more stringent energy efficiency standards on (1) small businesses that either manufacture or use distribution transformers, (2) manufacturers of niche products related to distribution transformers, and (3) small businesses operated by disadvantaged or minority populations.

Regarding users of distribution transformers, small businesses are included as part of the overall population examined by DOE in the LCC analysis. The results of that analysis estimated that between 26 and 61 percent of distribution transformer customers would experience positive economic impacts from the proposed standard.

Small distribution transformer manufacturing enterprises, as defined by the Small Business Administration, are those with no more than 750 employees. DOE identified and interviewed six small manufacturers of distribution transformers, five of which produce medium-voltage, dry-type transformers and one of which produces liquid-immersed transformers. Because the liquid-immersed distribution transformer industry largely produces customized transformers, small businesses can compete because each unique design is produced in relatively small volumes for a given customer's order. Implementation of an energy conservation standard would have a relatively minor differential impact on small manufacturers of liquid-immersed distribution transformers.

Because of the potential impacts of a standard on manufacturers of the medium-voltage, dry-type transformers, DOE determined that it cannot certify that the proposed rule (TSL2), if promulgated, would have no significant economic impact on a substantial number of small entities. Because DOE cannot certify this, due to the potential impacts on medium-voltage, dry-type manufacturers, it prepared an initial regulatory flexibility analysis (IRFA) for this rulemaking, which can be found in section VI.B of the NOPR. For additional information on this subject, see also section V.B.2.b of the NOPR and the manufacturer impact analysis (MIA) in Chapter 12 of the TSD.

DOE did not conduct a separate analysis to assess the impacts of a new standard on niche product manufacturers because it found no niche products for which the adoption of a new standard would raise special considerations.

DOE's LCC subgroup analysis (TSD Chapter 11) did not include small or disadvantaged businesses or populations as a subgroup. However, DOE believes that there are no disproportionately high and adverse human health or environmental effects on minority populations, and low-income populations resulting from more stringent energy efficiency standards. Positive impacts, such as decreased air emissions, would be equally shared among all populations.

The MIA (TSD Chapter 12), and the regulatory impact analysis (published with the TSD) examined impacts on various business populations. However, DOE received no data concerning differential impacts on businesses owned by minority or disadvantaged populations.

4.5 Energy Consumption

DOE used a detailed shipments and NES Spreadsheet Model to determine national energy savings as a result of increases in the minimum efficiency standard. This spreadsheet model forecasts the national shipments and energy use of distribution transformers with and without new standards. The shipments and NES analyses are described in detail in TSD Chapters 9 and 10, respectively.

4.6 Noise and Aesthetics

DOE considered how new energy conservation standards for distribution transformers may affect the noise and aesthetics of the equipment. To improve the efficiency of distribution transformers, increased amounts of heavier materials (e.g., steel) may be used that can enlarge the size of the equipment. DOE reviewed these components to determined if noise and aesthetics were impacted. DOE determined that the adopted standard would result in less than 10% increase in the volume distribution transformers and that the higher efficiency transformers are likely to have the same noise characteristics as existing transformers. Therefore, DOE estimates that there will be no significant impact on noise and aesthetics from the adopted standard.

5.0 ENVIRONMENTAL IMPACTS

5.1 Air Quality/Emissions Impacts

5.1.1 Power Sector Emissions

The results for the environmental analysis are similar to a complete NEMS run as published in the *AEO2006*, and include power sector emissions for CO_2 in five-year forecast increments, extrapolated to the year 2038. DOE reports the outcome of the analysis for each TSL as a deviation from the TMY System Load Reference Case. This is also referred to as the base case.

As discussed in section 4.2, the Clean Air Act Amendments of 1990 set an SO_2 emissions cap on all power generation, but permitted flexibility among generators through the use of emissions allowances and tradable permits. Similar rules provide power sector emissions caps on NO_X and Hg. Moreover, emissions trading implies that physical emissions effects of a standard will be zero because emissions will always be at, or near, the ceiling. Consequently, there is virtually no physical emissions reduction benefit for these pollutants from electricity conservation as long as there is enforcement of the emissions ceiling. Even though there is no physical environmental benefit from adopted standards, there are potential environmental economic benefits. Given reduced demand for coal generation, there is reduced demand for emission allowances and this may lower the allowance price and traded allowance volume. For these reasons, DOE's emissions reduction forecast from NEMS-BT indicated no significant emissions reductions from the adopted standard for SO_2, NO_X and Hg. Thus, DOE did not report these quantities.

