Distribution Transformer Energy Efficiency Task Force

Philip J Hopkinson, PE

1. **Introductions**
   - **Wes Patterson-Navigant Consulting**
2. **Minutes from Boston 11/1/2011**
3. **NOPR Issued By DOE**

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

1. **Schedule Ahead**
2. **New Issues for 2012**
3. **Final Rule expected October 1, 2012**
4. **Assignments**
5. **Next meeting in Milwaukee**

Distribution Transformer Energy Efficiency Task Force

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Meeting Minutes from Boston, November 1, 2011

Distribution Transformer Subcommittee

Task force / Working Group Report

Document #: _____ **Current Standard Date:** _____

Document Title: TF Transformer Efficiency And Loss Evaluation (DOE Activity)

Chair: S. Schull **Vice-Chair:** _____

PAR Date: _____ **PAR Expiration Date:** _____

PAR Status: _____

Current Draft Being Worked On: _____ **Dated:** _____

Meeting Date: 11/01/2011 **Time:** 3:15 pm

Attendance:		
	Members	27
	Guests	44
	Guests Requesting Membership	10
	Total	71

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Meeting Minutes from Boston, 11/1/2011 part 2

Meeting Minutes / Significant Issues / Comments:

The Minutes from the April 12, 2011, meeting in San Diego, California, were approved as written.

Mr. Hopkinson reported that Brian Coffey from Navigant was unable to attend the meeting. Navigant Consulting is a contractor working for DOE on the distribution transformer efficiency rulemaking.

1. Mr. Hopkinson reviewed slides from his presentation titled "Distribution Transformer Energy Efficiency Task Force." The presentation is posted on the IEEE Transformer Committee Website under the Distribution Transformers Subcommittee as "Fall 2011 Agenda & Presentation."

Brief overview of Negotiated Settlement in process for New Final Rules

- Richard Parker appointed by DOE as facilitator.
- 2 negotiating teams - 1 for LVDT, 1 for MVDT/Liquid-Filled
- Timing is short - target is end of 2011
- Consensus based on 100% agreement

Conservation advocates want higher efficiency, manufacturers and users want economically justified efficiencies with widely available materials

Major push to verify economic models, BIL sensitivity, and impacts on suppliers, manufacturers, and users.

If agreement not reached, reverts back to traditional rulemaking

Meetings scheduled November 8-9, and November 30-December 2.

2. Studies by Phil Hopkinson, Carlos Gaytan, and Wes Patterson

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Meeting Minutes from Boston, 11/1/2011 Part 3

Mr. Hopkinson reviewed portions of his analysis that was submitted to DOE is support of the rulemaking.
- There are inaccuracies in the OPS model used by DOE, and underestimates the amount of material used.
- There does not appear to be economic justification for higher efficiencies than the current mandatory levels

Carlos Gaytan reviewed his report submitted to DOE
- Highlighted steepness of cost curve of M3 steel compared to amporphous steel.

Wes Patterson reviewed his reports submitted to DOE
- 1 report highlights efficiency rules from other countries around the world
- 1 report shows weight of the transformer as efficiency is increased. 30% reduction in losses results in 15% increase in weight. If restricted to M3 steel, result is 85% increase in weight. DOE analysis underestimates the weight of efficient transformers.

Rebuilt transformers
- DOE rulemaking does not cover rebuilt transformers. There is a price point where customers will opt to rebuild transformers rather than purchase a new, more efficient transformer.

4. New Business

There was no new business.

The next meeting is planned for the spring in Nashville. The meeting adjourned at 4:32 PM.

Submitted By: Scott Choinski

Date: **11/01/2011**

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1. **NOPR in 77 FR 7282 10 Feb 12**
2. **DOE Link posted February 1, 2012:** http://www1.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html

Note

Proposed Rulemaking

- **Notice of Proposed Rulemaking and Public Meeting**
  - **Technical Correction**
  - **Public Meeting** There will be a public meeting on February 23, 2012, from 9 a.m. to 1 p.m., at the U.S. Department of Energy, Forrestal Building, Room 8E-089, 1000 Independence Avenue, SW., Washington, DC. If you wish to attend, please notify Ms. Brenda Edwards at (202) 586–2945. In addition, the meeting will be broadcast as a webinar. For additional information, see section VII, Public Participation, in the Notice of Proposed Rulemaking.
  - **Webinar:** Interested parties who are not able to attend the public meeting are invited to participate in the Webinar, to be broadcast live from the public meeting. Space is limited. You may reserve your Webinar seat now at https://www1.gotomeeting.com/register/568522776
  - Agenda
  - Presentation
  - Transcript (coming soon)
- Technical Support Document
- Analytical Tools
  - Engineering Analysis Spreadsheets
  - Life-Cycle Cost Analysis Spreadsheets for Liquid-Immersed Distribution Transformers
  - Life-Cycle Cost Analysis Spreadsheets for Low-Voltage Dry-Type Distribution Transformers
  - Life-Cycle Cost Analysis Spreadsheets for Medium-Voltage Dry-Type Distribution Transformers
  - National and Regulatory Impact Analysis Spreadsheets
  - Government Regulatory Impact Model (GRIM)

