The attached document, issued on May 29, 2012, provides a supplemental analysis to be addressed during the public meeting concerning the DOE's notice of proposed rulemaking: Energy Conservation Standards for Distribution Transformers, a rulemaking action issued by the DOE. Though it is not intended or expected, should any discrepancy occur between the Notice of Public Meeting and Supplemental Analysis and the document herein, the Federal Register publication controls, including any documents or analysis to which it refers. This document is being made available solely as a means to facilitate the public's access to this document.

APPENDIX 1-A. SUMMARY OF SUPPLEMENTAL POST-NOTICE OF PROPOSED RULEMAKING ANALYSES FOR DISTRIBUTION TRANSFORMERS

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APPENDIX 1-A. SUMMARY OF SUPPLEMENTAL POST-NOTICE OF PROPOSED RULEMAKING ANALYSES FOR DISTRIBUTION TRANSFORMERS

1-A.1 INTRODUCTION

Section 6295(o)(2)(A) of 42 United States Code (U.S.C.) requires the U.S. Department of Energy (DOE) to set forth energy conservation standards that are technologically feasible and economically justified, and would achieve the maximum improvement in energy efficiency. This chapter provides a description of the analysis performed following DOE's Notice of Proposed Rulemaking (NOPR) of February10, 2011.[a] This supplementary analysis builds upon of DOE's NOPR analysis, available on the Distribution Transformers rulemaking webpage: http://www1.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html. DOE announced the availability of this analysis in its notice of public meeting issued May 29, 2012.

In the NOPR and at the public meeting of February 23, 2012, DOE asked for comment on whether certain types of liquid-immersed distribution transformers that are currently part of the same equipment classes warranted separation into distinct equipment classes. For example, pole- and pad-mounted transformers are in the same equipment class and DOE asked for comment on whether they would be more appropriately evaluated as separate equipment classes.

A number of interested parties submitted written comments supporting an approach that separated pole- and pad-mounted liquid-immersed distribution transformers into separate equipment classes. Furthermore, many interested parties also urged DOE to consider separate equipment classes for network and vault distribution transformers, as well as those with basic impulse level (BIL) ratings above 200 kV.

In light of these comments, DOE decided to supplement its NOPR analysis to include several new trial standard levels (TSLs), which consider additional standards scenarios that represent the separate equipment classes that were supported by comments from several interested parties. The new TSLs, lettered "A" through "C," contain separate standards for pole- and pad-mounted distribution transformers, and also incorporate the separation of network- and vault-based distribution transformers and distribution transformers with BIL ratings 200 kV and above into separate equipment classes. The new TSLs relate only to liquid-immersed distribution transformers. No modifications have been made to the dry-type distribution transformers analysis for the purposes of this notice and the public meeting of June 20, 2012.

Furthermore, DOE used these TSLs to supplement certain NOPR analyses, including the life-cycle cost and payback period analysis and provide interested parties with a perspective on

[a] 77 FR 7282.

how separate equipment classes may alter the analytical results presented with the NOPR. This information, as well as the analytical tools from the NOPR, is available on DOE's distribution transformer rulemaking website, located at: http://www1.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html.

1-A.2 BACKGROUND

Since 1997, when DOE initiated the rulemaking process for distribution transformers, DOE has conducted numerous, rigorous analyses, while maintaining a robust public involvement process. For example, as outlined in the February 10, 2011, NOPR, beyond utilizing notice and comment rulemaking, DOE has held many public meeting and webinars. DOE has extensively documented these efforts on its website at:

http://www1.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html.

In addition, DOE engaged a broad array of interested parties in negotiations of its proposed standards for the energy efficiency of distribution transformers through establishment of a subcommittee under the Energy Efficiency and Renewable Energy Advisory Committee (ERAC), in accordance with the Federal Advisory Committee Act and the Negotiated Rulemaking Act. 77 FR 7792-7793. The subcommittee negotiated about three types of distribution transformers: low-voltage dry-type; medium-voltage dry-type; and medium-voltage liquid-immersed. While there was a consensus on medium-voltage dry-type distribution transformers, for the other two types, there was no consensus, though considerable data was generated during these discussions for use in the current supplemental analyses. Of these three, however, this TSD focuses upon and medium-voltage liquid-immersed distribution transformers, as further detailed below.[b]

Based on the negotiation process and additional public comment, DOE issued its NOPR. In the NOPR DOE presented analysis based on a certain equipment class structure, in which liquid-immersed distribution transformers were distinguished only by their phase count and kVA rating. The new equipment class structure further distinguishes these transformers by tank type, with separate consideration for liquid-immersed distribution transformers with tanks designed for network use or mounting on pads, poles, or in vaults.

DOE received numerous comments regarding the NOPR. Of importance to the current supplemental analysis was DOE's question number 12 regarding whether "separate equipment classes (EC) are warranted for pole-mounted, pad-mounted or other types of liquid-immersed

[b] Transcripts of the subcommittee meetings, the names of the participants, and all data and materials presented at the subcommittee meetings are available at the DOE website at: http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html.

transformers." 77 FR at 7378. A coalition of interested parties (Advocates)[c] in their NOPR comments of 4/10/12, implied that DOE should consider: (1) separate ECs for pad- and pole-mounted equipment at EL 1.5 (pads) and EL 0.5 (poles) (*Id*. at p. 13); and (2) urged DOE to examine a new trial standard level (TSL) 3.5, which would "correspond to efficiency level (EL) 1.5" for all medium-voltage liquid-immersed (MVLI) transformer classes *(Id.* at p. 9). Furthermore, Advocates joined these issues by stating "if DOE were to set a standard at the levels we suggest (modified TSL 4)" (e.g., a new TSL 3.5) "then we would be open to establishing a separate class product class for pole-mounted transformers" (*Id*. at p. 13). Other interested parties, including the Edison Electric Institute and National Electrical Manufacturers Association, support the concept of creating new ECs for polls and pads, but do not want resolution of this issue to delay issuance of the final rule beyond the 10/01/12 deadline. In addition their support is contingent on their ability to "evaluate" the proposal.[d]

Following publication of the NOPR, DOE began analyzing the comments, including those raised by the Advocates and others. In light of these comments taken as a whole, DOE presents a supplemental analysis and is providing additional time for notice and comment on the issues discussed in this TSD.

