

DOE Energy Efficiency for Distribution Transformers

By PJ Hopkinson, PE 04/01/07

- DOE Direction for Liquid Filled Transformers
- Flaws in DOE Tables TSL-2, TSL-3, and TSL-4
- Stakeholder Comments
- Dry Type Transformer direction
- Quick focused action needed to correct Problems
- Proposed action

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DOE Direction For Liquid Filled Transformers as of 3/21/07

Single Phase: TSL 3-4

Three Phase: TSL 2-3

Note: Direction indicated to Phil Hopkinson
by Tony Bouza on 3/21/07

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DOE TSL Definitions:

TSL1: NEMA TP-1

TSL-2: 1/3 way from TSL-1 to Life Cycle Cost Minimization point (LCC)

TSL-2: 2/3 way from TSL-1 to LCC

TSL-4: LCC

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Closer Look at LCC:

1. Determined by DOE subcontractor, Paul Gothe using OPS (Optimized Program Services) software.
2. Calculates energy consumption over entire 30 year expected life of transformer.
3. Used material costs that were the norm prior to 2004.
4. Assumes 1%/year load growth over life of product.
5. **Resulting designs not checked by careful Peer review prior to publication.**

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Flaw found in 3-Phase LCC

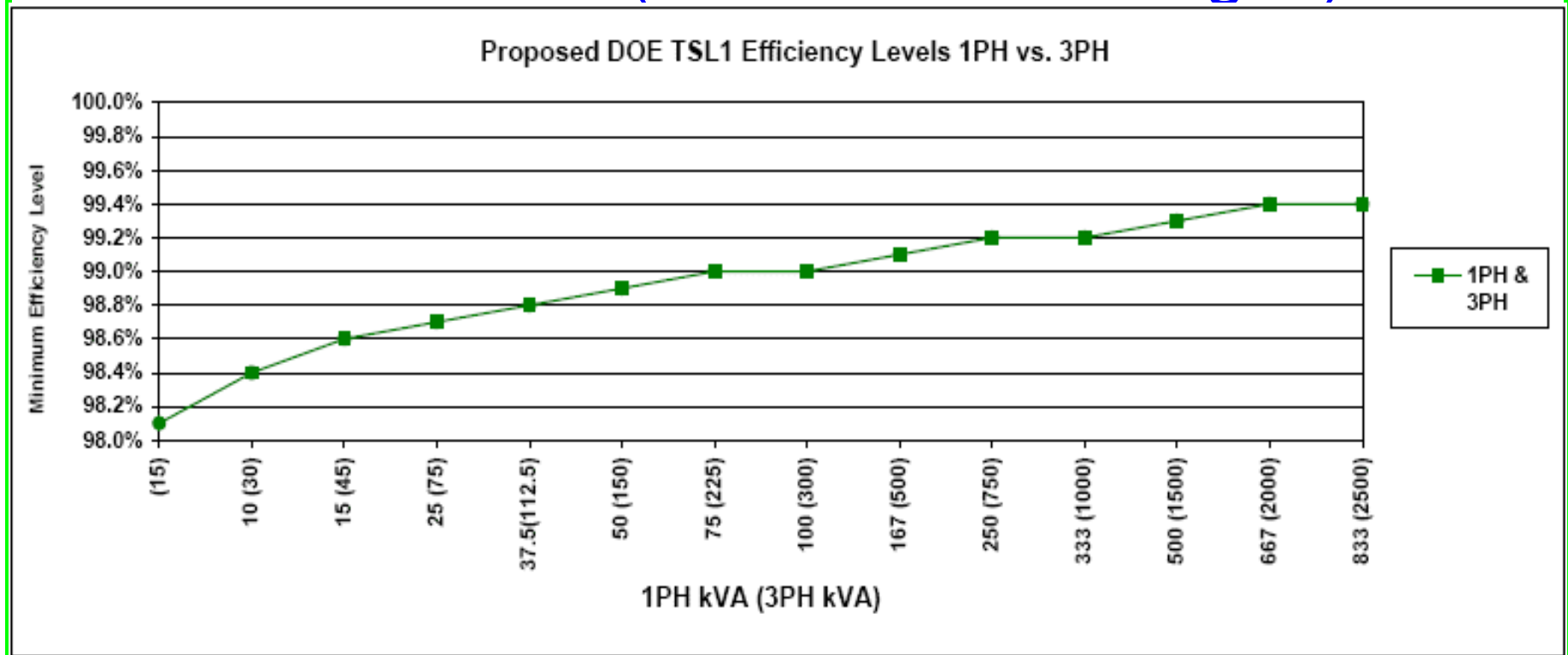
1.3 multiplying factor missing on core loss for transformers <750 kVA 3-Phase