After a regulatory action has been issued, Section 6(a)(3)(E) of EO 12866 requires agencies to identify in a complete, clear, and simple manner, the substantive changes between the draft submitted to Office of Information and Regulatory Affairs (OIRA) for review and the action subsequently announced, and identify those changes in the regulatory action that were made at the suggestion or recommendation of OIRA. The documents at the links below are intended to comply with this requirement.

- Energy Conservation Program: Energy Conservation Standards for Distribution Transformers Notice of proposed rulemaking and public meeting submitted to OMB on January 8, 2012 COMPARE with notice concluded on January 31, 2012

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1. NOPR in 77 FR 7282 10 Feb 12

TABLE I.1—PROPOSED ENERGY CONSERVATION STANDARDS FOR LIQUID-IMMERSED DISTRIBUTION TRANSFORMERS (COMPLIANCE STARTING JANUARY 1, 2016)

Equipment class	Design line	Type	Phase count	BIL	Proposed TSL
1	1, 2 and 3	Liquid-immersed	1	Any	1
2	4 and 5	Liquid-immersed	3	Any	1

Note: BIL means "basic impulse insulation level."

TABLE I.2—PROPOSED ENERGY CONSERVATION STANDARDS FOR LOW-VOLTAGE, DRY-TYPE DISTRIBUTION TRANSFORMERS (COMPLIANCE STARTING JANUARY 1, 2016)

Equipment class	Design line	Type	Phase count	BIL	Proposed TSL
3	6	Low-voltage, dry-type	1	≤10 kV	1
4	7 and 8	Low-voltage, dry-type	3	≤10 kV	1

Note: BIL means "basic impulse insulation level."

TABLE I.3—PROPOSED ENERGY CONSERVATION STANDARDS FOR MEDIUM-VOLTAGE, DRY-TYPE DISTRIBUTION TRANSFORMERS (COMPLIANCE STARTING JANUARY 1, 2016)

Equipment class	Design line	Type	Phase count	BIL	Proposed TSL
5	9 and 10	Medium-voltage, dry-type	1	25–45 kV	2
6	9 and 10	Medium-voltage, dry-type	3	25–45 kV	2
7	11 and 12	Medium-voltage, dry-type	1	46–95 kV	2
8	11 and 12	Medium-voltage, dry-type	3	46–95 kV	2
9	13A and 13B	Medium-voltage, dry-type	1	≥96 kV	2
10	13A and 13B	Medium-voltage, dry-type	3	≥96 kV	2

Note: BIL means "basic impulse insulation level," and measures how resistant a transformer's insulation is to large voltage transients.

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2. Definitions NOPR in 77 FR 7282 10 Feb 12

TABLE I.4—TRIAL STANDARD LEVEL TO ENERGY EFFICIENCY LEVEL MAPPING FOR PROPOSED ENERGY CONSERVATION STANDARD

Type	Design line	Phase count	Proposed TSL	Energy efficiency level
Liquid-immersed	1	1	1	1
	2	1		Base
	3	1		1
	4	3		1
	5	3		1
Low-voltage, dry-type	6	1	1	Base
	7	3		2
	8	3		2
Medium-voltage, dry-type	9	3	2	1
	10	3		2
	11	3		1
	12	3		2
	13A	3		1
	13B	3		2

- **TSL not the same as EL**
- **Base efficiency is Present DOE Mandatory Efficiencies**

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3. Liquid Filled NOPR in 77 FR 7282 10 Feb 12

Table I.5. Proposed Electrical Efficiencies for all Liquid-Immersed Distribution Transformer Equipment Classes (Compliance Starting January 1, 2016)

Standards by kVA and Equipment Class			
Equipment Class 1		Equipment Class 2	
kVA	%	kVA	%
10	98.70	15	98.65
15	98.82	30	98.83
25	98.95	45	98.92
37.5	99.05	75	99.03
50	99.11	112.5	99.11
75	99.19	150	99.16
100	99.25	225	99.23
167	99.33	300	99.27
250	99.39	500	99.35
333	99.43	750	99.40
500	99.49	1000	99.43
667	99.52	1500	99.48
833	99.55	2000	99.51
		2500	99.53

1 Phase separated from 3 Phase with losses reduced by 2.6-12.1%
3 Phase Losses reduced by 5.2-17.7%

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4. Low Voltage Dry NOPR in 77 FR 7282 10 Feb 12

