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APPA Response to the Department of Energy's (DOE) Notice of Proposed Rulings (NOPR) on Distribution Transformers

UNITED STATES DEPARTMET OF ENERGY
OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

Energy Conservation Program: Energy	)	Docket No. EERE-2019-STD-0018
Conservation Standards	)	
for Distribution Transformers	)	

COMMENTS OF THE AMERICAN PUBLIC POWER ASSOCIATION

The American Public Power Association (APPA) respectfully submits comments to the Department of Energy (DOE or Department) in response to its notice of proposed rulemaking (NOPR) on Energy Conservation Standards for Distribution Transformers (EERE-2019-BT-STD-0018).[1]

APPA is the national trade organization representing the interests of the nation's 2,000 not-for-profit, community-owned electric utilities. Public power utilities are in every state except Hawaii. They collectively serve over 49 million people and account for 15 percent of all sales of electric energy (kilowatt-hours) to end-use customers. Public power utilities are load-serving entities, with the primary goal of providing the communities they serve with safe, reliable electric service at the lowest reasonable cost, consistent with good environmental stewardship.

INTRODUCTION

APPA appreciates DOE's efforts to maximize distribution transformer efficiency when doing so is technologically feasible and economically justified in accordance with the standards established by the Energy Policy and Conservation Act (EPCA). APPA respectfully submits, however, that the NOPR's proposed distribution transformer efficiency standards and the analyses cited to support them would not comport with EPCA requirements, nor would they pass muster under Administrative Procedure Act (APA) and EPCA standards for agency rulemaking. Importantly, the proposed efficiency standards would worsen current distribution transformer supply shortages. APPA and its members strongly urge DOE to reconsider the NOPR's proposed efficiency standards, which to the extent that they are even feasible, would impose significant costs on consumers, while frustrating the Department's own goal of increasing efficiencies. It

[1] *Energy Conservation Program: Energy Conservation Standards for Distribution Transformers*, 88 Fed. Reg. 1722 (Jan. 11, 2023).

would also hinder further development of the electric grid to meet growing electric demand from electrified end-uses, as well as alternative sources of generation.

As a threshold matter, the NOPR's proposal to tighten distribution transformer efficiency standards comes at an extremely precarious time for electric utilities and their transformer suppliers. The electric industry is currently experiencing a critical shortage of distribution transformers, and the efficiency standards included in the NOPR would likely exacerbate a supply shortfall that has already reached crisis levels, threatening electric reliability, economic development, and the ongoing transition to lower emitting generating resources. It is difficult to overstate the concerns of APPA members and other electric utilities about the current transformer shortage. DOE's analysis of the proposed standards must account for the effects that the revised standards would have on suppliers' ability to meet industry demands,[2] and DOE should also consider the impact of the NOPR on near-term supply chain constraints.[3] These considerations alone warrant reconsideration of the proposal to revise distribution transformer efficiency standards at this time.

Even if DOE was to conclude that the distribution transformer supply chain crisis does not provide grounds to forego prescribing new efficiency standards at this time, the NOPR has not adequately supported a finding that the proposed standards would be technologically feasible and economically justified, as required by the EPCA. As APPA explains below, the NOPR fails to address a number of very significant costs and technical challenges that the revised efficiency standards would impose on distribution transformer suppliers, electric utilities, and/or electric consumers. Indeed, the number and variety of important issues on which DOE seeks comments tend to show the highly provisional nature of the NOPR's conclusions.[4]

After discussing the relevant EPCA standards, the first section of these comments addresses the current critical shortage of distribution transformers and explains how the NOPR's proposed efficiency standards would exacerbate these availability concerns. In section two, APPA discusses a number of significant cost and technical challenges that the NOPR does not adequately address and which, either singularly or collectively, undermine the NOPR's preliminary assessment that the proposed efficiency standards would be technologically feasible and economically justified. Section three of the comments identifies other issues that are essential to a sound economic and technical analysis of the proposed efficiency standards, but which are not adequately addressed in the NOPR.

Based on the concerns identified by in these comments, APPA urges DOE to:

1. Reconsider this proposed rule or delay the implementation of any final rule until the transformer supply base is strengthened enough to increase supply, reduce costs, and more diversity of component suppliers exist.

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[2] *See, e.g.*, 10 C.F.R. § 431.4; 10 C.F.R. part 430, subpart C, appendix A, sec. 6(b)(3)(ii) (requiring that technologies be screened for practicability to manufacture, install, and service).
[3] *See, e.g.,* 42 U.S.C. § 6295(o)(2)(B)(i)(VII) (providing for DOE to consider other relevant factors in determining whether a standard is economically justified).
[4] *See* NOPR, 88 Fed. Reg. at pp. 1852-54.

