Appliance Standards Awareness Project
American Council for an Energy-Efficient Economy
National Consumer Law Center
Natural Resources Defense Council
Northwest Energy Efficiency Alliance

March 27, 2023

Mr. Jeremy Dommu
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Office, EE-5B
1000 Independence Avenue SW
Washington, DC 20585

RE: Docket Number EERE-2019-BT-STD-0018: Energy Conservation Standards for Distribution Transformers

Dear Mr. Dommu:

This letter constitutes the comments of the Appliance Standards Awareness Project (ASAP), American Council for an Energy-Efficient Economy (ACEEE), National Consumer Law Center (NCLC) on behalf of its low-income clients, Natural Resources Defense Council (NRDC), and the Northwest Energy Efficiency Alliance (NEEA) on the notice of proposed rulemaking for standards for distribution transformers. 88 Fed. Reg. 1722 (January 11, 2023). We appreciate the opportunity to provide input to the Department.

We strongly support DOE's proposed standards for distribution transformers. Almost all electricity flows through one or more transformers so efficiency improvements can yield enormous energy and cost savings for the nation. Just like other energy efficiency improvements, cutting needless electricity waste from distribution transformers will reduce electricity generation requirements, making the goal of a net-zero grid both more attainable and affordable. DOE's proposed standards would reduce energy losses by 36% for liquid-immersed transformers and 47% for low-voltage dry-type transformers, resulting in over 10 quads of full-fuel cycle (FFC) energy savings over 30 years of sales.[1] DOE's proposal is also projected to save up to $15 billion—savings that should largely be accrued by electric customers—and avert 340 million metric tons of carbon dioxide emissions,[2] an amount equal to the annual emissions from 90 coal-fired power plants.

DOE's proposal sets performance standards and does not explicitly require a particular transformer core material. However, the most cost-effective designs under the proposed standards are typically amorphous metal (AM) core designs. AM transformers are a proven technology; it is estimated that over 3 million AM transformers are in service globally (many since the 1990s) and that over 90% of new

[1] 88 Fed. Reg. 1726-1728.
[2] *Ibid.*

liquid-immersed transformers in Canada utilize AM.[3] DOE notes that nearly all domestic liquid-immersed transformer manufacturers have some existing experience and capacity to produce AM transformers.[4]

DOE presents compelling evidence that the supply of AM used in the more efficient transformers will be both stable and reliable, resulting in a more secure supply for this essential grid component.[5] As DOE notes in the NOPR, the market for grain-oriented steel (GOES), the most common current transformer core material, is under extreme pressure from the electric vehicle (EV) market.[6] NEMA,[7] Carte International,[8] and Powersmiths[9] stated that some steel suppliers are shifting part of their grain-oriented electrical steel production capacity to non-oriented electrical steel production—limiting the availability and increasing the price of transformer-grade steels. As steelmakers increasingly focus on the fast growing, lucrative EV market, current GOES supply challenges will likely only worsen.[10]

Alternatively, raising transformer efficiency standards would create a pathway to a more robust domestic transformer supply chain. Amorphous steel is not used in EVs, and we understand that adding new AM production capacity is less capital intensive than adding additional GOES capacity. Thus, DOE's proposed standards would facilitate the creation of a more secure long-term domestic supply of distribution transformers.

The domestic supply of GOES is unable to meet current and future market demands. Distribution transformer purchasers are currently experiencing long lead times, with the primary culprit being the supply of GOES.[11] According to a 2021 Department of Commerce (DOC) report, nearly half of the US supply of transformer core steel in 2019 was imported, primarily from China, Japan, and Russia;[12] the DOC further noted that this share of imports was expected to grow in subsequent years. The DOC report also summarizes concerns raised in comments regarding the capabilities and capacity of the sole domestic GOES supplier, Cleveland-Cliffs (formerly AK Steel), submitted by 13 different stakeholders including transformer manufacturers and government agencies.[13] For example, Central Moloney, Southwest Electric Company, the US Chamber of Commerce, and others commented that Cleveland-Cliffs does not have the production capacity to keep pace with domestic GOES demand.