Tables EA.11 through EA.15 show annual total power sector CO$_2$ emissions for the various distribution transformer TSLs for each superclass. The liquid-immersed class considers 10 TSLs while the medium-volgate, dry-type class considers six TSLs. Annual CO$_2$ emissions reductions are the highest for liquid-immersed TSL 6 and are the lowest for medium-voltage, dry-type TSL 1. Tables EA.16 through EA.18 show the results for the cumulative emissions reductions through 2030 and 2038 for CO$_2$.

The results for the Low and High Economic Growth cases for the adopted standard of each product class are also shown in Tables EA.16 through EA.18. The differences between the reference and sensitivity cases are due to changes in the macroeconomic assumptions of NEMS-BT.

Reference Economic Growth

Table EA.11 Liquid Immersed Power Sector Emissions

		NEMS-BT Results											
	Emission	**2010**	**2015**	**2020**	**2025**	**2030**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2038**
						AEO2006 Reference Case with TMY System Load							
	CO$_2$ (Mt/a)[1,3]	2537.0	2672.0	2848.0	3038.0	3334.0						*Extrapolation*	
						Trial Standard Level							
1.0	CO$_2$ (Mt/a)	2537.0	2670.3	2845.1	3036.2	3325.9	0	-1.7	-2.9	-1.8	-8.1	-8.1	-8.1
2.0	CO$_2$ (Mt/a)	2537.0	2669.6	2843.9	3035.5	3322.6	0	-2.4	-4.1	-2.5	-11.4	-11.4	-11.4
3.0	CO$_2$ (Mt/a)	2537.0	2668.6	2842.2	3034.4	3318.0	0	-3.4	-5.8	-3.6	-16.0	-16.0	-16.0
4.0	CO$_2$ (Mt/a)	2537.0	2668.3	2841.6	3034.1	3316.5	0	-3.7	-6.4	-3.9	-17.5	-17.5	-17.5
5.0	CO$_2$ (Mt/a)	2537.0	2665.7	2837.1	3031.3	3304.1	0	-6.3	-10.9	-6.7	-29.9	-29.9	-29.9
6.0	CO$_2$ (Mt/a)	2537.0	2662.8	2832.2	3028.3	3290.6	0	-9.2	-15.8	-9.7	-43.4	-43.3	-43.3
A	CO$_2$ (Mt/a)	2537.0	2667.0	2839.3	3032.7	3310.2	0	-5.0	-8.7	-5.3	-23.8	-23.8	-23.8
B	CO$_2$ (Mt/a)	2537.0	2668.6	2842.1	3034.4	3317.8	0	-3.4	-5.9	-3.6	-16.2	-16.2	-16.2
C	CO$_2$ (Mt/a)	2537.0	2668.8	2842.4	3034.6	3318.7	0	-3.2	-5.6	-3.4	-15.3	-15.3	-15.3
D	CO$_2$ (Mt/a)	2537.0	2669.3	2843.3	3035.1	3321.2	0	-2.7	-4.7	-2.9	-12.8	-12.8	-12.8

[1] Comparable to Table A17 of AEO2006: Electric Generators

[2] Comparable to Table A8 of AEO2006: Emissions

[3] All results in metric tons (t), equivalent to 1.1 short tons

Table EA.12 Dry Type Power Sector Emissions

		NEMS-BT Results											
	Emission	**2010**	**2015**	**2020**	**2025**	**2030**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2038**
		AEO 2006 Reference Case with TMY System Load											
	CO_2 (Mt/a)[13]	2537.0	2672.0	2848.0	3038.0	3334.0						*Extrapolation*	
		Trial Standard Level											
1	CO_2 (Mt/a)	2537.0	2671.9	2847.9	3037.9	3333.6	0.0	-0.1	-0.1	-0.1	-0.4	-0.4	-0.4
2	CO_2 (Mt/a)	2537.0	2671.8	2847.7	3037.8	3333.2	0.0	-0.2	-0.3	-0.2	-0.8	-0.8	-0.8
3	CO_2 (Mt/a)	2537.0	2671.8	2847.6	3037.8	3332.9	0.0	-0.2	-0.4	-0.2	-1.1	-1.1	-1.1
4	CO_2 (Mt/a)	2537.0	2671.6	2847.3	3037.6	3332.0	0.0	-0.3	-0.6	-0.4	-1.6	-1.6	-1.6
5	CO_2 (Mt/a)	2537.0	2671.5	2847.1	3037.5	3331.6	0.0	-0.5	-0.9	-0.5	-2.4	-2.4	-2.4
6	CO_2 (Mt/a)	2537.0	2671.5	2847.1	3037.5	3331.6	0.0	-0.5	-0.9	-0.5	-2.4	-2.4	-2.4