2. Rework the cost-benefit case with the realistic numbers included in all responses to the NOPR.
3. Consider restricting any revised efficiency standards to pad-mount and overhead transformers and to not include vault, submersible, and other special installation transformers.

APPA's concerns regarding the proposed distribution transformer efficiency standards should not be interpreted as opposition to energy efficiency improvements generally, which can provide important economic, reliability, and environmental benefits. APPA submits, however, that there are several better options than mandating non-grain-oriented electric steel (NOES) transformers, including:

1. Improving building and renovation codes, as this offers an increase in energy efficiency of up to 12 percent as opposed to the less than 0.5 percent improvement in energy efficiency with distribution transformers.
2. Increasing the size of secondary conductors– the conductor from the service transformer to the service entrance. Secondary conductors in studies show losses of up to 20 percent, far greater than NOES transformer offers in energy efficiency. Those losses will continue to increase as premise load increases. The cost of the secondary replacement is less than the increased cost for NOES.

Relevant Legal Standards

As described in the NOPR,[5] DOE may not adopt any efficiency standard that would not result in the significant conservation of energy.[6] Further, DOE may not revise distribution transformer efficiency standards under EPCA if it finds that the proposed revised standards are not technologically feasible or economically justified. Assessing whether a standard is economically justified involves "determin[ing] whether the benefits of the standard exceed its burdens," taking into account six statutory factors.[7] The statute also gives DOE discretion to consider other factors it deems relevant to the economic justification analysis.[8] EPCA also forbids the adoption of standards that are likely to result in the unavailability of currently available product performance characteristics or features.[9] In addition to the specific EPCA requirements, any final rule in this proceeding must conform to APA requirements for agency rulemaking.[10] Thus, DOE's conclusions must be the product of reasoned decision-making and based on substantial evidence.

As discussed below, the NOPR's economic justification analysis would not comport with EPCA or APA requirements.

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[5] NOPR, 88 Fed. Reg. at pp. 1735-36.
[6] *Id.*
[7] *Id.*
[8] 42 U.S.C. § 6295(o)(2)(B)(i)(VII).
[9] 42 U.S.C. 6295(o)(4).
[10] *See*, *e.g.*, *Am. Pub. Gas Ass'n v. U.S. Dept. of Energy*, 22 F.4th 1018, 1024-25 (D.C. Cir. 2022). 5 U.S.C. § 706; 42 U.S.C. § 6306.

Section One: The Proposed Efficiency Standards Would Exacerbate the Ongoing Distribution Transformer Supply Chain Crisis

DOE issued this NOPR when there is a sustained supply chain crisis affecting the entire electric sector, particularly regarding distribution transformers. APPA conducted a survey of public power utilities in February and March 2022 on disruptions to the utility supply chain. One hundred twenty-one public power utilities responded to the survey, with 114 answering all questions. When asked to indicate which supply chain disruptions were most concerning to their utilities, 103 out of 121 respondents ranked transformers as their highest concern. An additional 13 ranked transformers as their second-highest concern.

The chart below shows that median quoted delivery times increased for several critical categories of equipment between 2018 and 2022. Transformer lead times increased fourfold for the utilities that participated in the survey.

Equipment	2018 Median Quoted Delivery Time	2022 Median Quoted Delivery Time
Transformers	3 months	12 months
Bare wires	1 month	5 months
Primary cable	2 months	6 months
Meters	2 months	6 months

Moreover, public power utilities' median transformer stock is at 75 percent of 2018 levels according to respondents. Eighty percent reported having either pad-mounted or pole-mounted distribution transformer inventories that were lower in 2022 than they were in 2018 and some utilities reported having only 10 to 15 percent of the number of transformers they had four years ago.

While utilities expressed some optimism that transformer lead times would improve in 2023, that has not been the case. Many APPA members have informed the association that lead times have gotten worse, with some members reporting lead times of between 18 to 24 months, and some even longer.

Evaluating the survey data individually, and assuming no changes to the current conditions, 19 out of 91 utility respondents or **21 percent will run out of new transformers within the quoted 12-month lead time for transformer shipments.** Most of these utilities are larger public power utilities.

Contingencies public power utilities have used to address the transformer shortage include refurbishing their own transformers, purchasing transformers from other utilities (where possible), or harvesting unused transformers already installed in their systems.

These supply chain constraints have material impacts on the grid and may negatively impact reliability. Transformer lead time delays make it more difficult to connect electric vehicle supply equipment (EVSE) and interconnect renewables, potentially inhibiting utilities' ability to transition to lower- and non-emitting resources. The North American Electric Reliability Corporation (NERC) has highlighted the reliability risk associated with the transformer shortage, noting in its most recent Winter Reliability Assessment, that "[i]nadequate supply of distribution transformers could slow restoration efforts following winter storms."[11]

These supply chain issues are directly harming consumers. Transformer unavailability has led to delays in housing construction, forcing thousands of new-home buyers to wait as work is halted on new home construction for months at a time. Among public power utilities, one in five projects were deferred or canceled.