Implies higher efficiency than is justifiable from real designs

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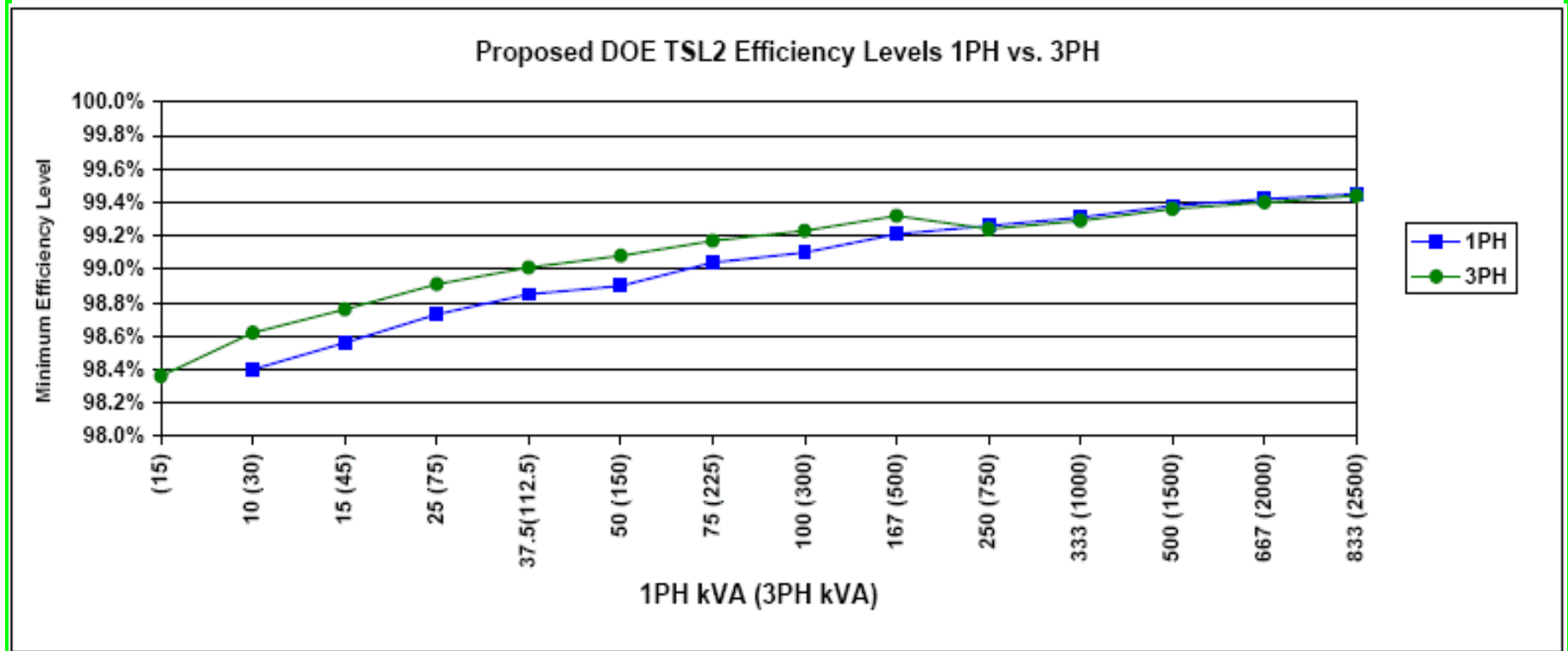
DOE TSL-1 (NEMA TP-1 Designs)