Recent decarbonization trends including EV production and charging infrastructure buildout are poised to put continued competitive pressure on domestic GOES production into the future.[14] GOES

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[3]Amorphous Core Liquid Immersed Distribution Transformers, Bonneville Power Administration, pp. 7, 17-18. www.bpa.gov/-/media/Aep/energy-efficiency/emerging-technologies/liquid-immersed-amorphous-core-distribution-transformers-2020-03-31-final.pd
[4]TSD, p. 3-43. www.regulations.gov/document/EERE-2019-BT-STD-0018-0060
[5]88 Fed. Reg. 1767.
[6]*Ibid.*
[7]p. 9, www.regulations.gov/comment/EERE-2019-BT-STD-0018-0050
[8]p. 3, www.regulations.gov/comment/EERE-2019-BT-STD-0018-0054
[9]p. 5, www.regulations.gov/comment/EERE-2019-BT-STD-0018-0046
[10]Electrical Grid Supply Review: Large Power Transformers and High Voltage Direct Current Systems, 02/22. p. viii www.energy.gov/sites/default/files/2022-02/Electric%20Grid%20Supply%20Chain%20Report%20-%20Final.pdf
[11]88 Fed. Reg. 1788.
[12]p. 130, www.bis.doc.gov/index.php/documents/section-232-investigations/2790-redacted-goes-report-20210723-ab-redacted/file
[13]p. 105, *Ibid*.
[14]88 Fed. Reg. 1767.

manufacturing is extraordinarily capital intensive and has very long lead times, making new domestic entries to the GOES market unlikely. A second domestic GOES manufacturer, ATI (Allegheny Ludlum), exited the market in 2016. Powersmiths stated in comments to DOE's 2021 preliminary standards analysis that increased domestic capacity for GOES would require significant investment and take years to come on-line.[15] Additionally, AK Steel (now Cleveland-Cliffs) stated as part of the DOC investigation that their GOES production was not profitable and that they didn't anticipate making additional investments in GOES production.[16]

Multiple transformer manufacturers commented as part of the DOC report that Cleveland-Cliffs' manufacturing equipment and processes are antiquated, and they lack the capability to produce the higher grades of GOES that are often preferred by transformer manufacturers today.[17] The low quality of most GOES produced by Cleveland-Cliffs is a considerable barrier to a reliable domestic supply of transformers. While Cleveland-Cliffs has recently signaled a willingness to invest in new GOES production, we are not aware of any plans to produce higher grades of GOES in significant quantities. Powersmiths reiterated these quality concerns in comments to DOE's 2021 preliminary analysis, stating that many of the high-performing GOES grades are only available from overseas suppliers, and recent shipping challenges have increased market uncertainty around access to those grades.[18] Thus, absent significant investments in production of higher-quality GOES, Cleveland-Cliffs is ill-equipped to meet the needs of a market that is increasingly demanding higher-quality transformer core steel.

Transitioning to AM distribution transformer cores should produce a stable, robust domestic supply chain. AM does not face the market pressure from other applications that is afflicting the global GOES market. Amorphous steel is not used in electric motors and thus will not compete with the EV market.[19] AM is also not widely used in large power transformers, which means that under DOE's proposal, distribution transformers would no longer compete with power transformers for core steel supply. Thus, once domestic capacity of AM ramps up, the supply of distribution transformer core steel should be significantly more stable than the current market.

DOE states in the NOPR that production capacity of AM is limited more by demand than constraints on potential domestic production capacity.[20] The Department further states that in the presence of an amended standard, it is expected that amorphous capacity would quickly rise to meet demand before the compliance date of amended energy conservation standards. Metglas, the domestic AM manufacturer, currently has 45,000 metric tons of installed capacity, and they have stated that they are ready to increase capacity by another 75,000 metric tons within 30 months;[21] together this AM capacity would be sufficient to meet about half of the distribution transformer core steel demand in the US.