[1] Comparable to Table A17 of AEO2006: Electric Generators
[2] Comparable to Table A8 of AEO2006: Emissions
[3] All results in metric tons (t), equivalent to 1.1 short tons

Low Economic Growth Power Sector Emissions

Table EA.13 Liquid Immersed Low Economic Growth Power Sector Emissions

		NEMS-BT Results											
	Emission	**2010**	**2015**	**2020**	**2025**	**2030**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2038**
		AEO 2006 Low Growth Case with TMY System Load											
	CO_2 (Mt/a)[1,3]	2491.0	2601.0	2711.0	2828.0	2989.0						*Extrapolation*	
		Trial Standard Level											
1	CO_2 (Mt/a)	2491.0	2599.9	2709.0	2824.8	2984.7	0.0	-1.1	-2.0	-3.2	-4.3	-4.3	-4.3
2	CO_2 (Mt/a)	2491.0	2599.4	2708.2	2823.5	2983.0	0.0	-1.6	-2.8	-4.5	-6.0	-6.0	-6.0
3	CO_2 (Mt/a)	2491.0	2598.8	2707.1	2821.7	2980.5	0.0	-2.2	-3.9	-6.3	-8.5	-8.5	-8.5
4	CO_2 (Mt/a)	2491.0	2598.6	2706.7	2821.1	2979.7	0.0	-2.4	-4.3	-6.9	-9.3	-9.3	-9.3
5	CO_2 (Mt/a)	2491.0	2596.9	2703.7	2816.3	2973.1	0.0	-4.1	-7.3	-11.7	-15.9	-15.9	-15.9
6	CO_2 (Mt/a)	2491.0	2595.0	2700.4	2811.0	2965.9	0.0	-6.0	-10.6	-17.0	-23.1	-23.0	-23.0
A	CO_2 (Mt/a)	2491.0	2597.7	2705.2	2818.7	2976.4	0.0	-3.3	-5.8	-9.3	-12.6	-12.6	-12.6
B	CO_2 (Mt/a)	2491.0	2598.8	2707.1	2821.7	2980.4	0.0	-2.2	-3.9	-6.3	-8.6	-8.6	-8.6
C	CO_2 (Mt/a)	2491.0	2598.9	2707.3	2822.0	2980.9	0.0	-2.1	-3.7	-6.0	-8.1	-8.1	-8.1
D	CO_2 (Mt/a)	2491.0	2599.2	2707.9	2823.0	2982.2	0.0	-1.8	-3.1	-5.0	-6.8	-6.8	-6.8

[1] Comparable to Table A17 of AEO2006: Electric Generators
[2] Comparable to Table A8 of AEO2006: Emissions
[3] All results in metric tons (t), equivalent to 1.1 short tons

Table EA.14 Dry Type Low Economic Growth Power Sector Emissions

		NEMS-BT Results											
	Emission	**2010**	**2015**	**2020**	**2025**	**2030**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2038**
						AEO2006 Low Growth Case with TMY System Load							
	CO_2 (Mt/a)[1,3]	2491.0	2601.0	2711.0	2828.0	2989.0						*Extrapolation*	
						Trial Standard Level							
1	CO_2 (Mt/a)	2491.0	2600.9	2710.9	2827.9	2988.8	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2
2	CO_2 (Mt/a)	2491.0	2600.9	2710.8	2827.7	2988.6	0.0	-0.1	-0.2	-0.3	-0.4	-0.4	-0.4
3	CO_2 (Mt/a)	2491.0	2600.8	2710.7	2827.6	2988.4	0.0	-0.2	-0.3	-0.4	-0.6	-0.6	-0.6
4	CO_2 (Mt/a)	2491.0	2600.7	2710.5	2827.2	2988.0	0.0	-0.2	-0.4	-0.6	-0.8	-0.8	-0.8
5	CO_2 (Mt/a)	2491.0	2600.7	2710.4	2827.1	2987.7	0.0	-0.3	-0.6	-0.9	-1.3	-1.3	-1.3
6	CO_2 (Mt/a)	2491.0	2600.7	2710.4	2827.1	2987.7	0.0	-0.3	-0.6	-0.9	-1.3	-1.3	-1.3