While the Energy Information Administration projects only a moderate annual increase of about less than one percent in total electric sales by 2050,[12] other trends suggest potentially much higher rates of electric end-use consumption. President Biden's Executive Order No. 14037 calls for 50 percent of all new passenger cars and light trucks sold in 2030 to be zero-emission vehicles.[13] There are a wide variety of projections of electric vehicle sales by 2030, but EV sales already reached nearly six percent of all new car purchases in 2022,[14] and that share is only expected to increase. Additionally, federal and state governments are mandating that homes and buildings be electrified and cut emissions.[15]

DOE and the Biden administration have acknowledged the severity of the distribution transformer shortage. In June 2022, working with electric service providers, Secretary Granholm directed the Electricity Subsector Coordinating Council to establish a "Tiger Team" to examine the supply chain crisis. The Tiger Team concluded that current transformer production is not meeting demand – demand that is expected to increase for the foreseeable future. The Biden administration also recognized the severity of this crisis by issuing the June 6, 2022, Presidential Determination through the Defense Production Act (DPA) to prioritize the domestic production of transformers to bolster grid resiliency and national security.[16]

Adoption of the distribution transformer efficiency standards proposed in the NOPR would likely cause even greater supply chain constraints at a time when the industry is already facing a critical shortage of transformers, leading to widespread unavailability of these critical components and exacerbating the adverse consequences associated with transformer shortages. DOE should take

[11] NERC 2022-2023 Winter Reliability Assessment at 5 (Nov. 2022), available at: https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_WRA_2022.pdf. NERC cites APPA survey data indicating that "many utilities have low levels of emergency stocks that are used for responding to natural disasters and catastrophic events." *Id.*

[12] https://www.eia.gov/outlooks/aeo/data/browser/#/?id=8-AEO2023&region=0-0&cases=ref2023&start=2021&end=2050&f=A&linechart=ref2023-d020623a.6-8-AEO2023&sourcekey=0

[13] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/08/05/executive-order-on-strengthening-american-leadership-in-clean-cars-and-trucks/.

[14] https://www.kbb.com/car-news/new-car-sales-fell-in-2022-but-new-electric-car-sales-rose-dramatically/.

[15] See, for example, https://www.energy.gov/articles/biden-harris-administration-announces-steps-electrify-and-cut-emissions-federal-buildings.

[16] See DOE Announcement at: https://www.energy.gov/articles/president-biden-invokes-defense-production-act-accelerate-domestic-manufacturing-clean

into account the current shortage and the NOPR's near-term and longer-term impacts on distribution transformer availability and decline to proceed with the NOPR at this time.[17]

With the additional strain on the supply chain resulting from the replacement of transformers in Ukraine by the federal government, lead times are now at all-time highs. Some transformer orders in March of 2023 are not scheduled for delivery until 2026 (130-134 weeks based on vendor quotes). Given the exceptionally long lead times, the increase in pricing, and the strong demand for products, one would assume that manufacturers would be expanding their factories and production capabilities. However, based on the very modest floor space expansions found throughout the industry, this is not the case. In discussions with major manufacturers, the main reason given as to why they are not rapidly expanding their manufacturing capabilities is *the pendency of this NOPR*, which would result in the rapid obsolescence of their investments. The second reason for lack of expansion is concerns about supply chain issues, which will only get worse with the lack of amorphous steel supply. The third reason is the existing labor shortage, which may worsen due to the need for additional skills and attention to detail related to amorphous core transformers (AMT). Thus, the already extensive lead times facing the industry will only increase if AMTs are required because of smaller supply and the increasing demand for transformers.

APPA has learned from discussions with vendors that as a result of the NOPR, vendors are very unlikely to increase production of grain-oriented steel (GOES) transformers. Based on current lead times and this proposed rule's effective date, transformers ordered in 2024 will have to be delivered as non-oriented electrical steel (NOES) transformers, requiring the industry to stop production to retool. APPA has also learned from discussions with smaller vendors that without major support, they may not be able to retool their facilities. Retooling, training, and supply chain issues will result in a six to nine month retooling time, which only increases lead times and the possibility of running out of transformers in a major event (e.g., hurricane, wildfire, or other natural disaster).

If this happens, gasoline or diesel fueled portable generators may be the only answer for residential customers that live in buildings small enough to be supported by these smaller generators. One community estimated that it may have to deploy more than 50,000 gasoline powered generators for up to 12 months if they are struck by a hurricane with current lead times and transformer stocking levels. This proposed rule from DOE will only make those deployments longer.