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[15]p. 6, www.regulations.gov/comment/EERE-2019-BT-STD-0018-0046
[16]p. 9, www.bis.doc.gov/index.php/documents/section-232-investigations/2790-redacted-goes-report-20210723-ab-redacted/file
[17]pp.106, 108, *Ibid*.
[18]pp. 5-6, www.regulations.gov/comment/EERE-2019-BT-STD-0018-0046
[19]88 Fed. Reg. 1832.
[20]*Ibid*.
[21]p. 37, www.regulations.gov/document/EERE-2019-BT-STD-0018-0075

Further, DOE discusses two historical examples in the NOPR that suggest that additional domestic AM capacity could be added quickly.[22] First, new AM producers in Asia were able to add 70,000 metric tons of AM capacity within two years. Further, public statements from a European manufacturer noted that since the expiration of an initial AM production patent, there have been several additional amorphous suppliers and material prices have been stable. Metglas has also publicly stated a willingness to license core-making technology and participate in joint ventures for AM production.[23] We understand that adding AM capacity is less capital intensive than adding GOES capacity. Overall, it is reasonable to expect that domestic AM production would expand rapidly in response to standards set at the proposed levels.

DOE's proposed standards would address the current market bias against amorphous transformers. For some representative units (RUs) in DOE's engineering analysis, AM is the cheapest design even at baseline efficiency levels.[24] This finding is supported by NEEA research suggesting that amorphous cores are lower first cost above 100 kVA for single-phase and above 500 kVA for three-phase transformers.[25] And yet, even given the ongoing GOES supply constraints, the current market for distribution transformers is still heavily geared towards GOES. This counterintuitive market situation is explained by the fact that transformer manufacturer production is geared towards GOES designs rather than AM; GOES transformer production is dominant in part because transformer purchases are largely driven by first cost and GOES has historically been cheaper, thus driving demand. DOE states in the NOPR that since current production is geared towards GOES, manufacturers have noted that "there is some degree of bias against amorphous transformers, regardless of what the first cost of a product is."[26] In particular, DOE's research found that AM transformers "cannot currently be fabricated in the quantities needed to meet the large order requirement of electric utilities."[27] The proposed standards would address this bias by spurring manufacturers to invest in producing AM transformers.

The proposed standards should have a positive impact on electrical steel manufacturing jobs. We understand that the expansion of domestic AM production capacity in response to standards set at the levels in the proposed rule would be expected to add hundreds of manufacturing jobs. Furthermore, DOE states in the NOPR that increased demand for EVs offers an alternative for current producers of GOES steel;[28] GOES is needed to build out EV charging infrastructure, and increased demand for EV non-oriented electrical steel (NOES)[29] affords the opportunity to switch some GOES production to NOES. One projection estimates that the global shortage of EV-grade NOES could rise to over 350,000 tons in 2027 and nearly 1 million tons by 2030.[30] Cleveland-Cliffs, the domestic supplier of GOES, has recently announced the introduction of a new product line of high-quality NOES for EV traction motors and has stated that they are well positioned to play a leading role in the buildout of EV charging stations using

[22] 88 Fed Reg. 1767.
[23] p. 36, www.regulations.gov/document/EERE-2019-BT-STD-0018-0075
[24] pp. 5-68 to 5-86. www.regulations.gov/document/EERE-2019-BT-STD-0018-0060
[25] p. 8, www.regulations.gov/comment/EERE-2019-BT-STD-0018-0051
[26] 88 Fed. Reg. 1755.
[27] 88 Fed. Reg. 1776.
[28] 88 Fed. Reg. 1832.
[29] www.wsj.com/articles/the-paper-thin-steel-needed-to-power-electric-cars-is-in-short-supply-dbd2a78e?mkt_tok=ODUwLVRBQS01MTEAAAGKwfJvOxccp7FZRBkOI_nKzAO0obyefSWW595bytNSbKK0uYauIWToi21pzpwBhkcMM7O_-_QqCdzPqwoMFC5v5z_RuxT6diavv87o9qdxa0Dd
[30] www.spglobal.com/mobility/en/research-analysis/electrical-steel-another-temporary-supply-chain-shortage.html

their GOES products.[31] These statements suggest that Cleveland-Cliffs is well-positioned to capitalize on the enormous future demand for EVs, preserving and perhaps even expanding employment at their existing domestic electrical steel manufacturing plants.