[1] Comparable to Table A17 of AEO2006: Electric Generators

[2] Comparable to Table A8 of AEO2006: Emissions

[3] All results in metric tons (t), equivalent to 1.1 short tons

High Economic Growth Power Sector Emissions

Table EA.15 Liquid Immersed High Economic Growth Power Sector Emissions

		NEMS-BT Results											
	Emission	**2010**	**2015**	**2020**	**2025**	**2030**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2038**
						AEO2006 High Growth Case with TMY System Load							
	CO_2 (Mt/a)[1,3]	2586.0	2764.0	3041.0	3339.0	3697.0						*Extrapolation*	
						Trial Standard Level							
1	CO_2 (Mt/a)	2586.0	2762.1	3035.9	3333.2	3688.3	0.0	-1.9	-5.1	-5.8	-8.7	-8.7	-8.7
2	CO_2 (Mt/a)	2586.0	2761.4	3033.8	3330.8	3684.8	0.0	-2.6	-7.2	-8.2	-12.2	-12.2	-12.2
3	CO_2 (Mt/a)	2586.0	2760.3	3030.8	3327.5	3679.8	0.0	-3.7	-10.2	-11.5	-17.2	-17.2	-17.2
4	CO_2 (Mt/a)	2586.0	2759.9	3029.9	3326.4	3678.2	0.0	-4.1	-11.1	-12.6	-18.8	-18.8	-18.8
5	CO_2 (Mt/a)	2586.0	2757.1	3022.0	3317.5	3664.9	0.0	-6.9	-19.0	-21.5	-32.1	-32.0	-32.0
6	CO_2 (Mt/a)	2586.0	2753.9	3013.4	3307.8	3650.5	0.0	-10.1	-27.6	-31.2	-46.5	-46.5	-46.5
A	CO_2 (Mt/a)	2586.0	2758.5	3025.9	3321.9	3671.5	0.0	-5.5	-15.1	-17.1	-25.5	-25.5	-25.5
B	CO_2 (Mt/a)	2586.0	2760.3	3030.7	3327.4	3679.6	0.0	-3.7	-10.3	-11.6	-17.4	-17.4	-17.4
C	CO_2 (Mt/a)	2586.0	2760.5	3031.3	3328.0	3680.6	0.0	-3.5	-9.7	-11.0	-16.4	-16.4	-16.4
D	CO_2 (Mt/a)	2586.0	2761.0	3032.9	3329.8	3683.2	0.0	-3.0	-8.1	-9.2	-13.8	-13.8	-13.8

[1] Comparable to Table A17 of AEO2006: Electric Generators

[2] Comparable to Table A8 of AEO2006: Emissions

[3] All results in metric tons (t), equivalent to 1.1 short tons

Table EA.16 Dry Type High Economic Growth Power Sector Emissions

	NEMS-BT Results											
	Emission	**2010**	**2015**	**2020**	**2025**	**2030**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2038**
	AEO2006 High Growth Case with TMY System Load												
	CO_2 (Mt/a)[1,3]	2586.0	2764.0	3041.0	3339.0	3697.0						*Extrapolation*	
	Trial Standard Level												
1	CO_2 (Mt/a)	2586.0	2763.9	3040.8	3338.7	3696.6	0.0	-0.1	-0.2	-0.3	-0.4	-0.4	-0.4
2	CO_2 (Mt/a)	2586.0	2763.8	3040.5	3338.4	3696.2	0.0	-0.2	-0.5	-0.6	-0.8	-0.8	-0.8
3	CO_2 (Mt/a)	2586.0	2763.7	3040.3	3338.2	3695.8	0.0	-0.3	-0.7	-0.8	-1.2	-1.2	-1.2
4	CO_2 (Mt/a)	2586.0	2763.5	3039.7	3337.6	3694.9	0.0	-0.4	-1.0	-1.2	-1.7	-1.7	-1.7
5	CO_2 (Mt/a)	2586.0	2763.4	3039.5	3337.3	3694.4	0.0	-0.6	-1.5	-1.7	-2.6	-2.6	-2.6
6	CO_2 (Mt/a)	2586.0	2763.4	3039.5	3337.3	3694.4	0.0	-0.6	-1.5	-1.7	-2.6	-2.6	-2.6