TABLE I.6—PROPOSED ELECTRICAL EFFICIENCIES FOR ALL LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMER EQUIPMENT CLASSES (COMPLIANCE STARTING JANUARY 1, 2016)

Standards by kVA and equipment class				
Equipment class 3		Equipment class 4		
kVA	%	kVA	%	3 Phase % reduction
15	97.73	15	97.44	14.7
25	98.00	30	97.95	18.0
37.5	98.20	45	98.20	20.7
50	98.31	75	98.47	23.5
75	98.50	112.5	98.66	25.5
100	98.60	150	98.78	27.9
167	98.75	225	98.92	28.1
250	98.87	300	99.02	30.0
333	98.94	500	99.17	33.6
		750	99.27	33.4
		1000	99.34	37.7

- **1 Phase remains at Base**
- **3 Phase losses reduced by 15-38%**
- **Anything > 25-30% appears to be very excessive and needs attention!**

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4. Low Voltage Dry NOPR in 77 FR 7282 10 Feb 12

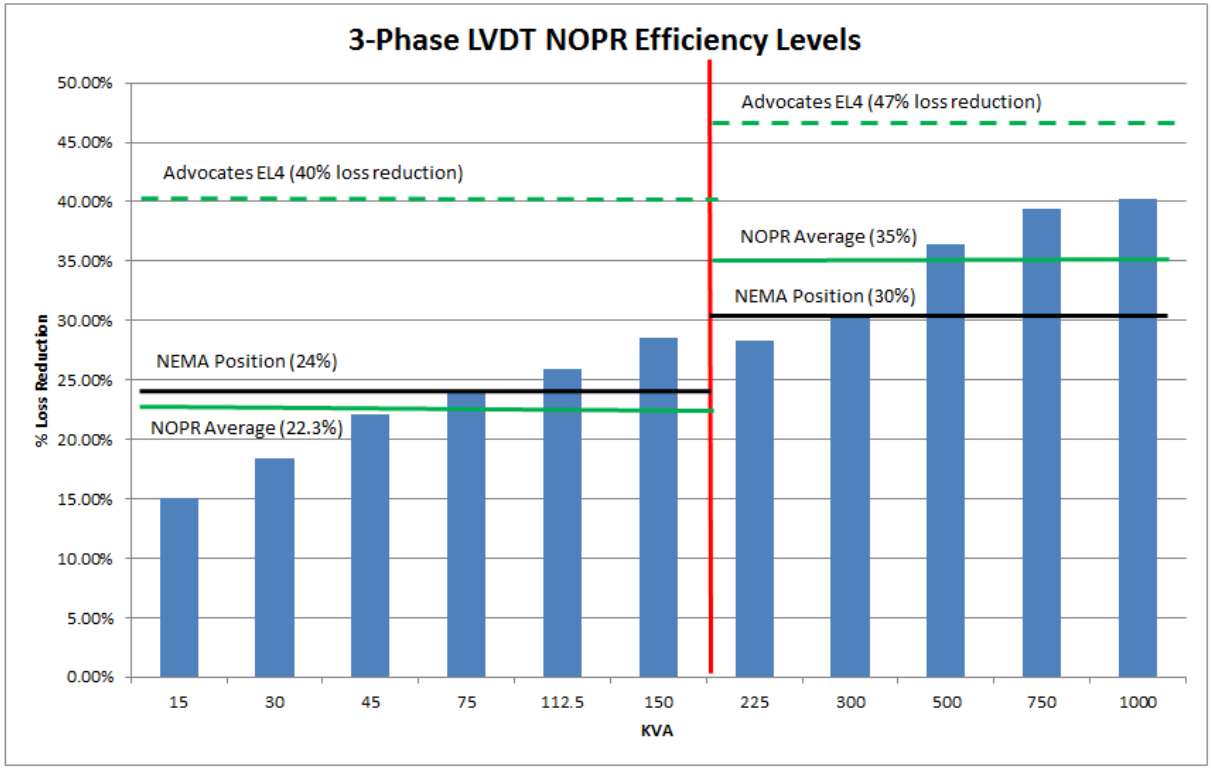

Chart Courtesy of Rob Greeson

3 Phase LV Dry Type kVA	% reduction
15	14.7
30	18.0
45	20.7
75	23.5
112.5	25.5
150	27.9
225	28.1
300	30.0
500	33.6
750	33.4
1000	37.7

- **1 Phase remains at Base**
- **3 Phase losses reduced by 15-38%**
- **Anything > 25-30% appears to be very excessive and needs attention!**

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5. Medium Voltage Dry NOPR in 77 FR 7282 10 Feb 12

TABLE I.7—PROPOSED ELECTRICAL EFFICIENCIES FOR ALL MEDIUM-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMER EQUIPMENT CLASSES (COMPLIANCE STARTING JANUARY 1, 2016)