The proposed standards would yield significant energy savings regardless of transformer load projections. As discussed in the NOPR, current average transformer loads are quite low—about 30% for liquid-immersed transformers based on DOE's analysis. Thus, reducing no-load losses through the use of AM core steel is the most straightforward means of reducing total transformer losses. We are unaware of any public data suggesting that current or future transformer loads exceed DOE's estimates, and some data suggests real-world loads may be even lower than DOE's estimates.[32] In California, municipal utilities including the Los Angeles Department of Water and Power, the largest public utility in the US, place much higher $/Watt loss values on no-load (i.e., core) losses when performing TOC evaluations for their transformer purchases;[33] this suggests that these utilities have lightly loaded transformers and expect light loads well into the future.

In the NOPR, DOE estimates transformer load growth of 0.5% per year, based on 2022 Annual Energy Outlook (AEO) electricity demand projections. In other words, DOE is assuming that 100% of electricity growth will be handled by existing transformers. While we agree that electricity consumption will likely grow due to electrification of the US economy, we understand that, historically, most additional load has been handled by new transformer installations rather than existing transformers.[34] Furthermore, it is likely that increases in average loads would correlate with increases in peak loads, and thus transformers due for replacement would likely be replaced with larger units that would mitigate any increases in average load. This practice of upsizing transformer replacements was mentioned by a utility at DOE's public meeting,[35] and we understand that other utilities are currently upsizing transformer replacements as well.

Importantly, even under significantly higher load growth projections, DOE's proposed standards would still provide large energy savings. The efficiency of liquid-immersed distribution transformers is evaluated at 50% load; the benefit of this test procedure loading condition, which is significantly higher than actual average loads, is that it ensures that transformers meeting the proposed standards will be efficient across a wide range of operating loads. Figure 1 plots annual transformer losses for a single unit installed in 2027 for RU2 and RU5 at the current standard level (EL0, red) and DOE's proposed standard level (EL4, blue) under two load growth scenarios, 0.5% (solid lines) and 4% (dashed lines) per year.[36]

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[31]www.clevelandcliffs.com/news/news-releases/detail/564/cleveland-cliffs-introduces-new-motor-max-non-oriented

[32]Data from the IEEE Distribution Transformer Subcommittee showed average loads for liquid-immersed transformers of about 15% and load factors (ratio of average load to peak load) of about 30% (i.e., peak loads were about 50% of nameplate capacity). Additional loading data from the Knoxville Utilities Board submitted to IEEE showed average loads of about 12% for liquid-immersed transformers and load factors of about 25%.

[33]Department of Water and Power, City of Los Angeles, Invitation for Bid for TRANSFORMERS, 34.4-KV, THREE-PHASE, PADMOUNT. p. B1-4, www.bidnet.com/bneattachments?/788248017.pdf

[34]pp. 5-6, www.regulations.gov/comment/EERE-2019-BT-STD-0018-0053

[35]p. 60, www.regulations.gov/document/EERE-2019-BT-STD-0018-0075

[36]First year load losses (LLs) and no-load losses (NLLs) are derived from Table 7.2.2 and 7.2.3 of the technical support document (TSD) (pp. 7-9, 7-10). Initial per-unit loads (PULs), 0.273 (RU2) and 0.305 (RU5) were derived

RU2 (left plot) is a small single-phase pole-mounted transformer representing the most shipped units, and RU5 (right plot) is a large three-phase pad-mount transformer representing the most shipped capacity. Under DOE's assumed load growth of 0.5%/year, cumulative energy savings over the transformer's average lifetime of 32 years are 44% and 35% for RU2 and RU5, respectively. Notably, Figure 1 highlights that even under a 4%/year growth scenario, which results in final (Year 32, 2058) average loads of 93% (RU2) and 102% (RU5), DOE's proposed standards would still provide energy savings; the cumulative energy savings over 32 years under this aggressive 4%/year load growth scenario are nearly 24% and 14%, for RU2 and RU5, respectively. For RU2 and RU5, total losses at EL4 exceed EL0 only when average loads are greater than 100%.