[1] Comparable to Table A17 of AEO2006: Electric Generators
[2] Comparable to Table A8 of AEO2006: Emissions
[3] All results in metric tons (t), equivalent to 1.1 short tons

Cumulative Power Sector Emission Impacts

Table EA.17 Cumulative Power Sector Emissions Impacts for Liquid-Immersed Transformers

Trial Standard Level	Emission	Reference		Low Economic Growth		High Economic Growth	
		2000-2030	2000-2038	2000-2030	2000-2038	2000-2030	2000-2038
1	CO_2 (Mt/a)	-60.9	-125.7	-47.1	-81.6	-88.2	-157.7
2	CO_2 (Mt/a)	-85.5	-176.4	-66.2	-114.5	-123.8	-221.3
3	CO_2 (Mt/a)	-120.4	-248.4	-93.2	-161.2	-174.3	-311.7
4	CO_2 (Mt/a)	-131.8	-271.9	-102.0	-176.5	-190.8	-341.1
5	CO_2 (Mt/a)	-225.1	-464.0	-174.2	-301.2	-325.8	-582.1
6	CO_2 (Mt/a)	-326.8	-673.6	-252.9	-437.2	-473.0	-845.0
A	CO_2 (Mt/a)	-179.0	-369.2	-138.5	-239.6	-259.1	-463.2
B	CO_2 (Mt/a)	-121.7	-251.1	-94.2	-163.0	-176.2	-315.0
C	CO_2 (Mt/a)	-115.1	-237.6	-89.1	-154.2	-166.7	-298.0
D	CO_2 (Mt/a)	-96.6	-199.3	-74.7	-129.4	-139.8	-250.0

[1] Comparable to Table A17 of AEO2006: Electric Generators
[2] Comparable to Table A8 of AEO2006: Emissions
[3] All results in metric tons (t), equivalent to 1.1 short tons

Table EA.18 Cumulative Power Sector Emissions Impacts for Dry-Type Transformers

Trial Standard Level	Emission	Reference		Low Economic Growth		High Economic Growth	
		2000-2030	2000-2038	2000-2030	2000-2038	2000-2030	2000-2038
1	CO_2 (Mt/a)	-2.8	-5.8	-2.2	-3.8	-4.1	-7.4
2	CO_2 (Mt/a)	-5.7	-11.8	-4.4	-7.6	-8.4	-15.0
3	CO_2 (Mt/a)	-8.3	-17.1	-6.4	-11.0	-12.0	-21.6
4	CO_2 (Mt/a)	-12.0	-24.8	-9.2	-16.0	-17.5	-31.4
5	CO_2 (Mt/a)	-17.9	-36.9	-13.7	-23.8	-26.0	-46.7
6	CO_2 (Mt/a)	-17.9	-36.9	-13.7	-23.8	-26.0	-46.7

[1] Comparable to Table A17 of AEO2006: Electric Generators
[2] Comparable to Table A8 of AEO2006: Emissions
[3] All results in metric tons (t), equivalent to 1.1 short tons

5.1.2 Discounted Emissions

Table EA.19 provides DOE's estimate of cumulative power sector CO_2 for an uncapped emissions scenario for the TSLs considered in this rulemaking. Because of the Clean Air Interstate Rule (CAIR), which the EPA issued on March 10, 2005, will permanently cap emissions of NO_X in 28 eastern states and the District of Columbia. 70 FR 25162 (May 12, 2005). As with sulfur dioxide emissions, for which a cap was previously in place, a cap on NO_X emissions means that equipment efficiency standards may have no physical effect on these emissions. Similarly emissions of Hg for the power sector are also subject to emissions caps during the evaluation period, so that distribution transformer standards may similarly result in no physical effect on these emissions. DOE evaluated the emissions forecasts from AEO2006 and found that because of these new regulations capped most power sector NO_X and Hg emissions, decreasing energy use from the adopted standard would not have any physical emissions reduction effects. The economic effects of emissions reductions are included in the forecasted projection of electricity prices and thus are included in DOE's NPV analysis, but are not reported separately.