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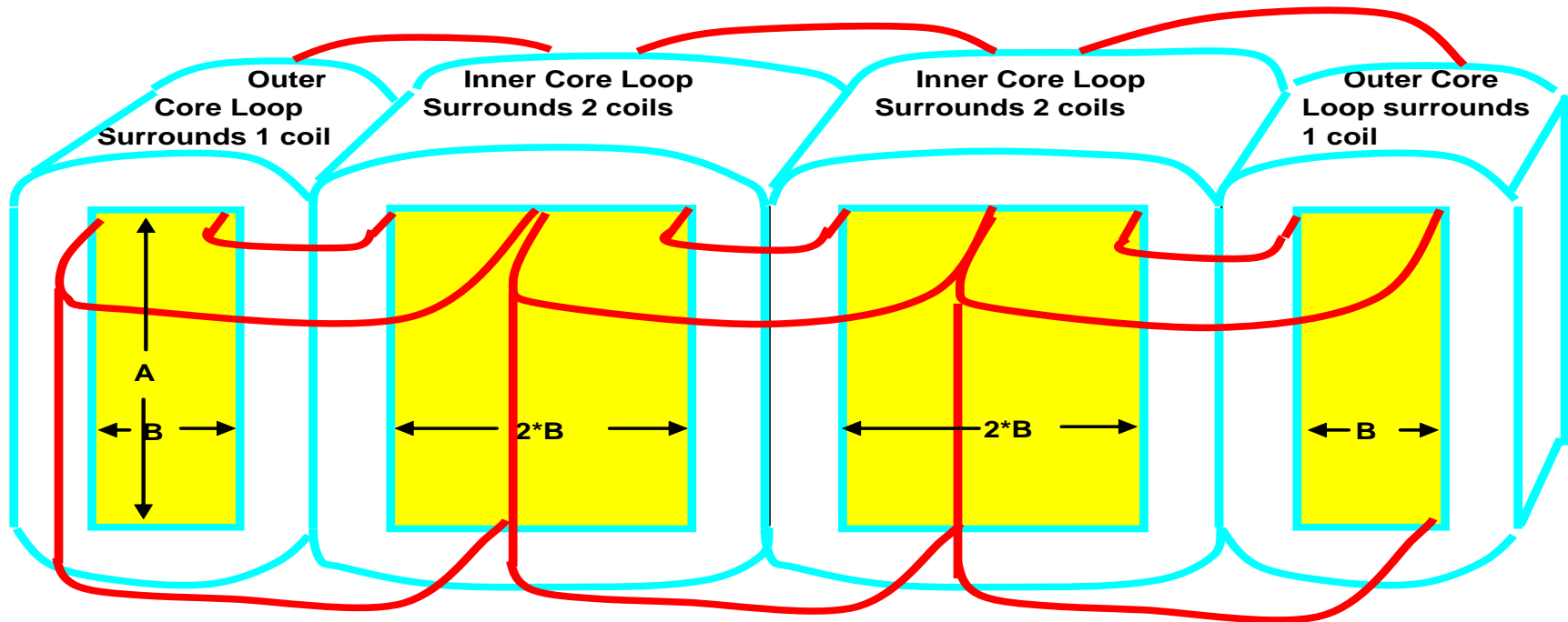
DOE TSL-2