1-A.3 REVISED EQUIPMENT CLASSES

DOE divides covered equipment into classes by: (a) the type of energy used; (b) the capacity; or (c) any performance-related features that affect consumer utility or efficiency. (42 U.S.C. 6295(q)) Different energy efficiency standards may apply to different equipment classes. In this document DOE presents an expansion of the 10 equipment classes in the NOPR analysis to 14 equipment classes and increase in the TSLs considered in the NOPR from 7 to 10, as explained in detail in section 1-A.4 below. First, this supplemental analysis expands the equipment classes by dividing the population of distribution transformers according to:

a) Type of transformer insulation - liquid-immersed or dry-type,
b) Number of phases - single or three,
c) Voltage class - low or medium (for dry-type units only),
d) Basic impulse insulation (BIL) level (for medium-voltage, dry-type and liquid-immersed and units only) and
e) Tank type: pad, pole, network/vault (for liquid-immersed units only).

DOE understands that distribution transformers may be manufactured with a wide variety of tank types, depending on the specific requirements of their purchasers. The tanks provide different utility to the consumer in the form of protection and containment, and also affect the

[c] The individual members of this coalition include American Council for an Energy-Efficient Economy (ACEEE), Appliance Standards Awareness Project (ASAP), National Resources Defense Council (NRDC) and Northwest Power Conservation Council (NPCC). Docket comment No 186

[d] EEI sought to review such ELs for technical and economic feasibility and questioned whether this could be better accomplished in a new rulemaking. NEMA said that if DOE decides to raise the levels higher, the notion of separate classes "will need to be studied and evaluated."

ability of a distribution transformer to be made more efficient. For these reasons, DOE is considering establishing equipment classes by tank type.

"Pole-mounted" transformers[e] are designed for mounting on vertical poles and out of easy reach. Relative to other distribution transformer types, pole-mounted transformers are required to be compact and lightweight to be safely mounted by their poles. They most often have round tanks. Furthermore, three-phase pole mounted units are ordinarily constructed by triplexing three, single-phase cores. For this reason, DOE believes it is appropriate for a three-phase pole-mounted transformer to receive the same standard as that of a single-phase pole-mounted transformer of one third of its kVA rating.

"Pad-mounted" transformers[f] are designed for mounting on (e.g.) concrete pads. Though they may have added levels of protection to prevent tampering or electrical shock, pad-mounted transformers have fewer of the size and weight concerns that pole-mounted transformers experience and, therefore, see lower incremental costs for added efficiency.

"Network[g]" and "Vault" transformers are designed for use in vaults and for occasional submerged operation which requires that they be built to a much higher level of ruggedness and durability. Furthermore, compactness is of utmost importance because the vaults themselves are frequently in dense urban environments where expanding a vault to accommodate a larger, more-efficient unit could be done only at great cost that would far outweigh any savings in operating cost.

Equipment classes are discussed in greater detail in chapter 3, section 3.4 of the NOPR TSD.

Second, regarding TSLs, the newly presented TSLs provide for different stringency levels for above-mentioned tank types, so that a standard may pursue maximum energy savings where it is economically justified to do so without risk of harming the utility of certain equipment types.

DOE presented analysis for liquid-immersed distribution transformer equipment classes for the NOPR and NOPR public meeting, these equipment classes separated the liquid-immersed design-space by transformer service type, either single or three-phase (Table 1-A.3.1). DOE requested and received comment on further refinements of the liquid-immersed design space. Based on these comment DOE proposes to modify the existing liquid-immersed equipment classes to separate pole and pad mounted distribution transformers and to include additional equipment classes for network/vault, and distribution transformers with greater than 200 kV BIL.[h]

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[e] Perhaps as specified in IEEE standard C57.12.20

[f] Perhaps as specified in IEEE standards C57.12.38 and C57.12.34

[g] Perhaps as specified in IEEE standard C57.12.40

Perhaps as specified in IEEE standards C57.12.23 or C57.12.24

[h] Basic Impulse Level

Table 1-A.3.1 Equipment Classes for Liquid-immersed Distribution Transformers Presented in the Notice of Proposed Rulemaking

EC	DL	Type of Distribution Transformer	kVA Range	Representative Unit for this Engineering Design Line
1	1	Liquid-immersed, single-phase, rectangular tank	10–167	50 kVA, 65°C, single-phase, 60Hz, 14400V primary, 240/120V secondary, rectangular tank, 95kV BIL
	2	Liquid-immersed, single-phase, round tank	10–167	25 kVA, 65°C, single-phase, 60Hz, 14400V primary, 120/240V secondary, round tank, 125 kV BIL
	3	Liquid-immersed, single-phase	250–833	500 kVA, 65°C, single-phase, 60Hz, 14400V primary, 277V secondary, 150kV BIL
2	4	Liquid-immersed, three-phase	15–500	150 kVA, 65°C, three-phase, 60Hz, 12470Y/7200V primary, 208Y/120V secondary, 95kV BIL
	5	Liquid-immersed, three-phase	750–2500	1500 kVA, 65°C, three-phase, 60Hz, 24940GrdY/14400V primary, 480Y/277V secondary, 125 kV BIL

1-A.3.1 Summary of Design Line Coverage

The following two figures summarize the coverage of each of the liquid-immersed design lines in relation to the various equipment classes and kVA ratings. Note that these figures are similar to those presented in the NOPR, but reflect new possibilities with respect to structuring equipment classes. The abbreviation DL stands for design line, and the row in the table where the phrase “Rep Unit” appears indicates the kVA rating of the representative unit from that design line. The representative unit is the kVA rating that DOE analyzed in the engineering and LCC analyses. For example, DL1 stands for design line 1, spanning from 10 to 833 kVA liquid-type, single-phase. The label “Rep Unit” appears in row 50 kVA, indicating that the 50 kVA is the representative unit for DL1. Similarly, the representative unit for DL2 is the 25 kVA unit.