DOE also calculated discounted values for future emissions, using the same seven-percent and three-percent real discount rates that it used in calculating the NPV. Table EA.19 also shows the discounted cumulative emissions impacts for both liquid-immersed and dry-type, medium-voltage transformers.

Table EA.19 Discounted CO_2 Emissions Reductions of the Trial Standard Levels by Design Line (in millions of metric tons)

Distribution Transformers	**Discount Rate %**	**Trial Standard Level**									
		1 (TP 1)	**2**	**3**	**4**	**5**	**6**	**A**	**B**	**C**	**D**
Liquid-Immersed	0	125	176	248	272	464	674	369	251	238	199
	3	62	87	123	135	230	334	183	124	118	99
	7	27	38	53	59	100	145	80	54	51	43
Dry-Type	0	5.8	11.8	17.1	24.8	36.9	36.9				
	3	2.9	5.8	8.5	12.3	18.3	18.3				
	7	1.2	2.5	3.7	5.3	8.0	8.0				

5.1.3 Fuel-Cycle Emissions

As discussed earlier, fuel-cycle emissions refer to the emissions associated with the amount of fuel used in the upstream production of electricity and downstream consumption of electricity, including energy used at the power plant. The amount of energy used to perform the upstream processes, such as natural gas production, is not linked to the downstream consumption of electricity attributed to natural gas. For this reason, changes in upstream emissions due to adopted standards are not counted in NEMS-BT. Although DOE does not report actual estimates of the effects of standards on upstream emissions, the emissions factors described here provide the reader with a sense of the possible magnitude of the effects.

Estimates of upstream emissions for CO_2 and NO_x are taken from a study in 1993 by Mark A. DeLuchi (sometimes spelled DeLucci), Ph. D., at Argonne National Laboratory. Dr. DeLuchi provides estimates of full fuel-cycle emissions factors for CO_2, CH_4, carbon monoxide (CO), non-methane organic compounds (NMOC), and NO_x from coal and natural gas production.[10] The emission factor for SO_2 is taken from the EPA Report AP-42, *Compilation of Air Pollutant Emission Factors*.[11] The EPA AP-42 report notes that coal-cleaning is the primary source for upstream SO_2 emissions from coal production, so the emission factor for SO_2 reflects only the coal-cleaning process. Transportation of coal is not addressed in EPA's study.

Emission factor estimates and corresponding percentages of contributions of upstream emissions from coal and natural gas production, relative to power plant emissions, are shown in Table EA.20 for CO_2, SO_2, and NO_x. The percentage relative to power plant emissions provides a means to estimate upstream emission savings based on the savings from the power plant. The values shown in Table EA.20 represent emissions from upstream processes as mass (g) per deliverable energy to end-use consumers, in gigajoules (GJ).

Table EA.20 Estimated Upstream Emission Factors and Corresponding Percentages of Direct Power Plant Combustion Emissions

	Coal		**Natural Gas**	
	Emission Factor *(g/GJ)*	**% of Combustion Emissions**	**Emission Factor *(g/GJ)***	**% of Combustion Emissions**
CO_2	8,147	2.7	20,000	11.9
SO_2	29.2	0.9	0	0
NO_x	41.7	5.8	153	40

Relative to the entire fuel cycle, Dr. DeLuchi estimates that approximately eight percent, by mass, of emissions from coal production are due to mining, preparation that includes cleaning the coal, and transportation from the mine to the power plant. Transportation emissions include emissions from the fuel used by the mode of transportation that moves the coal from the mine to the power plant. Also, Dr. DeLuchi estimates that approximately 14 percent of emissions from natural gas production result from upstream processes. In view of Table EA.20, this higher loss factor in natural gas production, compared to the emissions factor for coal, is likely due to the higher NO_x contribution. In sum, emissions factors relative to power plant emissions are a relatively small proportion of the energy losses attributable to upstream processes. With the exception of NO_x emissions from natural gas production, upstream emissions are less than 12 percent of power plant emissions.

5.2 Wetlands / Endangered and Threatened Species / Cultural Resources

DOE’s adopted action is not site-specific, nor would it impact land disturbance or use due to distribution transformer placement. Therefore, this action is not expected to affect the quality of wetlands, or threatened or endangered species. Further, this action is not expected to impact cultural resources such as historical or archaeological sites.