Moreover, as discussed below, the lack of repairability of AMTs is likely to increase lead times for distribution transformers. This proposed rule could raise lead times, which are already two

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[17] *See, e.g.,* 42 U.S.C. § 6295(o)(2)(B)(i)(VII). While DOE indicates that it screened the proposed technologies needed to meet the revised standards for practicability of manufacture, installation, and service by the proposed compliance date, NOPR, 88 Fed. Reg. at p. 1758, APPA's analysis indicates that the revised standards would likely lengthen lead times and extend supply chain constraints beyond the 2027 compliance date, as discussed below. Similarly, as discussed below, the NOPR understates the potential adverse impacts on manufacturing capacity of distribution transformers. *See* NOPR, 88 Fed. Reg. at p. 1817.

years or more for some utilities, by an additional six to 20 months, based on discussions with manufacturers.

Beyond the clear reliability concerns associated with further restricting distribution transformer availability, this proposed rule would negatively impact industry electrification efforts by exacerbating the supply chain crunch that is already impeding efforts to improve the grid to accommodate these new end uses. Lack of distribution transformers also threatens economic development and grid expansion needed to accommodate the evolving resource mix, including the growth of renewable resources.

DOE already mandates that distribution transformers be manufactured to incredibly high efficiency standards. APPA urges DOE to reconsider its proposal to minimally enhance these standards at this time given the ongoing supply chain crisis and the likely adverse impacts of the proposed standards on transformer availability and affordability.

Section 2: The NOPR Does Not Adequately Account for a Number of Important Considerations that Would Undermine Any Conclusion that the Proposed Standards Are Technologically Feasible and Economically Justified

DOE preliminarily concludes that the distribution transformer efficiency standards proposed in the NOPR are technologically feasible and economically justified. While APPA recognizes the complexity of performing the relevant technical and economic analysis to determine if the proposed efficiency standards satisfy EPCA's statutory standards, APPA respectfully submits that certain of the assumptions underlying the NOPR's technical and economic analyses are not adequately supported and/or overlook important considerations that are material to the conclusions. Accounting for these issues in a cost/benefit analysis would show that the proposed efficiency standards are not economically justified at this time. APPA discusses a number of these important issues below.

Critically, the NOPR's assumptions about transformer availability and cost are not adequately supported, and use of more accurate industry data would undercut the economic justification for the proposed revised standards. Transformer lead times and prices continue to increase, as shown in the tables below. The data in the tables were extracted from contract pricing for purchases in quantities of more than 200 units at a time. Lead times are from the same contractual documents. Note that the AMT costs are based on December 2022 dollars and there is an escalator clause for the AMT. The numbers below assume that the contract variables remain at current levels; however, if Vendor A's economic and commodity-cost adjustments reach their contractual maximum levels, then costs would rise by 2.5 times the amounts listed.

DOE did not anticipate the costs that the vendors are providing to APPA members. This difference in cost assumption directly impacts the DOE NOPR cost-benefit analysis resulting in increasing transformer costs.

Assuming the energy transition continues, eight to 12 million transformers will be replaced in the next 10 years. Based on the 2023 budgetary pricing from Vendor A, a 37.5 kilovolt-amps (kVA) transformer, would increase by $2,350 dollars per transformer. Thus, the total additional costs for eight million transformers would be $23.5 billion dollars, almost double the amount from the cost-benefit analysis that DOE provided in the NOPR. If escalator clauses are considered, then the total costs will increase even more.

Vendor A

Size	2017 Budgetary Pricing	2018 Budgetary Pricing	2023 Budgetary Pricing	AMT for 2027 Delivery
TRANSFORMER, Single Phase Pad, 25 KVA	$1,519	$1,489	$4,950.00	$6,200
TRANSFORMER, Single Phase Pad, 37-1/2 KVA	$1,638	$1,605	$6,650.00	$9,000
TRANSFORMER, Single Phase Pad, 50 KVA	$1,741	$1,706	$6,830.00	$9,800
TRANSFORMER, Single Phase Pad, 75 KVA	$2,004	$1,964	$6,960.00	$10,100
TRANSFORMER, Single Phase Pad, 100 KVA	$2,427	$2,378	$7,640.00	$11,500
Average Lead Time	11-18 Weeks	11-18 Weeks	100+ Weeks	Q1 2027

Vendor B

Size	2017 Budgetary Pricing	2018 Budgetary Pricing	2023 Budgetary Pricing
TRANSFORMER, Single Phase Pad, 25 KVA	$1,350	$1,400	$4,750
TRANSFORMER, Single Phase Pad, 37-1/2 KVA	$1,500	$1,550	$5,900
TRANSFORMER, Single Phase Pad, 50 KVA	$1,600	$1,700	$6,600
TRANSFORMER, Single Phase Pad, 75 KVA	$1,800	$1,900	$6,800

TRANSFORMER, Single Phase Pad, 100 KVA	$2,500	$2,800	$9,000
Average Lead Time	8-9 Weeks	8-10 weeks	140+ Weeks

Vault Replacement Costs

The economic analysis in the NOPR does not adequately account for vault replacement costs associated with meeting the new standards. In the NOPR, DOE says 2021 vault replacement costs should be as low as $23,550 for an 8' x 14' x 7' vault.[18] APPA assesses such costs as potentially much higher, especially if the vault must be enlarged for a larger replacement AMT type transformer, which may be located near multi-story buildings in an urban area.