Standards by kVA and equipment class											
Equipment class 5		Equipment class 6		Equipment class 7		Equipment class 8		Equipment class 9		Equipment class 10	
kVA	%	kVA	%	kVA	%	kVA	%	kVA	%	kVA	%
15	98.10	15	97.50	15	97.86	15	97.18				
25	98.33	30	97.90	25	98.12	30	97.63				
37.5	98.49	45	98.10	37.5	98.30	45	97.86				
50	98.60	75	98.33	50	98.42	75	98.13				
75	98.73	112.5	98.52	75	98.57	112.5	98.36	75	98.53		
100	98.82	150	98.65	100	98.67	150	98.51	100	98.63		
167	98.96	225	98.82	167	98.83	225	98.69	167	98.80	225	98.57
250	99.07	300	98.93	250	98.95	300	98.81	250	98.91	300	98.69
333	99.14	500	99.09	333	99.03	500	98.99	333	98.99	500	98.89
500	99.22	750	99.21	500	99.12	750	99.12	500	99.09	750	99.02
667	99.27	1000	99.28	667	99.18	1000	99.20	667	99.15	1000	99.11
833	99.31	1500	99.37	833	99.23	1500	99.30	833	99.20	1500	99.21
		2000	99.43			2000	99.36			2000	99.28
		2500	99.47			2500	99.41			2500	99.33

1 Phase remains at Base
3 Phase losses reduced by 0-23.5%

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6. LCC and Paybacks NOPR in 77 FR 7282 10 Feb 12

TABLE I.8—IMPACTS OF PROPOSED STANDARDS ON CUSTOMERS OF DISTRIBUTION TRANSFORMERS

Design Line	Average LCC savings (2010$)	Median payback period (years)
Liquid-Immersed		
1	36	20.2
2	*N/A	*N/A
3	2,413	6.3
4	862	5.0
5	7,787	4.0
Low-Voltage, Dry-Type		
6	*N/A	*N/A
7	1,714	4.5
8	2,476	8.4
Medium-Voltage, Dry-Type		
9	849	2.6
10	4,791	8.8
11	1,043	10.7
12	6,934	9.0
13A	25	16.5

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
	2	Liquid-immersed, single-phase, round tank	10–167	25 kVA, 65°C, single-phase, 60Hz, 14400V primary, 120/240V secondary, round tank
	3	Liquid-immersed, single-phase	250–833	500 kVA, 65°C, single-phase, 60Hz, 14400V primary, 277V secondary
2	4	Liquid-immersed, three-phase	15–500	150 kVA, 65°C, three-phase, 60Hz, 12470Y/7200V primary, 208Y/120V secondary
	5	Liquid-immersed, three-phase	750–2500	1500 kVA, 65°C, three-phase, 60Hz, 24940GrdY/14400V primary, 480Y/277V secondary
3	6	Dry-type, low-voltage, single-phase	15–333	25 kVA, 150°C, single-phase, 60Hz, 480V primary, 120/240V secondary, 10kV BIL
4	7	Dry-type, low-voltage, three-phase	15–150	75 kVA, 150°C, three-phase, 60Hz, 480V primary, 208Y/120V secondary, 10kV BIL
	8	Dry-type, low-voltage, three-phase	225–1000	300 kVA, 150°C, three-phase, 60Hz, 480V Delta primary, 208Y/120V secondary, 10kV BIL
6	9	Dry-type, medium-voltage, three-phase, 20-45kV BIL	15–500	300 kVA, 150°C, three-phase, 60Hz, 4160V Delta primary, 480Y/277V secondary, 45kV BIL
	10	Dry-type, medium-voltage, three-phase, 20-45kV BIL	750–2500	1500 kVA, 150°C, three-phase, 60Hz, 4160V primary, 480Y/277V secondary, 45kV BIL
8	11	Dry-type, medium-voltage, three-phase, 46-95kV BIL	15–500	300 kVA, 150°C, three-phase, 60Hz, 12470V primary, 480Y/277V secondary, 95kV BIL
	12	Dry-type, medium-voltage, three-phase, 46-95kV BIL	750–2500	1500 kVA, 150°C, three-phase, 60Hz, 12470V primary, 480Y/277V secondary, 95kV BIL
10	13	Dry-type, medium-voltage, three-phase, 96-150kV BIL	225–2500	2000 kVA, 150°C, three-phase, 60Hz, 12470V primary, 480Y/277V secondary, 125kV BIL

DOE Paybacks include switch to Amorphous Core. M3 paybacks longer

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Reaction to NOPR in 77 FR 7282 10 Feb 12

a. **NEMA and transformer makers believe proposal good**
b. **EEI and Utilities believe proposal good**
c. **Conventional core steel makers believe proposal good**

Advocates not pleased with DOE proposal and have raised challenges

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7. Considerations in NOPR in 77 FR 7282 10 Feb 12

a. Material prices supposed to reflect 2010-2011
b. Energy prices that are considerably higher than today's actuals.
c. Loading remains at 35% for LV and 50% for Medium Voltage
d. OPS designs that are sufficiently corrected from early errors
e. M3 core material and Amorphous
f. Transformer Selling price versus efficiency for both core materials
g. Dollars cost per watt saved analysis
h. Energy savings versus efficiency levels
i. Payback period versus efficiency
j. Manufacturing Impact
k. Market Impact
l. Core Steel impacts
m. Proposed efficiencies.