5.3 Socioeconomic Impacts

DOE's analysis has shown that the increase in the first cost of purchasing a more efficient distribution transformer at the adopted and alternative standard levels is offset by a reduction in the LCC of owning a more efficient piece of equipment. Although the adopted and alternative standards increase the first cost, the standard levels result in a decrease in LCC (due to reduced energy costs) for many consumers. The precise change in LCC varies by standard level, size, class of transformer, and type of customer. At the adopted standard level, approximately 75 percent of the market is either not affected or realizes LCC savings. For a complete discussion of the LCC impacts on consumers, see Chapter 8 of the TSD

5.4 Environmental Justice Impacts

According to Executive Order 12898 of February 11, 1994, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” DOE is required to examine the effect of more stringent energy-efficiency standards on (1) small businesses that either manufacture or use distribution transformers, (2) manufacturers of niche products related to distribution transformers, and (3) small businesses operated by disadvantaged or minority populations.

Regarding users of distribution transformers, small businesses are included as part of the overall population examined by DOE in the LCC analysis. The results of that analysis estimated that between 25 and 62 percent of distribution transformer customers would experience positive economic impacts from the adopted standard.

Small distribution transformer manufacturing enterprises, as defined by the Small Business Administration, are those with no more than 750 employees.[a] DOE identified and interviewed six small manufacturers of distribution transformers, five of which produce medium-voltage, dry-type transformers and one of which produces liquid-immersed transformers. Because the liquid-immersed distribution transformer industry largely produces customized transformers, small businesses can compete because each unique design is produced in relatively small volumes for a given order. Implementation of an energy conservation standard would have a relatively minor differential impact on small manufacturers of liquid-immersed distribution transformers.

Because of the potential impacts of a standard on manufacturers of the medium-voltage, dry-type superclass, DOE determined that it cannot certify that the adopted rule (TSL2), if promulgated, would have no significant economic impact on a substantial number of small entities. Because DOE cannot certify this, due to the potential impacts on medium-voltage, dry-type manufacturers, it prepared an initial regulatory flexibility analysis (IRFA) for this rulemaking, which can be found in section VI.B of the NOPR. For additional information on this subject, see also section V.B.2.b of the NOPR (71 FR 44356-44408) and the manufacturer impact analysis (MIA) in Chapter 12 of the TSD.

DOE did not conduct a separate analysis to assess the impacts of a new standard on niche product manufacturers because it found no niche products for which the adoption of a new standard would raise special considerations.

DOE's LCC subgroup analysis (TSD Chapter 11) did not include small or disadvantaged businesses or populations as a subgroup. However, DOE believes that there are no disproportionately high and adverse human health or environmental effects on small businesses, minority populations, and low-income populations resulting from more stringent energy-efficiency standards. Positive impacts, such as decreased air emissions, would be equally shared among all populations.

The MIA (TSD Chapter 12), and the regulatory impact analysis (published with the TSD) examined impacts on various business populations. However, DOE received no data concerning differential impacts on businesses owned by minority or disadvantaged populations. DOE requests comment on this issue.

5.5 Energy Consumption Impacts

The adopted standard levels for distribution transformers (TSL C for liquid-immersed and TSL 2 for medium-voltage, dry-type) would result in the national energy savings shown in Table EA.21 and EA.22. Energy savings for the other TSLs are also provided.

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[a] Small Business Administration -http://www.sba.gov/gopher/Financial-Assistance/Defin/defi4.txt (06/24/05)

5.6 Noise and Aesthetics

The adopted action is not likely to affect the sound power levels or sound quality levels associated with distribution transformers. Transformers have no moving parts but do often emit a buzz associated with 60-Hz alternating current. DOE's adopted standard is not expected to materially affect the noise of transformers. Higher-efficiency transformers tend to be larger; however, the efficiencies selected by DOE will not result in significant changes in transformer size nor in any other aesthetic feature. In sum, the noise and aesthetics of the more efficient distribution transformers covered under this EA would be virtually no different from equipment being installed today.

5.7 Summary of Environmental Impacts

Tables EA.22 to EA.24 provide a summary of the analysis results by superclass to aid the reader in the discussion of the benefits and burdens for the different TSLs as well as the no-action alternative.

