ENERGY STAR Distribution Transformers
Draft Specification Framework
December 9 2014

Please send comments to DistributionTransformers@energystar.gov no later than January 28, 2015

Background

The ENERGY STAR program, administered by the U.S. Environmental Protection Agency (EPA), with support from the U.S. Department of Energy (DOE), serves to identify energy-efficient products in the marketplace. For each product category, a tailored specification that sets the efficiency criteria that a product must meet to earn the ENERGY STAR label is developed. This specification development process relies on rigorous market, engineering, and energy savings analyses as well as collaboration with industry and other stakeholders. For new ENERGY STAR product categories, once a final specification is released, eligible products that have demonstrated compliance with the program requirements through an established third-party certification process may display the ENERGY STAR label.

With the launch of all ENERGY STAR new product specification development efforts, EPA engages early with stakeholders and often releases a framework document that initiates development of an approach for the specification as well as definitions and eligibility criteria. The ENERGY STAR specification development effort is an open and transparent process that depends on industry stakeholder engagement. As such, this ENERGY STAR Distribution Transformers specification framework includes requests for stakeholder clarification on issues key to developing an effective voluntary energy efficiency program.

Energy Savings Opportunity and Rationale for Labeling Distribution Transformers with ENERGY STAR

Since the most recent DOE standards, set to take effect in January 2016[1,2], EPA evaluated and identified an opportunity to advance medium voltage, liquid-immersed transformers whose energy efficiency can exceed the forthcoming standards. In its 2014 scoping report (see www.energystar.gov/scoping), EPA found that the efficiency of medium voltage, liquid-immersed distribution transformers can be increased beyond the 2016 federal standards by improving the material of the core and windings or altering the geometric configuration of the transformer for the specific application. In improving the efficiency of individual medium voltage, liquid-immersed transformers, resultant savings could grow to approximately 4-5 TWh per year if, over time, half of all newly installed and replaced medium voltage, liquid-immersed distribution transformers are more efficient than conventional ones.[3] EPA identified medium voltage, liquid-immersed distribution transformers as providing the greatest savings potential based on both opportunity for improvements in efficiency and market demand. For example, in 2009, the most recent year for which EPA has shipment data, approximately 740,000 units of medium voltage, liquid-immersed transformers shipped in the U.S. with a capacity of about 60,000 MVA. Shipments are projected to remain steady during the coming decade. In contrast, low voltage transformers represented only about 225,000 units shipped[4].

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[1] U.S Department of Energy (DOE): Distribution Transformers, Rulemaking for Low-Voltage Dry-Type Distribution Transformers Energy Conservation Standard, http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/43.

[2] DOE: Distribution Transformers, Rulemaking for Liquid-Immersed and Medium-Voltage Dry-type Distribution Transformers Energy Conservation Standard, http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/44.

[3] U.S. Environmental Protection Agency (EPA): "Market and Industry Scoping Report for Medium Voltage Transformers", February 2014, www.energystar.gov/scoping.

[4] U.S. Department of Energy (DOE): Technical Support Document, http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0048-0760.

In subsequent analysis, EPA determined that payback from more efficient medium voltage liquid-immersed transformers via avoided generation and capital costs varies by equipment class but is approximately 8-10 years. Since the lifetime of these products is approximately 32 years, EPA considers the payback period to be reasonable. Such payback analysis also reflects the use of the Total Cost of Ownership (TCO) approach that EPA encouraged utilities to use when evaluating more efficient transformers in its previous transformers program. With more efficient transformers, utilities, especially those tied to generation, could benefit from more energy efficient distribution transformers if such additional efficiency helps avoid costs associated with purchasing more energy and/or developing additional capacity.[5]

Currently, the most efficient transformers tend to be more expensive than conventional ones.[6] After discussion with stakeholders, EPA considers that an ENERGY STAR designation for more efficient medium voltage, liquid-immersed distribution transformers may help incentivize the manufacture and purchase of more efficient transformers, with the aim of driving down costs and, thus, transforming the market.