There are five liquid-immersed transformer design lines, three single-phase and two three-phase, as shown in Figure 1-A.4.1. To capture any design differences between a single-phase pole and a pad-mounted transformer, DOE analyzed units in both DL1, and DL2 and DL3, spanning the same kVA ratings (10 kVA to 833 kVA).

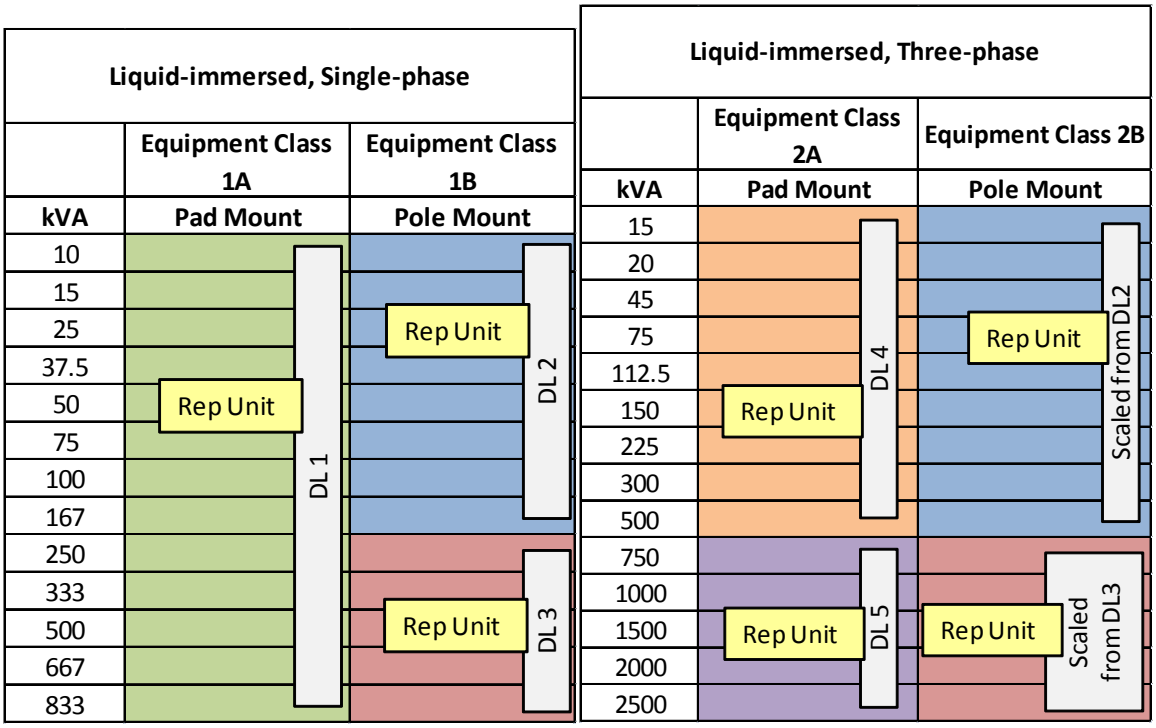

Figure 1-A.3.2 Liquid-Immersed Design Lines and Representative Units

1-A.3.2 Proposed Equipment Class 1A and 2A for Pad-mounted Distribution Transformers

Classes 1A and 2A respectively correspond to single- and three-phase pad-mounted liquid-immersed distribution transformers. Representative units remain unchanged from the NOPR, with a 50 kVA single-phase unit and both 150 and 1500 kVA three-phase units in design lines 1, 4, and 5.

Table 1-A.3.2 Potential Equipment Class 1A and 2A for Pad-mounted Distribution Transformers

EC	DL	Type of Distribution Transformer	kVA Range	Representative Unit for this Engineering Design Line
1A	1	Liquid-immersed, single-phase, pad mount, rectangular tank	10–833	50 kVA, 65°C, single-phase, 60Hz, 14400V primary, 240/120V secondary, rectangular tank, 95kV BIL
2A	4	Liquid-immersed, three-phase, pad-mount	15–500	150 kVA, 65°C, three-phase, 60Hz, 12470Y/7200V primary, 208Y/120V secondary, 95kV BIL
	5	Liquid-immersed, three-phase, pad-mount	750–2500	1500 kVA, 65°C, three-phase, 60Hz, 24940GrdY/14400V primary, 480Y/277V secondary, 125 kV BIL

Pad-mounted transformers represent a significant portion of liquid-immersed transformer shipments. DOE estimates that approximately 30 percent of single phase, and 95 percent of three phase shipments by capacity as pad-mounted transformers.

DOE analyzed EC 1A and 2A at a new EL of 1.5.