1. All sides want M3 Core Material to remain Viable
2. Utilities worried about selling price increases
3. Considerable concern about rebuild market

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8. Cautions by Utilities, Manufacturers, and Core Steel Makers in NOPR 77 FR 7282 10 Feb 12

a. Liquid filled single phase pads hit brick wall for efficiencies > EL1.
b. Liquid filled single phase poles already at brick wall with EL0.
c. Concerns expressed that M3 disappears with hard turn> EL1.
d. Medium Voltage Dry with mitered cores hits brick wall between EL2 and EL3.
e. LV Dry beyond EL1 must change to miter core or wound cores.
f. Small manufacturers may get squeezed out!

- Hi level letters written by NEMA and Steel Companies
- Multiple analyses submitted by several manufacturers
- Excellent analysis by Core Steel Makers
- Analysis submitted by Hopkinson
- Reality of M3 / Amorphous crossover may have been most convincing

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8. M3 and Amorphous cross over at Efficiency Level 1

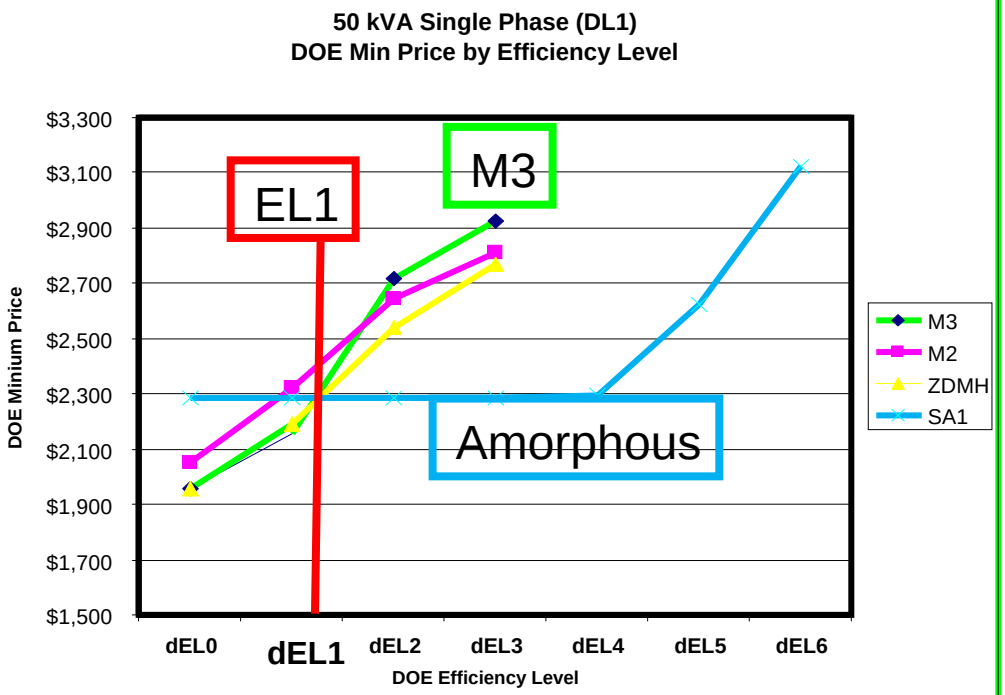

Chart Courtesy of Carlos Gaytan Based on 50 kVA single Phase Pad

Similar cost relationship for many manufacturers

- **M3, M2, and Hi B cost curves steep**
- **Amorphous cost curve flat**
- **Amorphous curve crosses M3 curve at EL1**
- **M3 not viable for efficiency > EL1**

