

# Eaton helps utilities meet 2016 U.S. Department of Energy efficiency requirements

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***New U.S. Department of Energy (DOE) efficiency standards for distribution transformers, which go into effect on January 1, 2016, require an increase in the electrical efficiency of critical equipment that distributes power. The changes will impact transformer designs and costs for utility applications. Understanding the new standard and its impact will help ensure a seamless transition to compliant transformer designs.***

## The benefits of transformer efficiency

Small increases in transformer efficiency can result in substantial savings because transformers typically operate continuously. As a result of this action, there will be a reduction in greenhouse gases.

Over the next 30 years, the national benefits of increasing transformer efficiency are expected to eliminate the need for 3.63 quadrillion British thermal units (Btu) of energy, which is roughly equivalent to the energy consumed by 40 million American households in one year. Approximately 264.7 million metric tons of carbon dioxide emissions will also be avoided, which is comparable to removing more than 51 million passenger vehicles from the road for one year. Additional expected benefits include the removal of 203,000 metric tons of nitrogen oxides, 182,900 metric tons of sulfur dioxide and 1,200 pounds of mercury.

## Transformer design changes

End users are in the process of updating their transformer specifications to include efficiencies that meet the DOE 2016 requirements; as a result, transformer size, weight and cost may increase. These changes will be design-dependent and determined based on changes between existing and new transformer designs.

Manufacturers are leading the transition to the new standard and working with utilities to plan for the impact of the efficiency changes. Eaton is optimizing transformer designs to meet the new DOE requirements while maintaining customer-specific design attributes.

## Exploring the scope of the new standards

The DOE 2016 standards will impact distribution transformers manufactured for sale in or imported into the U.S. This includes both medium- and low-voltage dry-type transformers and liquid-immersed medium-voltage distribution transformers; the required efficiency increases vary by transformer type and voltage rating.

Ruling applies to the following transformers	Ruling does not apply to the following transformers
<ul style="list-style-type: none"> <li>• Manufactured (or imported) for sale in the U.S. after January 1, 2016</li> <li>• Low-voltage dry-type</li> <li>• Medium-voltage dry-type</li> <li>• Liquid-filled distribution</li> <li>• Single-phase: 10–833 kVA</li> <li>• Three-phase: 15–2500 kVA</li> <li>• Input voltage of 34.5 kV or less</li> <li>• Output voltage of 600 V or less</li> </ul>	<ul style="list-style-type: none"> <li>• Autotransformers</li> <li>• Drive (isolation)</li> <li>• Grounding</li> <li>• Machine-tool (control)</li> <li>• Non-ventilated</li> <li>• Rectifier</li> <li>• Regulating</li> <li>• Sealed</li> <li>• Special impedance</li> <li>• Testing</li> <li>• Those with tap ranges of 20 percent or more</li> <li>• Those that are used, rebuilt or refurbished</li> <li>• Underground mining (medium- voltage dry-type only)</li> <li>• Uninterruptible power supply</li> <li>• Welding</li> </ul>

**Figure 1. DOE 2016 scope. This list is not exhaustive, but covers the most common exceptions.**



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## Exploring the scope of the new standards continued

The new requirements update the 2010 DOE-established guidelines, which were the first official transformer efficiency standards in the U.S. The increase in efficiency levels is the only significant change between the 2010 and 2016 guidelines. Otherwise, the new rule is much like the previous one; it's identical in scope, compliance methodology and exceptions. The regulations outline efficiency requirements according to transformer type (liquid vs. dry-type distribution transformers), single- or three-phase transformers, ampere rating, and basic impulse level (dry-type transformers only).

Previously, the DOE 2010 regulations targeted efficiencies ranging from 98.36 to 99.49 percent; the updates that take effect in 2016 further increase efficiency, ranging from 98.70 to 99.55 percent. (Figures 2 and 3 show the efficiency requirements for liquid-immersed distribution transformers per the DOE 2016 regulations).