1-A.3.3 Proposed Equipment Class 1B and 2B for Pole-mounted Distribution Transformers

Classes 1B and 2B correspond to single- and three-phase pole-mounted liquid-immersed distribution transformers. Representative units remain unchanged from the NOPR, with 25 and 500 kVA single-phase units in design lines 2 and 3. Although no representative unit exists for three-phase pole-mounted transformers, DOE understands that three-phase pole-mounted units are typically built by triplexing three single-phase units and, therefore, plans to set a standard for these units equal to that of the single-phase unit of one third the capacity.

Table 1-A.3.3 Potential Equipment Class 1B for single-phase pole mounted distribution transformers

EC	DL	Type of Distribution Transformer	kVA Range	Representative Unit for this Engineering Design Line
1B	2	Liquid-immersed, single-phase, pole mount, round tank	10–167	25 kVA, 65°C, single-phase, 60Hz, 14400V primary, 120/240V secondary, round tank, 125 kV BIL
	3	Liquid-immersed, single-phase, pole mount, round tank	250–833	500 kVA, 65°C, single-phase, 60Hz, 14400V primary, 277V secondary, 150kV BIL

Pole-mounted transformers represent a significant portion of liquid-immersed transformer shipments. DOE estimates that approximately 70 percent of single phase, and 5 percent of three phase shipments by capacity as pole-mounted transformers.

DOE recognizes that for utilities, as the primary purchaser of pole-mounted transformers, there is concern about increases in transformer size and weight and. Utility stakeholders have maintained during the negotiations, and in written comment that increases to weight and volume disproportionately increase the installation cost for pole-mounted transformers and in extreme cases necessitating that a utility replace existing poles with a new stronger pole to support the weight of the new heavier transformer. To address these concerns DOE has estimated additional installation costs associated with pole replacement, this methodology is described in chapter 6, section 6.3.1of the NOPR TSD. This methodology has been maintained for design line 3, with adjustment for the larger and heavier design line 3 described in section 2.2 of this document.

Table 1-A.6.2 shows the average weight increase for single-phase pole-mounted distribution transformers.

Table 1-A.3.4 Summary of Weight for Pole-mounted Design Lines by Efficiency Level (lbs)

		Efficiency Level								
		Base	**0.5**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
DL 2	min	463	467	480	540	558	601	692	799	663
	avg	473	487	522	544	561	602	697	799	664
	max	545	535	625	582	586	606	748	799	699
DL 3	min	2653	2802	2343	2802	2937	2985	3149	3773	4832
	avg	2812	2984	2932	2905	2979	3020	3177	3827	4864
	max	3218	3370	3285	3192	3144	3212	3269	3985	4950

Table 1-A.3.5 Summary of Relative Weight Changes from the Base Case for Pole-mounted Design-lines by Efficiency Level (%)

		Efficiency Level								
		Base	**0.5**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
DL 2	min	0.0	0.9	3.8	16.5	20.5	29.7	49.4	72.6	43.2
	avg	0.0	2.9	10.2	14.9	18.5	27.1	47.2	68.9	40.3
	max	0.0	-1.9	14.7	6.8	7.6	11.2	37.3	46.7	28.4
DL 3	min	0.0	5.6	-11.7	5.6	10.7	12.5	18.7	42.2	82.1
	avg	0.0	6.1	4.2	3.3	5.9	7.4	13.0	36.1	73.0
	max	0.0	4.7	2.1	-0.8	-2.3	-0.2	1.6	23.8	53.8

DOE analyzed EC 1A and 2A at a new EL of 0.5.

1-A.3.4 Potential Equipment Class 2C for Network/Vault Distribution Transformers

DOE received many comments indicating stakeholders' support of the work done by the negotiating committee on this topic. This work includes both the definition of the new equipment class and recommends that due to potential size increases with increased efficiency, the standard for this new equipment class remain at level of the 2007 Final Rule. DOE estimates network and vault transformers to make up roughly 5 percent of sales by capacity of distribution transformers. The definition outlined in the NOPR:

i. A "network transformer" is one–

(i) designed for use in a vault,

(ii) designed for occasional submerged operation in water,

(iii) designed to feed a system of variable capacity system of interconnected secondaries, and

(iv) built per the requirements of IEEE C57.12.40.

ii. A "vault-type" transformer is one–

(i) designed for use in a vault,

(ii) designed for occasional submerged operation in water, and

(iii) built per the requirements of IEEE C57.12.23 or IEEE C57.12.24, respectively.

1-A.3.5 Potential Equipment Class 2D for Distribution Transformers with ≥ 200 kV BIL

In the 2007 final rule, DOE established equipment classes for medium-voltage, dry-type (MVDT) transformers using basic impulse insulation level (BIL) rating, a measure of resistance to very high voltages resulting from (e.g.) lightning strikes. Although certain consumers derive utility from transformers of greater BIL rating, it is costlier (and in some cases impossible) to build transformers of greater BIL rating to given efficiency levels. Because liquid-immersed transformers are less affected performance-wise by BIL rating than are MVDT transformers, DOE did not previously separate them by BIL rating. However, as higher standards are considered, BIL may start to become a more important consideration for even liquid-immersed units.

Several interested parties commented that in many cases, units built to the highest BIL rating ordinarily used in DOE's scope of coverage (200 kV) are difficult to construct even to current standard levels. Further increases could cause these units to become expensive to a degree that far outweighs any potential savings from reduced losses.

For this reason, DOE is considering establishing a separate equipment class for liquid-immersed transformers of BIL rating 200 kV and above.

1-A.4 REVISED TRIAL STANDARD LEVELS

DOE presented analysis for liquid-immersed distribution transformers for a series of trial standard levels (TSLs) in the NOPR and at the NOPR public meeting. The current TSL composition for liquid-immersed transformers is shown below in Table 1-A.9.1. These TSL are described in detail in the chapter 10 of the NOPR TSD.