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The 3-Phase Transformer



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The 3-Phase Transformer

1-Phase Core loss watts = watt/lb * Weight

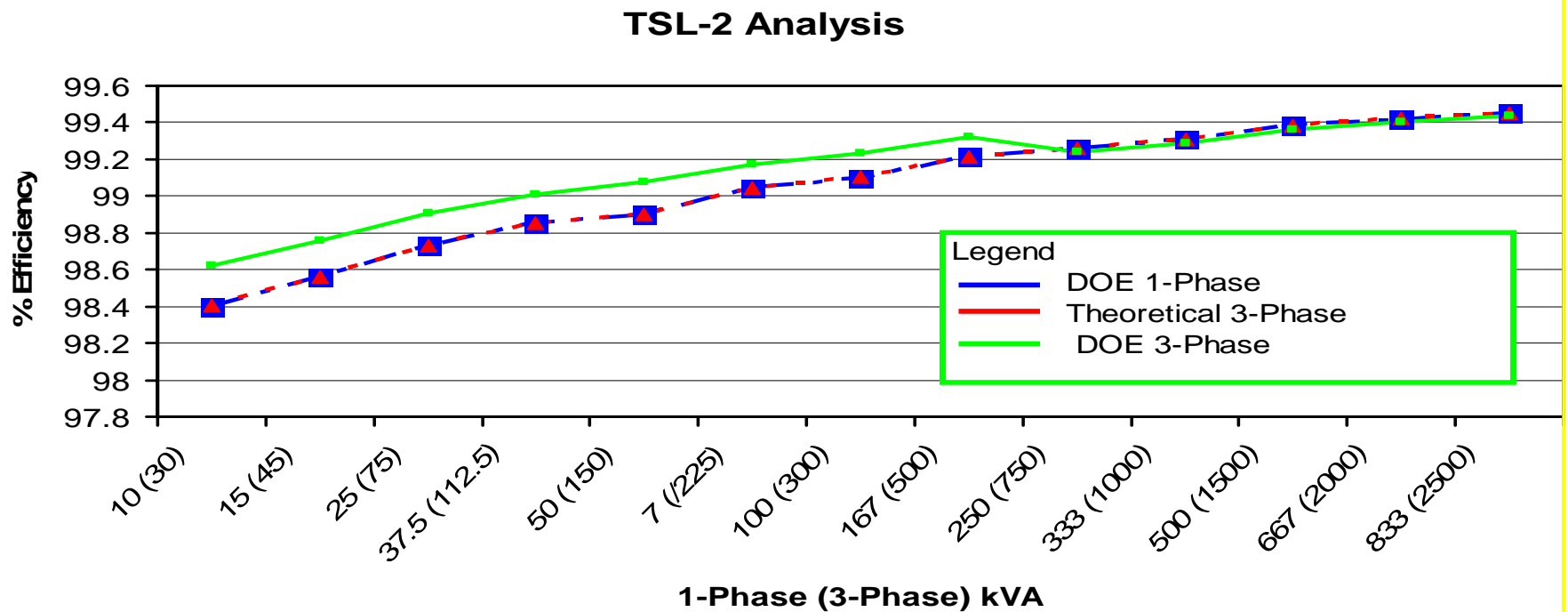
3-Phase Core loss watts = watt/lb. * weight * **1.3**