Opportunity to Overcome Market Barriers to Uptake of Efficient Transformers

In speaking with stakeholders, EPA identified purchasing practices and regulatory structures as the largest barriers to employing more efficient transformers. Though utilities are encouraged to examine the long-term impact of distribution system purchases, seek alternatives, and report the resulting efficiency in some states,[7] in many cases, utilities—including both investor-owned and municipally-owned utilities—remain incentivized to seek lowest-cost transformers, despite the 8-10 year payback with more efficient models. In addition, for utilities not using a TCO approach, regulatory structures often limit their ability to recover costs for investing up front in more efficient technology. Therefore, more efficient transformers may be most attractive for utility purchasers who use a TCO approach and/or those who are able to recover costs. EPA's aim is to increase the availability of more efficient choices in the market via the ENERGY STAR program. In doing so, we expect the price to decrease so that up-front costs are less of a barrier.

During its scoping, EPA also identified a number of opportunities not previously available or widely recognized that allow for more favorable manufacture and uptake of more efficient transformers. First, EPA has learned that production capacity can be scaled up to increase the domestic supply of amorphous steel used to create the most efficient medium-voltage, liquid-immersed transformers.[8] According to stakeholders, production can be scaled up with limited capital investments to increase the supply of these transformers to meet the projected demand due to the ENERGY STAR program.[9] Moreover, the amorphous ribbon material used to manufacture amorphous cores was initially patented, but the patents have expired.[10] While some stakeholders consider efficient transformers to be less reliable, EPA learned that the materials in amorphous core transformers were comparatively stable and reliable after undergoing accelerated aging processes when evaluated against the performance of traditional transformers.[11] Though ferroresonance can be corrected by adding an arrester either outside or inside the transformer at a cost of approximately $100,[12] small changes to the operating practices of utilities can also correct ferroresonance without additional cost. Lastly, EPA has come to understand that while amorphous cores are often

[5] EPRI/CRIEPI, "Commercial Acceptance of the Amorphous Metal Distribution Transformer", http://digitalcollections.library.cmu.edu/awweb/awarchive?type=file&item=486173.

[6] M. Scholand, T. Blackburn, E. Carey, P. Hopkinson and M. Sampat: "SEAD Standards & Labelling Working Group Distribution Transformers Collaboration," CLASP, 2013.

[7] G. Daniels (MA Dept. of Public Utilities), Telephone Interview, with Matt Malinowski (ICF International), 21 March 2014.

[8] D. Millure, J. Allen (Metglas), and P. Ryan (Hitachi Metals America Ltd.), Interviewees, Telephone Interview with Matt Malinowski (ICF International), 28 March 2014.

[9] R. Dugan (EPRI). Email Correspondence with Douglas Frazee (ICF International) 31 January 2013.

[10] D. Millure et al.

[11] CIRED, "Amorphous Materials and Energy Efficient Distribution Transformers," June 2010.

[12] B. Kennedy, *Energy Efficient Transformers*. New York: McGraw-Hill, 1998, 146.

larger than a silicon steel core due to a lower space factor and lower flux density,[13] more efficient medium-voltage, liquid-immersed transformers that make use of amorphous cores may actually be smaller and lighter than previously thought because their higher efficiency requires less heat-sinking.[14] Therefore, current models may not be as costly or challenging to install.

Specification Framework

This framework is intended to outline EPA's initial assessment of distribution transformers for the purpose of developing a first draft Version 1.0 specification. Included are EPA's initial thoughts on terms and definitions, scope, test method, and structure of efficiency requirements. EPA developed this framework document to mirror the ENERGY STAR specification structure and included questions to generate discussion about the proposed approach and further EPA's understanding of this product category. Please note that this document is not intended to be a comprehensive review of the ENERGY STAR perspective on distribution transformers. Rather, this framework serves as a starting point for EPA's specification development efforts.

I. Definitions

A. *Purpose*: Each product specification has its own set of terms and definitions that explicitly describe the features and functionality of products covered by the specification.

B. *Approach*: EPA prefers to make use of existing, industry accepted definitions and aligns with DOE's definitions. The definitions will be aligned with those adopted by DOE in the Code of Federal Regulations, 10 CFR 431.192.

Feedback Request: Should EPA consider any definitions in addition to those in the Code of Federal Regulations, 10 CFR 431.192?

II. Scope

A. *Purpose*: In each product specification, EPA identifies specific product categories to be covered by the specification and, likewise, identifies product types that are ineligible for ENERGY STAR qualification. Products are ineligible for inclusion in the scope of the specification if they are unable to be tested with the identified test method, feature proprietary technologies, have limited availability of efficiency data, or are not able to be differentiated from conventional products based on their energy efficiency.