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Design Line 12 Engineering

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

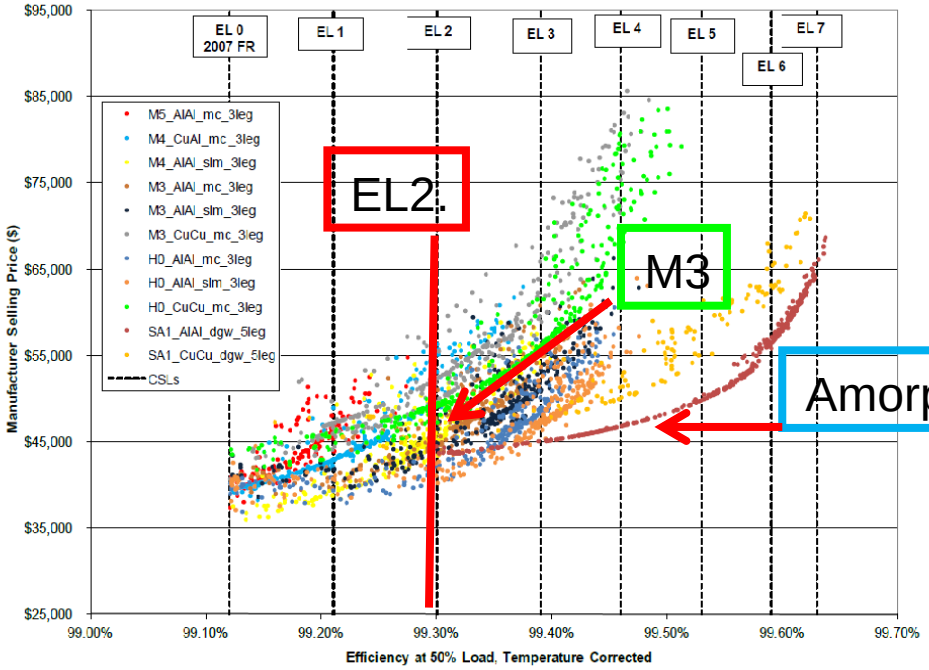

Chart Courtesy of LBL
Based on 1500 kVA Three Phase MV Dry

Similar cost relationship for many manufacturers

- **M3, M2, and Hi B cost curves steep**
- **Amorphous cost curve flat**
- **Amorphous curve crosses M3 curve at EL1**
- **M3 not viable for efficiency > EL2**

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9. Advocates Counter in February 23 Public Meeting

a. **Positive savings seen in DOE data to Efficiency Level 3 or higher. However manufacturers attribute this to an all Amorphous design.**
b. **Arguments about rebuild market rejected.**
c. **Push to reduce Measured load levels to emphasize core loss.**
    1. **35% instead of 50% for Liquid Filled Transformers**
    2. **18% instead of 35% for Low Voltage Dry Transformers**
d. **Arguments presented suggesting minimal investment required by manufacturers to move Low Voltage Dry to Miter Core.**
e. **DOE challenged to justify impact on small manufacturers.**
f. **DOE challenged to justify loading.**
g. **DOE challenged to justify breakeven point between M3 and amorphous**

Advocates challenges require further DOE investigation

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What's Ahead?

a. **Negotiations completed. Medium Voltage Dry Settled.**
b. **Public Meeting Raised new questions for DOE to study.**
c. **April 18 deadline established for public comment**
d. **DOE Final Rule targeted for October 1, 2012**

Stakeholders asked to respond to DOE's 30 questions raised in 373 page publication from February 1 DOE Public Meeting announcement
http://www1.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html

10. DOE has raised 30 Questions to Stakeholders

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

E. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1. DOE requests comment on primary and secondary winding configurations, on how testing should be required, on efficiency differences related to different winding configurations, and on how frequently transformers are operated in various winding configurations.

10. DOE has raised 30 Questions to Stakeholders

2. DOE requests comment on its proposal to require transformers with multiple nameplate kVA ratings to comply only at those ratings corresponding to passive cooling.
3. DOE requests comment on its proposal to maintain the requirement that transformers comply with standards for the BIL rating of the configuration that produces the highest losses.
4. DOE requests comment on its proposal to maintain the current test loading value requirements for all types of distribution transformers.

10. DOE has raised 30 Questions to Stakeholders

5. DOE requests comment on its proposal to require rectifier and testing transformers to indicate on their nameplates that they are for such purposes exclusively.
6. DOE requests comment on its proposal to maintain the definition of mining transformer but also requests information useful in precisely expanding the definition to encompass any activity that entails the removal of material underground, such as digging or tunneling.
7. DOE requests comment on its proposal to maintain the current kVA scope of coverage.

10. DOE has raised 30 Questions to Stakeholders

8. DOE requests comment on its proposal to continue not to set standards for step-up transformers.
9. DOE requests comment on the negotiating committee's proposal to establish a separate equipment class for network/vault transformers and on how such transformers might be defined.
10. DOE requests comment on the negotiating committee's proposal to establish a separate equipment class for data center transformers and on how such transformers might be defined.

10. DOE has raised 30 Questions to Stakeholders

11. DOE seeks comment on the operating characteristics for data center transformers. Specifically DOE seeks comment on appropriate load factors, and peak responsibility factors of data center transformers.

12. DOE requests comment on whether separate equipment classes are warranted for pole-mounted, pad-mounted, or other types of liquid-immersed transformers.