Replacing vaults and their associated transformers are not only projects requiring time for proper planning and engineering, but emergency situations may require last-minute substitutions and replacements. If a vault-mounted transformer fails in an urban area, the utility might have to try to replace the vault and transformer at the same time. The utility may be faced with closing city streets, gathering permits, informing businesses, and may face possible legal challenges or structural woes if building foundations are near the vault. In such cases, the first day's costs alone would likely exceed $25,000 and the cost of the long outage in an urban area would be significantly greater.

APPA's assessment on vault replacement costs shows that:

1. The $23,550 cost assigned by DOE is low by at least $200,000 for simple single-story buildings with parking lot-located vaults. There may be as much as a $4,000,000 to $50,000,000 discrepancy with the DOE vault replacement cost assumption if a multi-story building must be braced and supported to have the foundation removed to expand the vault, depending on the geotechnical issues of the building foundation. In addition, there are costs from business disruption:
    a. Temporary relocation of building tenants
    b. Street closures
    c. Disruption of adjacent buildings (including evacuation that may go on for weeks to months in extreme situations)
    d. Loss of power to nearby buildings to make the area safe for excavation.
    e. Potential rerouting of gas, water, sewage, communications, and other underground services (which may take days to weeks and cause outages to surrounding buildings)
    f. Insurance and contract risk costs
2. The likelihood of damages and lawsuits from vault replacement near the foundation of a multi-story building is high.

[18] NOPR, 88 Fed. Reg. at p. 1785 (Table IV.18).

3. The likelihood that the city government will allow several days to several weeks of city street closure, and building evacuation is low. Businesses impacted by the vault replacement will expect compensation for the disruption, and those costs are not accounted for in the DOE vault replacement costs.
4. There is no inventory of vaults, vault locations, or space available in vaults. Most vaults were built to "fit" the equipment that is housed within the vault, and currently many do not have "safe working space" for workers, given the changes to those rules since they were built. The vaults are currently grandfathered into many of the work rules, but having to expand them to take a new transformer that is larger will mean also retrofitting them to safe working space rules. This means that even if the transformer is only 10 or 15 percent larger than the vault, expansion will likely be much larger.
5. Even if another location for the vault could be found, the new location would mean increasing secondary cable length, which would, in most cases, negate any minimal efficiency gains of the AMT. In many cases the longer secondary cable would reduce the total efficiency of system after the AMT installation.

Degradation of Efficiency Over Time

Amorphous metal is very brittle and does not withstand continuous mechanical stress. Vibrations, step-loads, and short-circuits will degrade the amorphous metal and its efficiency permanently. This leads to a higher no-load loss over time.

Research articles dating back to 1996 show that amorphous core transformers have a degradation of efficiency over time.[19] Based on literature, degradation in performance can be as much as 20 percent over 20 years. Despite a 0.3 percent efficiency improvement in no-load performance, losing an average of one percent of efficiency per year means that within a year, the AMT will not outperform the current generation of transformers. Papers were published in the 2010-2014 period with proposed methods to reduce losses. DOE undertook a study at the Pacific Northwest National Laboratory (PNNL) in 2017[20] to look at AMT losses over time. To date, no progress reports on this study have been made public that APPA has been able to locate. Discussions with Australian distribution system providers indicate that, at least with AMTs that are installed in the grid in Australia, that degradation of performance is happening, and these providers estimate that within five to seven years, the performance of an AMT is lower than the transformers using GOES. With a potential lifespan of 30 to 40 years for AMTs (based on replacement rates reported in conversations with Australian utilities), the lifetime losses are likely greater than the lifetime losses from existing GOES transformers.

[19] https://www.sciencedirect.com/science/article/pii/S1002007112000512
[20] https://www.energy.gov/eere/buildings/articles/2017-bto-peer-review-distribution-transformer-data-testing-and-control .

Properly accounting for the efficiency degradation of AMTs over time would, by itself, undermine the economic justification for the proposed standard, as well as the presumed efficiency improvements.