Table 1-A.4.1 Notice of Proposed Rulemaking Trial Standard Levels for Liquid-Immersed Distribution Transformers

EC	DL	Trial Standard Levels by Efficiency Level						
		TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7
1	1	EL 1	EL 1	EL 1	EL 2	EL 3	EL 4	EL 6
1	2	Base	EL 1	EL 1	EL 2	EL 3	EL 4	EL 6
1	3	EL 1	EL 1	EL 2	EL 4	EL 3	EL 5	EL 7
2	4	EL 1	EL 1	EL 1	EL 2	EL 3	EL 4	EL 7
2	5	EL 1	EL 1	EL 2	EL 4	EL 3	EL 5	EL 6

DOE received comment in the NOPR from the Advocates requesting that their final negotiating position from the negotiation committee be analyzed. Their final position was stated as efficiency level (EL) 2 [Advocates 186 pg 9] for all liquid-immersed equipment classes. DOE analyzed EL 3 as their final position in the NOPR, this is represented by TSL C In addition, DOE is presenting two TSLs to examine potential energy savings below EL 2.

Table 1-A.4.2 Notice of Public Meeting Trial Standard Level for Liquid-immersed Distribution Transformers

EC	DL	Phases	Type	Trial Standard Levels by Efficiency Level		
				A	B	C
1A	1	1	pad	EL 1	EL 1.5	EL 2
1B	2	1	pole	EL 0.5	EL 0.5	EL 2
1B	3	1	pole	EL 1	EL 1	EL 2
2A	4	3	pad	EL 1	EL 1.5	EL 2
2A	5	3	pad	EL 1	EL 1.5	EL 2
2B	-	3	pole	scaled	scaled	scaled
2C	-	3	network/vault	EL 0	EL 0	EL 0
2D	-	3	≥ 200 kV BIL	EL 0	EL 0	EL 0

1-A.5 ADDITIONAL LIFE-CYCLE COST AND PAYBACK PERIOD RESULTS

The analytical results presented here are based on the NOPR LCC spreadsheet tools available from the DOE website.[i] These spreadsheets were prepared with a "custom" efficiency input that was added so end-users could examine the impacts of efficiencies other than those presented by DOE. For this analysis DOE used this feature to examine the impacts of the new efficiency levels.

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

To address the pole replacement costs for DL3 DOE used the same methodology that was used for DL2. For DL 3 the following inputs were changed to better approximate the costs associated with installing a larger capacity, 500 kVA transformers. For DL3 DOE used RSMeans 2011 to estimate the range of installation costs to include the use of a heavier crane, and additional crew. The estimated range of installation costs associated with pole replacement for a 500 kVA transformer is between $5877 and $7935. DOE also adjusted the weight change-out threshold by scaling the 150 pounds use for DL2 with the 0.75 scaling rule to 1418 pounds for DL3. The changes to the design line 3 spreadsheet tool have been made available from the DOE website[j].

1-A.5.6 Design Line 1 Life-Cycle Cost and Payback Period Results

Table 1-A.5.1 Summary Life-Cycle Cost Results for Design Line 1 Representative Unit

	Efficiency Level						
	1	**1.5**	**2**	**3**	**4**	**5**	**6**
Efficiency (%)	99.16	99.19	99.22	99.25	99.31	99.42	99.50
Transformers with Net Increase in LCC (%)	57.94	36.30	4.77	4.77	8.00	13.63	55.36
Transformers with No Impact on LCC (%)	0.23	0.10	0.23	0.23	0.00	0.00	0.00
Transformers with Net LCC Savings (%)	41.83	63.60	95.00	95.00	92.00	86.37	44.64
Mean LCC Savings ($)	36	305	641	641	532	629	50
Median LCC Savings ($)	-64	44	650	650	540	563	-104

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

Table 1-A.5.2 Summary Payback Period Results for Design Line 1 Representative Unit

	Efficiency Level						
	1	**1.5**	**2**	**3**	**4**	**5**	**6**
Mean Payback (Years)	32.2	21.1	8.2	8.2	10.4	12.0	19.9
Median Payback (Years)	20.2	17.9	7.9	7.9	10.0	11.5	19.2
Transformers having Well Defined Payback (%)	85.02	89.40	99.77	99.77	99.89	99.99	99.95
Transformers having Undefined Payback (%)	14.98	10.60	0.23	0.23	0.11	0.01	0.05
Mean Retail Cost ($)	2,244	2,240	2,446	2,446	2,549	2,802	3,333
Mean Installation Costs ($)	2,230	2,229	2,271	2,271	2,344	2,415	2,606
Mean Operating Costs ($)	209	218	156	156	153	132	126
Mean Incremental First Cost ($)	327	327	569	569	746	1,070	1,792
Mean Operating Cost Savings ($)	18	21	71	71	74	95	100
Payback of Average Transformer	18.2	15.8	8.0	8.0	10.1	11.2	17.8

1-A.5.7 Design Line 2 Life-Cycle Cost and Payback Period Results

Table 1-A.5.3 Summary Life-Cycle Cost Results for Design Line 2 Representative Unit

	Efficiency Level							
	0.5	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Efficiency (%)	98.95	99.00	99.07	99.11	99.18	99.31	99.41	99.46
Transformers with Net LCC Cost (%)	42.80	14.23	9.82	11.20	15.75	58.18	80.16	86.51
Transformers with No Change in LCC (%)	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transformers with Net LCC Benefit (%)	53.50	85.77	90.18	88.80	84.25	41.82	19.84	13.49
Mean LCC Savings ($)	54	309	338	300	250	-445	-736	-599
Median LCC Savings ($)	-558	322	341	308	262	-91	-390	-535

Table 1-A.5.4 Summary Payback Period Results for Design Line 2 Representative Unit