The 1.3 factor necessary to account for 3rd harmonic flux in wound cores

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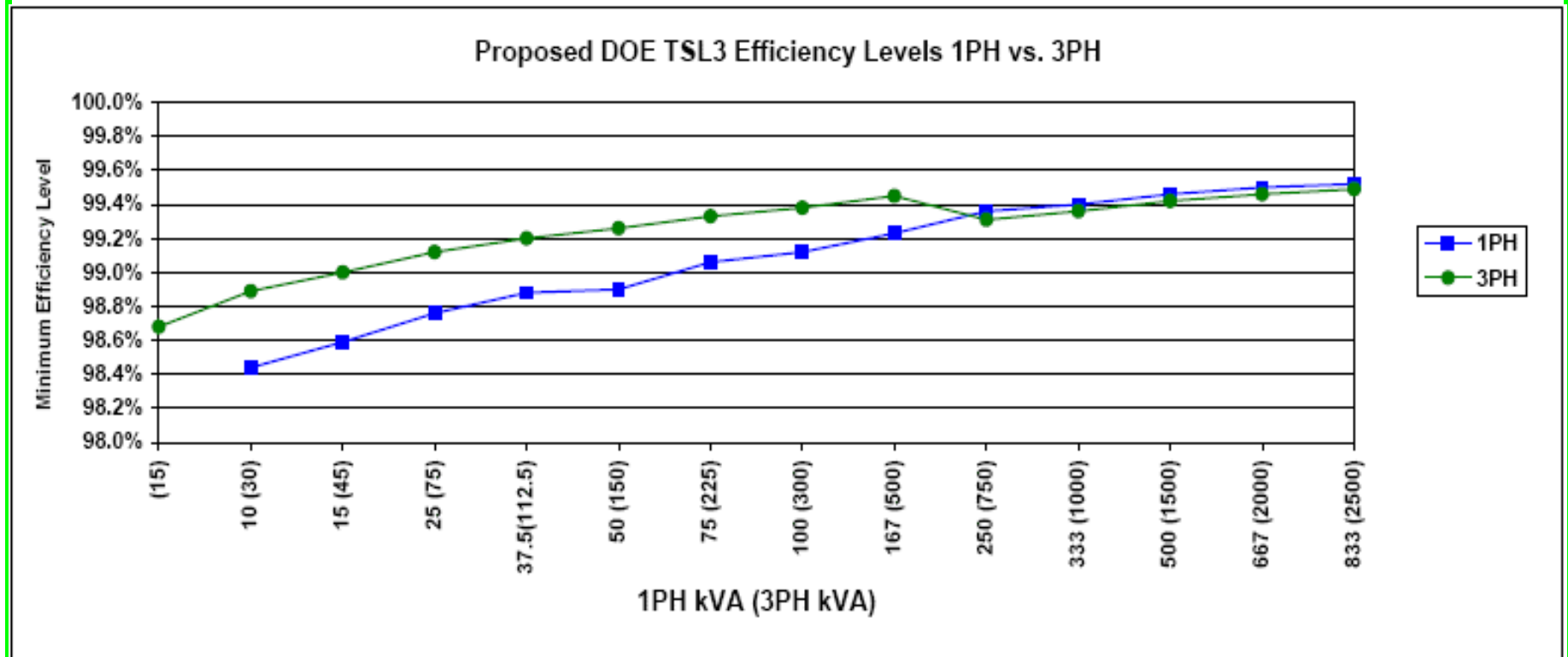
Hypothetical TSL-2 recalculated including 1.3 factor



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3-Phase errors widen for TSL-3