B. *Approach*: EPA proposes that the scope of the transformers specification include medium voltage, liquid-immersed distribution transformers that operate between 1–36 kV input voltage.

Feedback Request: Should EPA consider including other sizes and types of distribution transformers, based on their energy savings potential?

III. Qualification Criteria

A. *Purpose*: Once products' eligibility is determined, EPA will identify applicable metrics and propose energy efficiency performance criteria that recognize the top performing products in the marketplace. Efficiency metrics referenced by the ENERGY STAR specification are based on widely accepted test procedures.

B. *Approach*: EPA is considering proposing the Trial Standard Level (TSL) 4 efficiency values that were outlined in the DOE technical support document used to develop the 2016 standards[15] as a starting point for the first draft of a specification for medium voltage, liquid-immersed transformers. TSL 4 represents the efficiencies that will result in the maximum net present value at a 7% discount rate. Table 1 below shows the efficiency gains of TSL 4 (highlighted in green) compared to the January 2016 Federal Standards (highlighted in yellow). The design lines are based on representative liquid-immersed units that have a given capacity, number of phases, and geometry.

[13] B. Kennedy, 139–140, 145–146.

[14] D. Millure et al.

[15] U.S. Department of Energy (DOE): Technical Support Document

Table 1: TSL 4 efficiency levels versus TSL 1, the January 2016 Federal Standard levels, for liquid-immersed distribution transformer design lines[16]

Design Line	Baseline	TSL						
		1	2	3	4	5	6	7
	Percent							
1	99.08	99.11	99.16	99.16	99.22	99.25	99.31	99.50
2	98.91	98.95	99.00	99.00	99.07	99.11	99.18	99.41
3	99.42	99.49	99.48	99.51	99.57	99.54	99.61	99.73
4	99.08	99.16	99.16	99.16	99.22	99.25	99.31	99.60
5	99.42	99.48	99.48	99.51	99.57	99.54	99.61	99.69

EPA is also aware of international energy efficiency harmonization efforts for distribution transformers and will consider these during the specification development process.

Feedback Request:

a. EPA is seeking feedback on the approach under consideration.
b. Should EPA consider other product characteristics that provide energy savings opportunities for inclusion in the specification, such as 'smart' functionality (i.e., ability to communicate and respond to fluctuations in supply and demand)?

IV. Test Method

A. *Purpose*: Product testing has the following important roles:
   a. To yield accurate and repeatable energy consumption values for establishing ENERGY STAR levels;
   b. To create a level playing field and fair comparison of products; and
   c. To verify labeled products are performing at the appropriate levels and delivering on ENERGY STAR's promise to consumers.

B. *Approach*: EPA will use the Department of Energy (DOE) test procedure in 10 CFR 431.193.
Feedback Request: In addition to the load percentages outlined in the DOE test procedure, should distribution transformers also be tested at other load percentages to optimize energy efficiency for specific applications? Efficiency at other loading points would be determined via the DOE test procedure.

As EPA moves forward with developing new program requirements, EPA will solicit input from all stakeholders on an ongoing basis via draft specifications, e-mail correspondence, and stakeholder meetings.

Next Steps and Schedule

No later than **January 28, 2015**, stakeholders are encouraged to submit written comments on the specification framework as well as any feedback associated with the development of an ENERGY STAR specification for medium voltage, liquid-immersed distribution transformers. Please send all comments and supporting information to distributiontransformers@energystar.gov. EPA will host a launch webinar on January 14, 2015 to discuss further. EPA thanks you for your interest in the transformers specification and looks forward to working with you on its development.

Launch Webinar	January 14, 2014
Deadline for Written Comments on Framework Document	January 28, 2015
Draft 1 Specification Issued	February/March 2015
Draft 1 Stakeholder In-Person Meeting	March 2015
Additional Draft Specifications Issued and Associated Stakeholder Webinars	Spring/Summer 2015
Final Specification Issued	Summer/Fall 2015
Specification Effective	Summer/Fall 2015

[16] U.S. Department Of Energy (DOE), "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers Final Rule," 78 FR 23397