High AMT Failure Rates and Monitoring Costs

Even with laser slitting (the cleanest and most accurate form of cutting metal) of the amorphous foil to coil width, the metal is brittle enough that small fractures happen during the process. Fractures are even more common with mechanical slitting. In an oil filled AMT, where the oil acts as an insulator and coolant in the transformer, Australian utilities are finding that the vibration of the 50 hertz (Hz) hum is enough to release small pieces of fractured foil into the transformer oil. These small pieces may cause short circuits across layers of the coil, changing the characteristics of the transformers and eventually causing failure of the transformers. This condition can lead to repeated partial discharges of the transformer. These partial discharges can lead to the formation of hydrogen and other gases within the distribution transformer, potentially leading to transformer explosions, further damage from the dissolved materials, transformer fires, or if the utility is lucky, the transformer will just stop working without damage to the surroundings.

Oil monitoring is not common on distribution service transformers today but may have to be in the future. Gas monitoring devices are $2,500 per transformer and more. Adding communications, cybersecurity, and other costs, and having to install a gas monitor will double the cost of a 25kVA AMT from a projected cost of $6,400 to a cost of $12,000, not including operations and maintenance costs. Today's GOES service transformers are typically run to failure (no operations and maintenance costs) devices that last 40 to 70 years. AMTs are likely (based on the same discussions) devices with lifespans of 20 to 40 years. When an AMT fails, it is likely that the gas monitors can be removed and installed on a replacement transformer in the future. However, the cost of labor to remove and install the gas monitor and the cost of a replacement transformer still needs to be accounted for.

The NOPR does not account for the costs associated with more than 10 million gas monitors, which would equate to $25 billion based on the figures cited above. These additional costs alone would exceed the $13 billion of economic benefits cited in the NOPR.

Lack of AMT Repairability

Rewinding of GOES transformers (used when one coil fails but the rest of the components remain usable) is a common occurrence, especially for 300 kVA and larger transformers. Because the tank (shell) of the transformer and most of the other parts can be reused, lead times on rewinds are shorter and the cost to rewind is lower than buying a new transformer. In most cases a new core can be made and installed in the old transformer.

Many utilities have rewinding equipment. Not only does this save up to 100 weeks of lead time currently, but it reduces costs for the utility, which are passed on to customers. GOES transformer rewinding equipment is incompatible with NOES transformers, so the ability to rewind is negated. NOES rewinding equipment is far more complex and expensive. The process to rewind is far more technical and the tolerances for rewinding are as much as two orders of magnitude tighter than for GOES transformers, relegating the rewind ability to core manufacturers. This relegation means that rebuilding transformers will not cut the lead time for transformers. It also means that the sources for transformers will drop, cutting the total industry capacity for transformers. Today more than 15 percent of the transformers used in the US grid are rebuilt units, either from utility rewind shops or from small family-owned businesses that make rewinding their main business.

This loss of repairability means that lead times for all transformers will increase, as discussed above. This proposed rule could raise lead times, which are already two years or more for some utilities, by an additional six to 20 months, based on discussions with manufacturers.

In 2023, if the US were to be hit by two or more hurricanes that were as destructive as Hurricane Katrina, it may be up to a year to fully restore power to the impacted communities. The lack of spare transformers is an urgent issue. This proposed rule will make that urgency worse since any factory expansion to meet the current crisis will be obsolete within five years and the investment stranded. The economic impacts associated with a significant, long-duration outage caused by lack of replacement transformers could alone negate the economic benefits of the standards presented by DOE in the NOPR.

The loss of the ability of distribution transformer consumers to repair transformers also implicates section 325(o)(4) of EPCA, which forbids the adoption of a new or revised standard where a preponderance of the evidence shows that the standard is likely to result "in the unavailability in the United States in any covered product type (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the United States."[21] As noted, the ability to rewind GOES transformers is an attribute of the product commonly recognized by consumers. Effectively foreclosing the repairability of AMTs would eliminate this feature, to the detriment of the relevant consumers.[22]

AMT Low Short Circuit Current Survival

Due to the brittle properties of amorphous steel, amorphous core transformers are built in a rectangular shape. Rectangular shape cores have a lower ability to withstand short-circuit fault effects. This is because the distribution of forces on a rectangle is uneven as compared to a round shape. Uneven distribution of forces causes more stress on some of the coils and leads to more heat and faster disintegration in those stressed areas.

[21] 42 U.S.C. 6295(o)(4).
[22] The loss of repairability is also germane to the Department's assessment of whether the revised efficiency standards would result in "[a]ny lessening of the utility or the performance of the covered products." 42 U.S.C. § 6295(o)(2)(B)(i)(IV).

While in the normal impedance range as required by IEEE Std C57.12.34, impedance of AMT tends to be lower compared to conventional units unless specified by consumers. This could permit an extremely high fault current in the event of a short circuit.