### Single-Phase Liquid-Immersed Distribution Transformer Efficiencies

Phase Quantity	kVA	DOE 2010 Efficiency Percent	DOE 2016 Efficiency Percent
1	10	98.62	98.70
1	15	98.76	98.82
1	25	98.91	98.95
1	37.5	99.01	99.05
1	50	99.08	99.11
1	75	99.17	99.19
1	100	99.23	99.25
1	167	99.25	99.33
1	250	99.32	99.39
1	333	99.36	99.43
1	500	99.42	99.49
1	667	99.46	99.52
1	833	99.49	99.55

**Figure 2. (Department of Energy Conservation Program: Energy Conservation Standards for Distribution, 2013)**

### Three-Phase Liquid-Immersed Distribution Transformer Efficiencies

Phase Quantity	kVA	DOE 2010 Efficiency Percent	DOE 2016 Efficiency Percent
3	15	98.36	98.65
3	30	98.62	98.83
3	45	98.76	98.92
3	75	98.91	99.03
3	112.5	99.01	99.11
3	150	99.08	99.16
3	225	99.17	99.23
3	300	99.23	99.27
3	500	99.25	99.35
3	750	99.32	99.4
3	1000	99.36	99.43
3	1500	99.42	99.48
3	2000	99.46	99.51
3	2500	99.49	99.53

**Figure 3. (Department of Energy Conservation Program: Energy Conservation Standards for Distribution, 2013)**

The impact of the new efficiency standard is dependent on application requirements (including dimensional and weight constraints) as well as transformer type and rating.

In general, a redesign process must be completed to confirm size, weight and price changes. It's important to understand that:

- Core/coil weight increases are likely
- Transformer footprint could change, but new designs can meet dimensional constraints

#### Liquid-filled transformer design benefits

Now may be the time to consider changing from dry-type transformers to a liquid-filled alternative. While on a percentage basis, the efficiency increase in the DOE 2016 standard is greater for certain dry-type transformers, the actual efficiency of liquid-filled transformers is significantly higher. This results in less radiated heat to contend with inside buildings, lower losses and significantly reduced operating costs for liquid-filled transformers. Further, liquid-filled transformer technology can help extend equipment life and enhance safety for indoor applications, compared to dry-type transformers.

To amplify the 2016 DOE efficiency requirements and the positive environmental impact of the ruling, customers can take advantage of environmentally friendly liquid-filled transformer technology. For example, Eaton's Cooper Power™ series liquid-filled transformer technology uses Envirotemp™ FR3™\* high fire point dielectric fluid. This liquid-filled transformer technology provides the benefits noted above and uses a non-toxic fluid that is soybean based, biodegradable, and renewable and reduces greenhouse gas emissions relative to mineral oil.

## Optimize core materials

As the industry develops liquid-filled transformer designs to meet the DOE 2016 requirements, different types of core material will be used, including conventional grain-oriented electrical steel (GOES) and amorphous metals. Manufacturers will select materials on what's most economical to build.

It's anticipated that amorphous metals will primarily be used in three-phase transformer designs with high current secondaries, while evidence suggests that conventional steel will provide the lowest cost option for 2016-compliant single-phase transformer designs.

For two transformers having equivalent DOE efficiencies, the amorphous design may be more efficient at low loading levels and the conventional steel design may be more efficient at higher loading levels.

All that said, single- and three-phase distribution transformers are engineered to order based on specific application requirements. Criteria such as impedance, loading factors, temperature rise requirements, fluid requirements, overloading, space constraints and many others must also be considered when designing transformers that meet the DOE 2016 efficiency levels

## Conclusion

Fundamentally, electrical manufacturers will help manage transition to the DOE 2016 standard and ensure transformers manufactured for sale in the U.S. are compliant. It's imperative that utilities embrace and understand the impact of the DOE 2016 efficiency requirements and work with manufacturers to implement a transition plan. Utilities that plan in advance for the impact of the new standard will be better positioned to meet project deadlines and goals.

The DOE is far more likely to continue to increase energy-efficiency requirements than loosen regulations. Therefore, it's critical for utilities to work with manufacturers that are able to accommodate evolving regulations effectively, meeting not only new efficiency standards, but also addressing project and equipment objectives cost-effectively.

Eaton is a longtime power management leader and continues to deliver innovation and high-efficiency technology to customers. The expansion and upgrades to three Eaton Milwaukee-area plants will help meet growing demand from utility customers for distribution transformers, enhancing the company's capabilities to deliver high-quality products at a faster pace. The projects will add capacity for the transformer business and support increased core and coil manufacturing. Additionally, Eaton's investments in robotic welding and other manufacturing technologies will help achieve these goals.

## References

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## About Eaton

Eaton is a power management company with 2014 sales of \$22.6 billion. Eaton provides energy-efficient solutions that help our customers effectively manage electrical, hydraulic and mechanical power more efficiently, safely and sustainably. Eaton has approximately 102,000 employees and sells products to customers in more than 175 countries.

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