Table EA.21 Summary of the Analysis Results for Liquid-Immersed Transformers

	No Action	Trial Standard Level									
		1	**2**	**3**	**4**	**5**	**6**	**A**	**B**	**C**	**D**
Cumulative Emission Reductions*											
CO_2 Equivalent (Mt)	0.0	125	176	248	272	464	674	369	251	238	199
Cumulative Primary Energy Saved (quads)*	0.0	1.38	1.94	2.76	3.00	5.07	7.37	4.07	2.75	2.61	2.18
Socioeconomic Impacts – All Consumers											
Transformers with non-negative LCC savings (%) based on underlying DLs	NA	87.9 to 98.6	79.3 to 98.6	81.1 to 98.0	55.7 to 87.6	15.2 to 42.3	0.5 to 15.2	20.4 to 67.6	57.5 to 91.9	57.5 to 97.5	79.3 to 98.6
Payback periods (years), based on underlying DLs	NA	2.3 to 7.8	2.4 to 10.4	2.4 to 11.4	7.8 to 11.4	19.3 to 23.4	21.6 to 52.1	10.6 to 24.7	8.9 to 15.7	4.3 to 15.7	3.6 to 10.4
Environmental Justice Impacts	None	None	None	None	None	None	None	None	None	None	None
Wetlands/Endangered and Threatened Species/Cultural Resources Impacts	None	None	None	None	None	None	None	None	None	None	None
Fuel-Cycle (Upstream) Emissions Impacts	None	**	**	**	**	**	**	**	**	**	**
Noise and Aesthetics Impacts	None	None	None	None	None	None	None	None	None	None	None

* Cumulative total is over a time period starting in 2010 and ending in 2038.

** DOE does not report actual estimates of the effects of standards on upstream emissions, but section 5.1.2 above provides a sense of the possible magnitude of effects.

Table EA.22 Summary of the Analysis Results for Dry-Type, Medium-Voltage Transformers

	No Action	Trial Standard Level					
		1	2 (Adopted Action)	3	4	5	6
Cumulative Emission Reductions*							
CO_2 Equivalent (Mt)	0.0	5.8	11.8	17.1	24.8	36.9	36.9
Cumulative Primary Energy Saved (quads)*	0.0	0.06	0.13	0.19	0.27	0.40	0.40
Socioeconomic Impacts – All Consumers							
Transformers with non-negative LCC savings (%) based on underlying DLs	NA	96.7 to 99.7	84.4 to 98.7	81.5 to 92.6	54.0 to 75.8	21.9 to 63.5	21.9 to 63.5
Payback periods (years), based on underlying DLs	NA	0.5 to 5.0	1.8 to 6.4	3.4 to 7.0	5.9 to 9.6	7.8 to 18.7	7.8 to 18.7
Environmental Justice Impacts	None	None	None	None	None	None	None
Wetlands/Endangered and Threatened Species/Cultural Resources Impacts	None	None	None	None	None	None	None
Fuel-Cycle (Upstream) Emissions Impacts	None	**	**	**	**	**	**
Noise and Aesthetics Impacts	None	None	None	None	None	None	None

* Cumulative total is over a time period starting in 2010 and ending in 2038.

** DOE does not report actual estimates of the effects of standards on upstream emissions, but section 5.1.2 above provides a sense of the possible magnitude of effects.

DOE has adopted energy-efficiency standards for distribution transformers at TSL C for liquid-immersed transformers and TSL 2 for medium-voltage, dry-type transformers. The adopted standards would apply to all covered products offered for sale in the United States and its Territories, with a compliance date of January 1, 2010. The justification for selecting the adopted action, adopting these standard levels over the other TSLs considered, is fully explained in the final rule. The final rule is available on the internet at: http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html under “Final Rule.”

In addition to reducing the secondary energy lost in the distribution transformers themselves, the adopted standards would save even more energy at the electric power plant source, where less primary energy (e.g., oil, coal, or natural gas) directly attributable to the losses from distribution transformers would be burned. Burning less oil, coal, or natural gas reduces greenhouse gas emissions and pollutants, creating a cleaner environment.

In the 28-year period after the new standards become effective, the Nation will save about 2.74 quadrillion British thermal units (quads) of primary energy. Additionally, these energy savings would significantly reduce emissions of air pollutants and greenhouse gases associated with electricity production, by 250 Mt of CO_2. This is equivalent to all the energy consumed by 27 million American households in a single year. Furthermore, the adopted standards would eliminate the need for construction of roughly six new 400-megawatt (MW) power plants by 2038.

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