Due to higher inrush current (the power surge at the input of a power supply), this would require review and change of protective devices, such as relays, at an additional cost. These include costs for equipment, engineering time to evaluate the location and determine the right settings (programming) for the protective devices, and the installation of the protective devices.

There is also a lack of published reports and research studies on these issues. The lack of published research means that utilities are going to have to make semi-educated guesses at the correct fuse and protective device settings. This will lead to:

1) Transformer protective devices tripping for no reason at all because the protective settings are too restrictive. When transformer protective devices trip more frequently than they should, the result is an increase in the outage statistics and the number of minutes that customers are without power.
2) Transformers often failing due to protective settings being too permissive.

In both cases, returning to manually remove and replace transformer fuses is a cost that DOE has not accounted for in its economic justification analysis, nor have the costs associated with premature failure of the transformers been adequately addressed.

Each truck roll to replace fuses or change protection settings costs between $200 and $1,000 depending on how the transformer is installed. With more than 3,000 electric utilities in the United States, millions of dollars will be spent before utilities will determine what the best approaches are for fuse and protection device settings.

At a minimum, DOE should publish protection standards and short circuit current information about this mandated change. Ideally this information would be available at least 48 months before the proposed rule goes into effect so that training can happen in an orderly manner for new line and instrumentation staff. Typically, it takes two years to complete changes to the training process (research, drafting, testing, rewriting, piloting, updating, building training fixtures, and deploying to training) and then an additional two-year training cycle for unfamiliar staff. This information needs to be shared with approximately 100 training facilities. Providing a four-year lead time would allow people entering the industry to have the proper training to work with AMT.

Poor Overload Capacity in AMT

The saturated flux (the state reached when an increase in applied external magnetic field cannot increase the magnetization of the material further) of amorphous metal is much lower than electrical steel. It is easy for the metal to be over-excited (an increase in energy level above the chosen starting point) resulting in the overload capacity of AMT (the ability to withstand currents above its continuous rating) being much lower than conventional transformers. Eighty percent of load is dangerous for AMTs, whereas the conventional transformer can run with 120 percent of load. Not only does this diminish the technical argument for using AMT, but it may lead to increased costs as more AMTs will need to be installed in subdivisions than are typical for traditional transformers to avoid overloading circuits.

Noise Pollution from AMT Coils

During manufacturing, the core of an amorphous core transformer cannot withstand compression. Larger gaps exist between each layer of the sheet. These gaps contribute to the noise emitted through magnetostriction and are significantly higher compared to conventional transformers.

Research on AMTs has found that at 120 Hz, the level of noise from vibration is higher in NOES than in GOES.[23] This can be explained by the physics of NOES versus GOES cores,[24] [25] and the increase in audible noise from physical vibrations is not any easy fix. Once the winding of the foil is done, any abnormality in the coil is almost impossible to remove. The NOES foil is so thin it does not typically unwind without tearing and attempts to rewind normally are worse than the first attempt. Since there are no standards for evenness of the coil, and no regulations on what is acceptable, manufacturers typically install most of the coils with little or no inspection. Since there is little research into what specific defects cause the noise, manufacturers do not know what to look for. A visual inspection will likely not find a defect in the inner windings of the coil.

Some of the field reports on NOES transformers show measurable sound levels at 20 feet from the transformer that exceed 70 decibel (dB), though more commonly it is in the 61-64 dB range. The sound is quite loud and annoying that people have objected to the transformer placement and asked that it be moved further away from their yard, balcony, or other outdoor space. But solving the noise issue creates another problem, as moving the transformer necessitates increased secondary cable length. Based on studies submitted by DTE to the Michigan Public Service Commission, secondary cable losses can be up to 20 percent of the energy recorded on the meter, and an increase in secondary cable length of 20 feet can add 0.1 to 0.3 percent loss in energy. This is three to 10 times the improvement in losses that the AMT offers.

The NOPR does not address the technical or potential economic impacts of increased background noise from installing AMTs. However, the National Institutes of Health issued a series of papers about noise annoyance and its impact on mental health.[26] While the reference does not deal with transformer noise specifically, it does deal with constant background noise that the person has no control over.

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[23] https://www.researchgate.net/publication/224348167_Audible_Noise_From_Amorphous_Metal_and_Silicon_Steel-Based_Transformer_Core.

[24] https://www.electricalindia.in/noise-level-measurements-in-amorphous-crgo-core-distribution-transformers/

[25] https://aip.scitation.org/doi/10.1063/1.4978759.

[26] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4873188/.