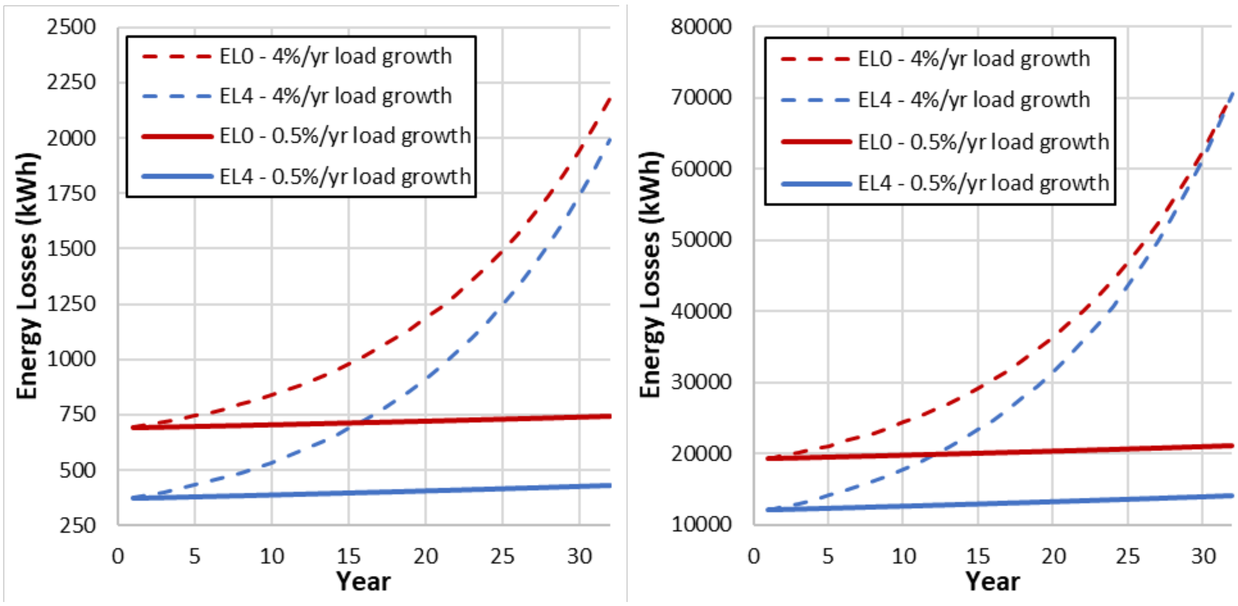

Figure 1. Total annual energy losses for a single RU2 (left) and RU5 (right) unit installed in 2027 at baseline efficiency (EL0, red) and DOE's proposed standard level (EL4, blue) under 0.5%/yr (solid lines) and 4%/yr (dashed lines) load growth.

Any size-related impacts resulting from DOE's proposal are not expected to significantly impact transformer installations. As of 2015, more than 4 million AM transformers had been sold globally, with about 600,000 installed in the US, over 1 million in China, and 1.3 million in India;[37] we understand that this number of installed global AM units has increased several-fold since. It is also estimated that over 90% of liquid-immersed transformers sold in Canada use AM.[38] While we understand that well-designed AM transformers are not meaningfully larger than current GOES transformers, DOE's NOPR analysis considered the potential impact of increased transformer size on pole and vault installations.