	Efficiency Level							
	0.5	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Mean Payback (Years)	18.3	10.0	9.7	11.3	13.4	27.9	32.7	30.3
Median Payback (Years)	6.47	6.9	8.0	9.5	11.5	18.7	24.3	26.3
Transformers having Well Defined Payback (%)	72.00	98.55	99.93	99.71	99.83	99.75	99.77	99.90
Transformers having Undefined Payback (%)	28.00	1.45	0.07	0.29	0.17	0.25	0.23	0.10
Mean Retail Cost ($)	1,281	1,437	1,480	1,530	1,598	1,846	2,052	2,577
Mean Installation Costs ($)	1635	1722	1761	1790	1859	2500	2678	2093
Mean Operating Costs ($)	146	101	95	93	89	79	75	71
Mean Incremental First Cost ($)	140	235	317	396	533	1,422	1,807	1,746
Mean Operating Cost Savings ($)	66	34	40	41	46	55	60	64
Payback of Average Transformer	2.1	7.0	8.0	9.6	11.7	25.8	30.2	27.4

1-A.5.8 Design Line 3 Life-Cycle Cost and Payback Period Results

Table 1-A.5.5 Summary Life-Cycle Cost Results for Design Line 3 Representative Unit

	Efficiency Level							
	0.5	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Efficiency (%)	99.50	99.48	99.51	99.54	99.57	99.61	99.69	99.73
Transformers with Net Increase in LCC (%)	13.44	16.07	11.86	5.35	3.87	3.65	7.37	24.82
Transformers with No Impact on LCC (%)	0.35	0.35	0.30	0.00	0.00	0.00	0.00	0.00
Transformers with Net LCC Savings (%)	86.21	83.58	87.84	94.65	96.13	96.35	92.63	75.18
Mean LCC Savings ($)	2777	2370	3809	5218	5586	6576	6924	4294
Median LCC Savings ($)	3421	1751	3652	5269	5607	6631	6587	3421

Table 1-A.5.6 Summary Payback Period Results for Design Line 3 Representative Unit

	Efficiency Level							
	0.5	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Mean Payback (Years)	8.2	9.2	6.7	5.6	5.4	6.0	9.4	15.2
Median Payback (Years)	6.4	6.1	4.0	4.6	4.7	5.2	8.1	13.3
Transformers having Well Defined Payback ()	97.14	95.56	97.38	99.89	99.98	100.00	99.94	99.74
Transformers having Undefined Payback ()	2.86	4.44	2.62	0.11	0.02	0.00	0.06	0.26
Mean Retail Cost ($)	7,698	8,546	8,944	9,534	9,679	10,280	12,500	15,917
Mean Installation Costs ($)	4,234	4,334	4,311	4,370	4,402	4,523	4,996	5,732
Mean Operating Costs ($)	1,422	1,222	1,104	984	957	872	724	656
Mean Incremental First Cost ($)	1,184	948	1,323	1,972	2,149	2,871	5,564	9,717
Mean Operating Cost Savings ($)	1,161	200	318	438	465	550	698	766
Payback of Average Transformer	1.0	4.7	4.2	4.5	4.6	5.2	8.0	12.7

1-A.5.9 Design Line 4 Life-Cycle Cost and Payback Period Results

Table 1-A.5.7 Summary Life-Cycle Cost Results for Design Line 4 Representative Unit

	Efficiency Level							
	1	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**
Efficiency (%)	99.16	99.19	99.22	99.25	99.31	99.42	99.50	99.60
Transformers with Net LCC Cost (%)	5.95	12.62	1.91	1.91	1.86	1.82	4.87	31.10
Transformers with No Change in LCC (%)	0.58	0.62	0.58	0.58	0.58	0.17	0.00	0.00
Transformers with Net LCC Benefit (%)	93.47	86.76	97.51	97.51	97.56	98.01	95.13	63.87
Mean LCC Savings ($)	862	857	3356.0	3356.0	3362.3	3437.2	3193	1274
Median LCC Savings ($)	670	577	3418.7	3418.7	3423.6	3489.8	3054	956

Table 1-A.5.8 Summary Payback Period Results for Design Line 4 Representative Unit

	Efficiency Level							
	1	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**
Mean Payback (Years)	6.6	9.4	4.4	4.4	4.4	4.6	8.2	15.1
Median Payback (Years)	5.0	7.2	4.1	4.1	4.1	4.3	7.9	14.6
Transformers having Well Defined Payback (%)	99.37	99.38%	99.27	99.27	99.33	99.81	99.94	94.96
Transformers having Undefined Payback (%)	0.63	0.62%	0.73	0.73	0.67	0.19	0.06	0.01
Mean Retail Cost ($)	5,894	5,892	6,443	6,443	6,451	6,536	7,615	10,601
Mean Installation Costs ($)	4,090	4,095	4,184	4,184	4,183	4,223	4,584	4,709
Mean Operating Costs ($)	668	420	483	483	482	471	400	334
Mean Incremental First Cost ($)	438	440	1,081	1,081	1,088	1,214	2,653	5,763
Mean Operating Cost Savings ($)	76	74	261	261	262	274	344	414
Payback of Average Transformer	5.7	6.0	4.1	4.1	4.1	4.4	7.7	13.9

1-A.5.10 Design Line 5 Life-Cycle Cost and Payback Period Results

Table 1-A.5.9 Summary Life-Cycle Cost Results for Design Line 5 Representative Unit