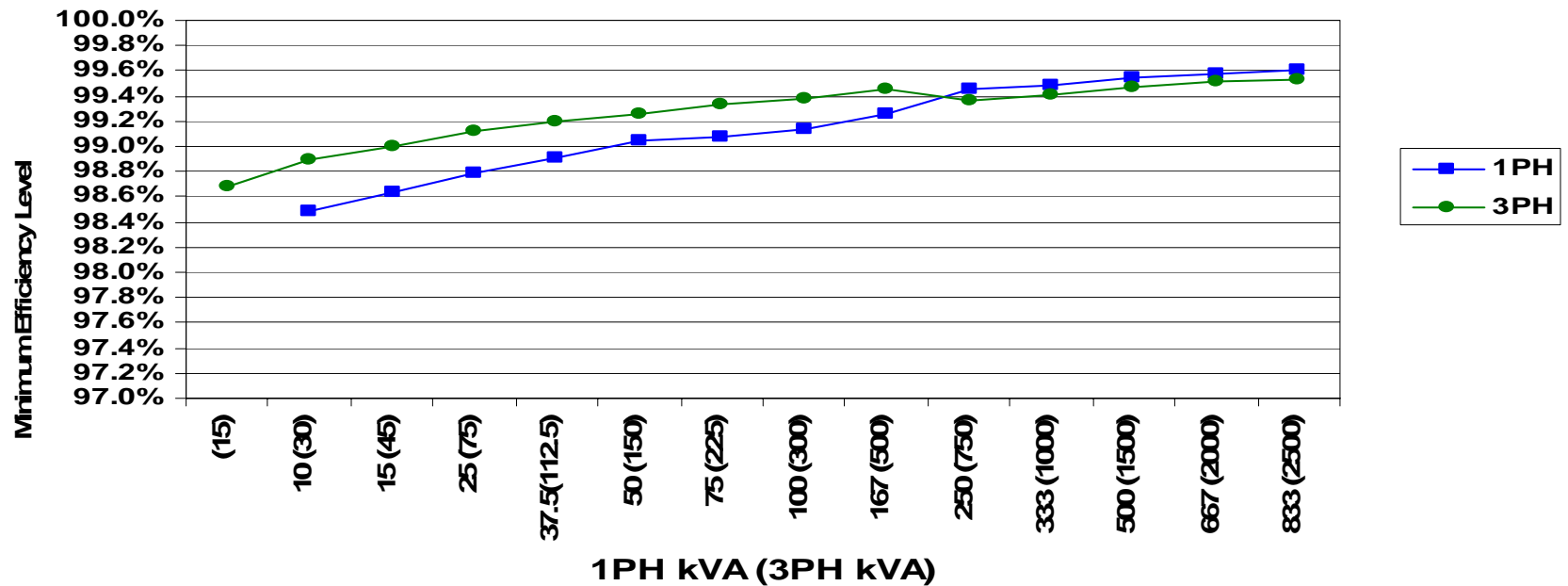


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3-Phase errors continue for TSL-4

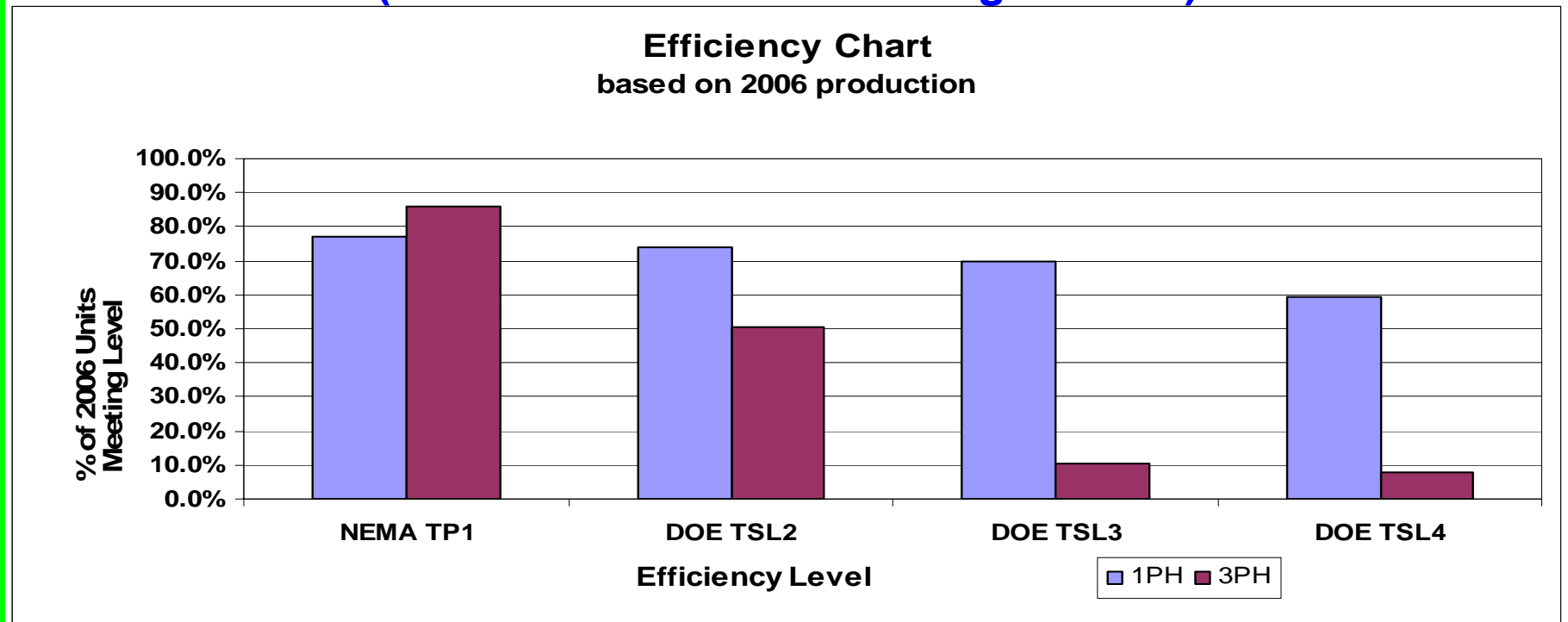
Proposed DOE TSL4 Efficiency Levels 1PH vs. 3PH