10. DOE has raised 30 Questions to Stakeholders

13. DOE requests comment on setting standards by BIL rating for liquid-immersed distribution transformers as it currently does for medium-voltage, dry-type units.

14. DOE requests comment on how best to scale across phase counts for each transformer type and how standards for either single- or three-phase transformers may be derived from the other type.

15. DOE requests comment on its proposal to scale standards to unanalyzed kVA ratings by fitting a straight line in logarithmic space to selected efficiency levels (ELs) with the understanding that the resulting line may not have a slope equal to 0.75.

16. DOE seeks comment on symmetric core designs.

10. DOE has raised 30 Questions to Stakeholders

17. DOE seeks comment on nanotechnology composites and their potential for use in distribution transformers.
18. DOE requests comment on its materials prices for both 2010 and 2011 cases.
19. DOE requests comment on the current and future availabilities of high-grade steels, particularly amorphous and mechanically-scribed steel in the United States.
20. DOE requests comment on particular applications in which transformer size and weight are likely to be a constraint and any data that may be used to characterize the problem.
21. DOE requests comment on its steel supply availability analysis, presented in appendix 3A of the TSD.
22. DOE seeks comment on its proposed additional distribution channel for liquid-immersed transformers that estimates that approximately 80 percent of transformers are sold by manufacturers directly to utilities.

10. DOE has raised 30 Questions to Stakeholders

23. DOE seeks comment on any additional sources of distribution transformer load data that could be used to validate the Energy Use and End-Use Load Characterization analysis. DOE is specifically interested in additional load data for higher capacity three phase distribution transformers.

24. DOE seeks comment on its pole replacement methodology that is used estimate increased installation costs resulting from increased transformer weight due the proposed standard. The pole replacement methodology is presented in chapter 6, section 6.3.1 of the TSD.

25. DOE seeks comment on recent changes to utility distribution transformer purchase practices that would lead to the purchase of a refurbished, specifically re-wound, distribution transformer over the purchase of new distribution transformer.

10. DOE has raised 30 Questions to Stakeholders

26. DOE seeks comment on the equipment lifetimes of refurbished, specifically re-wound distribution transformers and how it compares to that of a new distribution transformer.

27. DOE seeks comment on recent changes in distribution transformer sizing practices. In particular, DOE would like comments on any additional sources of data regarding trends in market share across equipment classes for either liquid-immersed or dry-type transformers that should be considered in the analysis.

28. DOE requests comment on the possibility of reduced equipment utility or performance resulting from today's proposed standards, particularly the risk of reducing the ability to perform periodic maintenance and the risk of increasing vibration and acoustic noise.

10. DOE has raised 30 Questions to Stakeholders

29. DOE requests comment and corroborating data on how often distribution transformers are operated with their primary and secondary windings in different configurations, and on the magnitude of the additional losses in less efficient configurations.

30. DOE requests comment on impedance values and on any related parameters (e.g., inrush current, X/R ratio) that may be used in evaluation of distribution transformers. DOE requests particular comment on how any of those parameters may be affected by energy conservation standards of today's proposed levels or higher.

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11. Comment Period ends April 18, 2012.

- **a. NEMA sending in Comments.**
- **b. Others encouraged to comment.**

DOE needs data and arguments to support their NOPR Proposal

Distribution Transformer Energy Efficiency Task Force

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12. Significant Background Documents

a. NEMA letter to Secretary Chu
b. Steel Company letter to Secretary Chu
c. DOE Summary Presentation and White Paper by Cooper
d. HVOLT DOE Analysis 092411
e. ProlecGE Simplified Cost Efficiency Charts
f. ABB analysis
g. Core Steel Comparison

DOE needs data and arguments to support their NOPR Proposal

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Key Issues to establishing New Standards

1. **Transformer RMS Equivalent Load proposed to remain unchanged**
   a. Currently 35% for LV
   b. Currently 50% for MV
2. **Present worth value of a watt saved in 30 years with 3% inflation and 7% cost of money**
   a. Worth may be $6.71 for Utilities
   b. Worth probably < $9.91 for Industrials and Commercials as 30 years horizon believed excessive by manufacturers and users
3. **Core materials to be the basis of a minimum national standard**
   a. **M3 believed to be limit by manufacturers and domestic steel makers**
   b. Amorphous pushed by Conservation advocates
4. **Transformer selling price versus efficiency**
   a. OPS data questioned by LV and MV manufacturers
   b. Cost data some issues on materials costs.

References of Value

1. **DOE Materials**
   a. August 31, 2011 issued documents
   b. March 2011 documents
   c. Updated February, 2012
2. **Studies by Carlos Gaytan, Wes Patterson, and Phil Hopkinson**
   a. M3 based designs have steep cost curve versus efficiency
   b. The cost /watts saved for each makes higher efficiency look costly
   c. Amorphous cost curve much flatter versus efficiency
3. **AK Steel Global steel report**
   a. M3 believed as far as domestics can support
   b. ZDMH not available in the US
   c. Amorphous not adequately available to support 100% of DT's
4. **Reports by Utilities, Amorphous makers, users including field failures**
   a. Loading examined
   b. Field failures analyzed.