	Efficiency Level						
	1	**1.5**	**2**	**3**	**4**	**5**	**6**
Efficiency (%)	99.48	99.50	99.51	99.54	99.57	99.61	99.69
Transformers with Net Increase in LCC (%)	19.05	16.99	13.15	10.41	7.77	7.88	39.92
Transformers with No Impact on LCC (%)	0.39	0.28	0.09	0.01	0.00	0.00	0.00
Transformers with Net LCC Savings (%)	80.56	82.73	86.76	89.58	92.23	92.12	60.08
Mean LCC Savings ($)	7787	9010	10288	11395	12513	12746	3626
Median LCC Savings ($)	8300	9649	10741	11658	12666	12838	3083

Table 1-A.5.10 Summary Payback Period Results for Design Line 5 Representative Unit

	Efficiency Level						
	1	**1.5**	**2**	**3**	**4**	**5**	**6**
Mean Payback (Years)	7.0	7.3	6.5	7.8	7.8	9.7	18.7
Median Payback (Years)	4.0	4.1	4.2	5.7	6.3	8.3	16.9
Transformers having Well Defined Payback (%)	91.63	89.93	96.04	98.89	99.82	99.97	100.00
Transformers having Undefined Payback (%)	8.37	10.07	3.96	1.11	0.18	0.03	0.00
Mean Retail Cost ($)	28,574	25,391	29,040	30,872	31,980	35,448	56,798
Mean Installation Costs ($)	8,551	8,438	8,631	8,875	9,030	9,498	9,834
Mean Operating Costs ($)	3,407	4,414	3,259	3,105	2,994	2,802	2,185
Mean Incremental First Cost ($)	3,296	3,721	3,842	5,918	7,181	11,116	32,803
Mean Operating Cost Savings ($)	718	3,434	866	1,020	1,131	1,323	1,940
Payback of Average Transformer	4.6	1.1	4.4	5.8	6.3	8.4	16.9

1-A.6 ADDITIONAL NATIONAL IMPACTS ANALYSIS RESULTS

The national impacts analysis results present here we estimated using the NOPR spreadsheet tool available from the DOE website.[k] To disaggregate the impacts for pad- and pole-mounted transformers from the equipment classes presented in the NOPR DOE associated the fraction of savings with the volume of capacity shipment for each of the new proposed equipment classes.

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

1-A.6.11 Summary National Impact Analysis Results

Table 1-A.6.1 National Impact Analysis Results for Liquid-immersed Transformers

	NOPR Trial Standard Level								NOPM Trial Standard Level		
	Base	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**A**	**B**	**C**
Transformer Shipments 2015-2044 (Billion KVA)	1.95	1.95	1.95	1.95	1.94	1.94	1.94	1.91	1.95	1.95	1.95
Equipment Cost ($Billions)	32.28	-1.26	-2.51	-2.61	-4.26	-4.48	-6.32	-19.88	-1.57	-2.00	-3.72
Operating Cost (Savings in TSLs) ($Billions)	23.26	2.01	4.03	4.33	7.22	7.13	8.08	11.64	2.50	3.21	6.71
Cumulative Source Savings 2044 (Quads)		0.36	0.74	0.82	1.44	1.42	1.70	2.70	0.45	0.60	1.30
Net Present Value at 3% Discount Rate ($Billions)		3.66	7.39	8.24	14.21	13.48	13.17	-1.11	4.66	6.04	13.51
Net Present Value at 7% Discount Rate ($Billions)		0.75	1.51	1.73	2.96	2.65	1.76	-8.25	0.93	1.21	2.99

1-A.6.12 Summary National Impact Analysis Results for Single-phase Liquid-immersed Distribution Transformers

Table 1-A.6.2 Results for Notice of Proposed Rulemaking Equipment Class 1

	NOPR Trial Standard Level								NOPM Trial Standard Level		
	Base	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**A**	**B**	**C**
Transformer Shipments 2015-2044 (Billion KVA)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.79	0.80	0.80	0.80
Equipment Cost ($Billions)	22.36	-0.52	-1.78	-1.79	-2.61	-3.03	-4.05	-12.11	-0.84	-1.13	-2.60
Operating Cost (Savings in TSLs) ($Billions)	11.37	0.34	2.36	2.38	3.76	3.89	4.23	5.84	0.78	1.23	3.69
Cumulative Source Savings 2044 (Quads)		0.09	0.47	0.47	0.75	0.80	0.90	1.37	0.18	0.27	0.75
Net Present Value at 3% Discount Rate ($Billions)		0.13	3.87	3.93	6.64	6.28	5.51	-4.64	0.94	1.78	6.44
Net Present Value at 7% Discount Rate ($Billions)		-0.19	0.58	0.60	1.15	0.85	0.19	-6.27	-0.06	0.10	1.09

Table 1-A.6.3 Results for Notice of Public Meeting Equipment Class 1A – Pad-mounted Distribution Transformers

	Trial Standard Level								NOPM Trial Standard Level		
	Base	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**A**	**B**	**C**
Transformer Shipments 2015-2044 (Billion KVA)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Equipment Cost ($Billions)	6.71	-0.16	-0.53	-0.54	-0.78	-0.91	-1.21	-3.63	-0.25	-0.34	-0.78
Operating Cost (Savings in TSLs) ($Billions)	3.41	0.10	0.71	0.72	1.13	1.17	1.27	1.75	0.23	0.37	1.11
Cumulative Source Savings 2044 (Quads)		0.03	0.14	0.14	0.23	0.24	0.27	0.41	0.05	0.08	0.22
Net Present Value at 3% Discount Rate ($Billions)		0.04	1.16	1.18	1.99	1.88	1.65	-1.39	0.28	0.53	1.93
Net Present Value at 7% Discount Rate ($Billions)		-0.06	0.17	0.18	0.34	0.26	0.06	-1.88	-0.02	0.03	0.33

Table 1-A.6.4 Results for Notice of Pubic Meeting Equipment Class 1B – Pole-mounted Distribution Transformer