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**3-Phase errors obvious with this graph
(ERMCO Production meeting TSL 1-4)**



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Stakeholder Comments Summary

- 181 Comments submitted
- Representation from Manufacturers, Customers, Canada, and Interested parties
- EEI, NRDC, GE, and Green Groups want TSL-4
- Several key Utilities want TSL-4
- Howard wants TP-1
- ERMCO wants TSL-2
- Canada proposes TP-1
- Generally, those who only read the 1-Phase want TSL-4
- Howard, Cooper, ERMCO and ABB see problems with 3-Phase

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Stakeholder Comments Summary

#158: Key Input dated Feb, 9 of 2007

- Edison Electric Institute
- American Public Power Association
- Natural Resources Defense Council
- American Council for an Energy-Efficient Economy
- Alliance to Save Energy
- Northeast Energy Efficiency
- Partnership Appliance Standards Awareness Project

Two Tiered Proposal

- **Purchase 80% of all Distribution Transformers sold in the US**
- **Propose TSL-2 for Compliance 1/1/09**
- **Propose TSL-4 for compliance for 1/1/13**

No differentiation for 1-Phase, 3-Phase, Liquid or Dry

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Stakeholder Comments Summary

#157: Justice Department

- Concerned about standards more stringent than TSL-2
- Concerned about size limitations
- Concerned about disadvantaged suppliers
- Concerned about lessened competition
- Seems to concentrate on Coal Mines

No specific action only raised questions

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DOE Thoughts on Medium Voltage Dry Type Transformers

Three BIL Levels

- 20-45 kV BIL
- 46-95 kV BIL
- >96 kV BIL

Four TSL Levels: 1, 2, 3, and 4

1-Phase and 3-Phase equivalents in line at all kVA's

DOE Direction favors TSL-2 for all Dry Transformers

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Summary Of Potential Problems with DOE Program

1. Liquid 3-phase transformers <750 kVA disadvantaged relative to Single Phase.
2. Liquid 3-Phase transformers <750 kVA disadvantaged relative to Dry Transformers

Hits the Justice Department concern and left uncontested would alter market preferences.

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Phil Hopkinson appointed IEEE Distribution Transformer Subcommittee Chair to bring concerns to DOE on 3/14/07 at IEEE Timing is most important as March 12 Deadline has passed

Two-Prong Direction planned:

- 1. Send Letter to DOE pointing out the problems with the present 3-phase Liquid Filled Transformer TSL-2, TSL-3, and TSL-4**
- 2. Send duplicate copy to IEEE Distribution Transformers Subcommittee Chair, Ken Hanus for IEEE Endorsement.**

Best chance to correct problems

Would then allow TSL-4 selection for 1-Phase or 3-Phase with no hardship for Liquid Filled Industry