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DOE Material Cost Reference for Liquid Filled Transformers

Table 5.4.1 Typical Manufacturer's Material Prices for Liquid-Immersed Design Lines

Material	Units	2010 Price *2010$*	Min. Price (2006 – 25%) *2010$*	Max. Price (2008 + 25%) *2010$*	2010 *2010$*	2009 *2010$*	2008 *2010$*	2007 *2010$*	2006 *2010$*
M6 core steel	*$/lb*	$ 1.46	$ 0.94	$ 2.19	$ 1.46	$ 1.64	$ 1.75	$ 1.58	$ 1.26
M5 core steel	*$/lb*	$ 1.51	$ 0.99	$ 2.24	$ 1.51	$ 1.67	$ 1.79	$ 1.61	$ 1.32
M4 core steel	*$/lb*	$ 1.59	$ 1.03	$ 2.30	$ 1.59	$ 1.70	$ 1.84	$ 1.64	$ 1.38
M3 core steel	*$/lb*	$ 1.88	$ 1.06	$ 2.60	$ 1.88	$ 1.96	$ 2.08	$ 1.70	$ 1.41
M3 core steel (Lite Carlite)	*$/lb*	$ 1.95	$ 1.47	$ 2.44	$ 1.95	$ -	$ -	$ -	$ -
M2 core steel	*$/lb*	$ 2.00	$ 1.32	$ 2.79	$ 2.00	$ 2.01	$ 2.23	$ 2.18	$ 1.76
M2 core steel (Lite Carlite)	*$/lb*	$ 2.10	$ 1.58	$ 2.63	$ 2.10	$ -	$ -	$ -	$ -
ZDMH (mechanically-scribed core steel)	*$/lb*	$ 2.05	$ 1.41	$ 3.22	$ 2.05	$ 2.02	$ 2.57	$ 2.29	$ 1.88
SA1 (amorphous) finished core, volume production	*$/lb*	$ 2.38	$ 1.72	$ 3.64	$ 2.38	$ 2.29	$ 2.91	$ -	$ -
Copper wire, formvar, round #10-20	*$/lb*	$ 4.87	$ 3.33	$ 5.97	$ 4.87	$ 3.81	$ 4.77	$ 4.78	$ 4.44
Copper wire, enameled, round #7-10	*$/lb*	$ 4.84	$ 3.31	$ 5.93	$ 4.84	$ 3.78	$ 4.74	$ 4.75	$ 4.41
Copper wire, enameled, rectangular sizes	*$/lb*	$ 4.97	$ 3.41	$ 6.09	$ 4.97	$ 3.91	$ 4.87	$ 4.88	$ 4.54
Aluminum wire, formvar, round #9-17	*$/lb*	$ 3.07	$ 2.30	$ 3.91	$ 3.07	$ 3.00	$ 3.13	$ 3.08	$ 3.07
Aluminum wire, formvar, round #7-10	*$/lb*	$ 2.57	$ 1.93	$ 3.28	$ 2.57	$ 2.50	$ 2.63	$ 2.58	$ 2.57
Copper strip, thickness range 0.02-0.045	*$/lb*	$ 4.97	$ 3.41	$ 6.09	$ 4.97	$ 3.91	$ 4.87	$ 4.88	$ 4.54
Copper strip, thickness range 0.030-0.060	*$/lb*	$ 4.97	$ 3.41	$ 6.09	$ 4.97	$ 3.91	$ 4.87	$ 4.88	$ 4.54
Aluminum strip, thickness range 0.02-0.045	*$/lb*	$ 2.08	$ 1.56	$ 2.67	$ 2.08	$ 2.01	$ 2.14	$ 2.09	$ 2.08
Aluminum strip, thickness range 0.045-0.080	*$/lb*	$ 2.08	$ 1.56	$ 2.67	$ 2.08	$ 2.01	$ 2.14	$ 2.09	$ 2.08
Kraft insulating paper with diamond adhesive	*$/lb*	$ 1.52	$ 1.17	$ 1.93	$ 1.52	$ 1.54	$ 1.54	$ 1.56	$ 1.56
Mineral oil	*$/gal*	$ 3.35	$ 1.94	$ 3.84	$ 3.35	$ 2.89	$ 3.07	$ 2.51	$ 2.59
Tank Steel	*$/lb*	$ 0.38	$ 0.32	$ 0.60	$ 0.38	$ 0.39	$ 0.48	$ 0.43	$ 0.43

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Future Posted Materials

1. **Reference Materials released to me**
2. **Decisions by DOE**

Next Meeting in Milwaukee