	Trial Standard Level								NOPM Trial Standard Level		
	Base	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**A**	**B**	**C**
Transformer Shipments 2015-2044 (Billion KVA)	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.55	0.56	0.56	0.56
Equipment Cost ($Billions)	15.65	-0.37	-1.25	-1.25	-1.83	-2.12	-2.83	-8.48	-0.59	-0.79	-1.82
Operating Cost (Savings in TSLs) ($Billions)	7.96	0.24	1.65	1.67	2.63	2.72	2.96	4.09	0.55	0.86	2.58
Cumulative Source Savings 2044 (Quads)		0.07	0.33	0.33	0.53	0.56	0.63	0.96	0.13	0.19	0.52
Net Present Value at 3% Discount Rate ($Billions)		0.09	2.71	2.75	4.65	4.40	3.85	-3.25	0.66	1.24	4.51
Net Present Value at 7% Discount Rate ($Billions)		-0.13	0.41	0.42	0.80	0.60	0.13	-4.39	-0.04	0.07	0.77

1-A.6.13 Summary National Impact Analysis Results for Three-phase Liquid-immersed Distribution Transformers

Table 1-A.6.5 Results for Notice of Proposed Rulemaking Equipment Class 2

	NOPR Trial Standard Level								NOPM Trial Standard Level		
	Base	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**A**	**B**	**C**
Transformer Shipments 2015-2044 (Billion KVA)	1.15	1.15	1.15	1.15	1.15	1.15	1.14	1.13	1.15	1.15	1.15
Equipment Cost ($Billions)	9.92	-0.73	-0.73	-0.82	-1.65	-1.45	-2.27	-7.78	-0.73	-0.87	-1.12
Operating Cost (Savings in TSLs) ($Billions)	11.88	1.67	1.67	1.95	3.46	3.25	3.84	5.80	1.72	1.98	3.01
Cumulative Source Savings 2044 (Quads)		0.27	0.27	0.35	0.69	0.63	0.80	1.33	0.27	0.33	0.55
Net Present Value at 3% Discount Rate ($Billions)		3.53	3.53	4.31	7.57	7.21	7.66	3.53	3.71	4.26	7.07
Net Present Value at 7% Discount Rate ($Billions)		0.94	0.94	1.13	1.82	1.80	1.57	-1.98	0.99	1.11	1.90

Table 1-A.6.6 Results for Notice of Public Meeting Equipment Class 2B – Pad-mounted Transformers

	Trial Standard Level								NOPM Trial Standard Level		
	Base	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**A**	**B**	**C**
Transformer Shipments 2015-2044 (Billion KVA)	1.10	1.09	1.09	1.09	1.09	1.09	1.09	1.07	1.09	1.09	1.09
Equipment Cost ($Billions)	9.42	-0.70	-0.70	-0.78	-1.57	-1.38	-2.16	-7.39	-0.70	-0.83	-1.06
Operating Cost (Savings in TSLs) ($Billions)	11.29	1.58	1.58	1.85	3.29	3.08	3.65	5.51	1.64	1.88	2.86
Cumulative Source Savings 2044 (Quads)		0.26	0.26	0.33	0.65	0.60	0.76	1.26	0.26	0.31	0.53
Net Present Value at 3% Discount Rate ($Billions)		3.35	3.35	4.10	7.19	6.85	7.28	3.35	3.53	4.05	6.72
Net Present Value at 7% Discount Rate ($Billions)		0.89	0.89	1.07	1.72	1.71	1.49	-1.88	0.94	1.05	1.80

Table 1-A.6.7 Results for Notice of Public Meeting Equipment Class 2B – Pole-mounted Distribution Transformers

	Trial Standard Level								NOPM Trial Standard Level		
	Base	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**A**	**B**	**C**
Transformer Shipments 2015-2044 (Billion KVA)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Equipment Cost ($Billions)	0.50	-0.04	-0.04	-0.04	-0.08	-0.07	-0.11	-0.39	-0.04	-0.04	-0.06
Operating Cost (Savings in TSLs) ($Billions)	0.59	0.08	0.08	0.10	0.17	0.16	0.19	0.29	0.09	0.10	0.15
Cumulative Source Savings 2044 (Quads)		0.01	0.01	0.02	0.03	0.03	0.04	0.07	0.01	0.02	0.03
Net Present Value at 3% Discount Rate ($Billions)		0.18	0.18	0.22	0.38	0.36	0.38	0.18	0.19	0.21	0.35
Net Present Value at 7% Discount Rate ($Billions)		0.05	0.05	0.06	0.09	0.09	0.08	-0.10	0.05	0.06	0.09

1-A.7 REQUEST FOR COMMENT

1. DOE requests comment on the new equipment class definitions.

2. DOE requests data on distribution transformer shipments for each of the presented equipment classes by kVA rating. similar to the data presented in Table 9.3.2 of the NOPR TSD, presented here for reference.

Table 1-A.7.1 Estimated Shipments of Liquid-Immersed, Medium-Voltage Transformers, 2009

Single-Phase		Three-Phase	
Capacity *kVA*	**Units Shipped**	**Capacity *kVA***	**Units Shipped**
10	58,090	15	–
15	169,083	30	–
25	243,583	45	1,438
37.5	41,755	75	3,753
50	119,455	112.5	790
75	26,338	150	7,426
100	18,679	225	1,969
167	4,357	300	7,340
250	1,905	500	6,650
333	238	750	3,502
500	238	1,000	3,171
667	5	1,500	2,941
833	–	2,000	2,497
–		2,500	2,260

3. DOE requests comment on the appropriate efficiency levels for network/vault and ≥200 kV BIL equipment classes.

4. DOE request from utilities pole replacement costs by transformer capacity.