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from Table 2.8.1 of the preliminary analysis (p. 2-60). First year load losses and the initial per-unit loads were used to estimate load losses at 100% ($LL_{100\%}$). Total losses (TLs) were estimated via Eq. 3.3 of the TSD (p. 3-34): TL = NLL + $LL_{100\%}$ x $[PUL]^2$. The LLs increase in each year due to the load growth rates while NLLs are constant over time.

[37]metglas.com/wp-content/uploads/2016/12/Metglas-Power-Brochure.pdf

[38]Amorphous Core Liquid Immersed Distribution Transformers, Bonneville Power Administration, pp. 7, 17-18. www.bpa.gov/-/media/Aep/energy-efficiency/emerging-technologies/liquid-immersed-amorphous-core-distribution-transformers-2020-03-31-final.pd

DOE studied several pole-mount scenarios and determined that the increase in transformer weight expected from the proposed standards would be unlikely to require additional pole installations or pole replacements.[39] For example, DOE's analysis of a 167 kVA unit showed that even with a transformer weight increase of 75%, or 1400 lbs, much greater than the expected real-world increase resulting from the proposed standards, allowable pole wind spans (i.e., the spacing between utility poles) would still be greater than a typical span of 150 feet.

DOE also examined vault or underground installations. In some of these below grade installations, a transformer with a larger footprint may not fit within the existing vault. However, DOE has proposed a separate equipment class for submersible transformers with proposed standard levels consistent with the current liquid-immersed transformer standards.[40] We understand that most vault-based liquid-immersed transformers (e.g., urban network-based transformers) meet DOE's proposed definition of a submersible transformer. Thus, these specialty size-constrained transformers would not be affected by the proposed standards.

DOE's robust economic analysis demonstrates that the proposed standards are cost-effective for purchasers. DOE's proposed rule is supported by a thorough economic analysis that considers all the costs associated with higher efficiency levels as well as the operating cost savings over the life of the equipment. For example, DOE's estimates of installed costs account for any additional installation costs associated with heavier transformers,[41] and the electricity costs for liquid-immersed and dry-type transformers reflect hourly and monthly marginal electricity prices, respectively.[42] Overall, DOE found that the proposed standards would yield net present value savings for purchasers of up to $15 billion, indicating that the operating cost savings would significantly outweigh the estimated increase in upfront cost. For example, for RU2, the estimated discounted operating cost savings are 90% greater than the estimated upfront cost increase; for RU5, the operating cost savings are 37% greater than the increase in upfront cost.[43]

We support DOE's proposed scope expansion to include larger transformers with capacities up to 5,000 kVA. DOE's current distribution transformer definition specifies a capacity range of 10 kVA to 2,500 kVA for liquid-immersed transformers and 15 kVA to 2,500 kVA for dry-type transformers. While the Energy Policy and Conservation Act (EPCA) does not specify capacity limitations, in practice the voltage limitations included within EPCA (e.g., 600 V or less output) place an effective upper limit on distribution transformers subject to DOE standards. However, industry has commented that larger distribution transformers within the EPCA voltage limitations are available, and DOE notes in the NOPR that in interviews, some manufacturers expressed the concern that amended standards could increase the incentive to build transformers just above the current scope (e.g., 2,501 kVA).[44] Thus, DOE is proposing to expand the scope of both liquid-immersed and dry-type transformers to 5,000 kVA. We support DOE's proposal to ensure that these larger capacity transformers meeting the EPCA definition are subject to energy conservation standards.

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[39] TSD, pp. 8-17 to 8-20. www.regulations.gov/document/EERE-2019-BT-STD-0018-0060
[40] 88 Fed. Reg. 1748, 1749.
[41] TSD, pp. 8-13 to 8-16. www.regulations.gov/document/EERE-2019-BT-STD-0018-0060
[42] TSD, pp. 8-26 to 8-34. www.regulations.gov/document/EERE-2019-BT-STD-0018-0060
[43] 88 Fed. Reg. 1797, 1798.
[44] 88 Fed. Reg. 1746.

Thank you for considering these comments.

Sincerely,

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