Added Losses from Longer/Larger Secondary Cables

Based on APPA's discussion with member utilities, average loading losses on secondary cables are four percent and almost 10 percent on peak loading. Research has also found that the older the neighborhood, and the lower the income, the higher the losses were. This is mostly because of two factors:

1) Smaller secondary conductor size, causing faster heating and higher impedance.
2) Longer secondary from transformers located further away, using a shared secondary on the poles, rather than individual, shorter secondary runs to the individual premise.

AMTs are larger and more expensive, but the expense does not rise linearly with the capacity of the transformer. Higher capacity transformers are cheaper per kW than smaller ones, so to save money, it is only logical that where shared secondary cable already exists, one should replace two or more transformers with a single transformer and combine the shared portion of the secondary network. This has been shown to increase losses in the shared secondary cable to between 0.6 and 2.2 percent of total power delivered, far out stripping the increased efficiency of the AMT. Although DOE could consider working with utilities on secondary issues for more efficiency, the NOPR's analysis does not adequately account for this issue, which would undercut the efficiency conclusions in the proposed rule.

Changes Required to Surrounding Equipment

Amorphous core transformers experience higher inrush currents creating the need for external protective devices (for example, fuses) to be reviewed and changed. The amount of core steel significantly increases. This additional steel creates a much heavier device that could force the utility to rerate framing hardware while increasing pole size and class. This will potentially increase costs in a way that DOE has not addressed.

<u>Section Three: Important Issues that Are Not Addressed in the NOPR</u>

In addition to the specific technical and cost issues discussed in Section Two above, APPA has identified numerous other issues and questions that would be important to a reasoned consideration of the proposed distribution transformer efficiency standards, but that are not addressed in the NOPR. APPA respectfully submits that adoption of the proposed standards without addressing these issues would undermine DOE's technical and economic analysis and run afoul of applicable APA requirements.[27] A number of these issues and questions are identified below.

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[27] A process of reasoned decision-making requires an agency to engage the arguments presented by interested parties, and an agency decision is arbitrary and capricious if it "entirely fail[s] to consider an important aspect of the problem" or "runs counter to the evidence before the agency." *Farmers Union Cent. Exch., Inc. v. FERC*, 734 F.2d 1486, 1499–1500 (D.C. Cir. 1984); *see also Am. Pub. Gas Ass'n*, 22 F.4th at 1025. Similarly, agencies are

Gases

DOE needs to investigate whether the gases produced by the transformer change with the new fluids and steels in the transformer, as well as with the changes in temperature when operating. If so, does the frequency of the best practice testing change and does the testing equipment need to change? If testing equipment needs to change, then what will the cost of this new equipment be? There also needs to be an examination of whether fluid breakdown in the AMT poses any new hazards or changes in frequency of the existing hazards, and whether extra precautions are needed in areas prone to wildfires.

Operating Temperature

None of the materials in the NOPR showed how the efficiency of AMTs is altered by changes in operating temperature. This important information would include any environmental test data where the transformer is subject to temperatures down to minus 70 degrees Fahrenheit (Montana's modern record cold temperature) and also any data testing the performance of the transformers through at least 60 days of continuous cold temperatures. Environmental test data would also be needed in cases where the transformer's internal operating temperature exceeds 250 degrees Fahrenheit, as well as testing transformers in cases where there are at least 120 days of continuous hot temperatures.

Overloading

Based on literature searches, there seem to be changes to the cooling time for AMTs and decreases in overload capability relative to existing GOES transformers. Reasoned analysis of the revised efficiency standards would require consideration of the changes in these two parameters, including:

a. What should the emergency load rating be as a percentage of load for an AMT?
b. Analysis of AMT behavior during an overload situation at 150 to 200 percent of nameplate.
c. After an overload situation of 150 percent or higher, a showing that the transformer recovers from the event without any permanent change in operating characteristics.
d. An estimate of the failure rate for AMTs when they are overloaded for 30, 60, and 90 minutes at 120, 150 and 200 percent loading.
e. Comparison between the existing GOES transformers and the NOES transformers for:
    i. Dimensions
    ii. Weight
    iii. Impedance

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obligated to "respond to objections that on their face seem legitimate." *Gulf Restoration Network v. Haaland*, 47 F. 4th 795, 803 (D.C. Cir. 2022) (internal quotes and citations omitted).

iv. Losses at zero, 50, 90, 100, 120, and 150 percent loading.

Effects of Electrification

With electric vehicles, solar photovoltaic, building decarbonization, and other energy transition technologies, the average household will move from an average of load of two kW to an average of six kW and a peak of five kW to a peak of 10 to 25kW (range is based on electric vehicle EVSE sizing). Currently, 25 kVA transformers serve two to six residences. Transformers are going to have at least twice the load and will have fewer low/no load hours. A reasoned economic justification analysis for the proposed distribution transformer efficiency standards would need to address the change in the way transformers are going to operate during and after the transition and analyze how NOES transformer efficiency will be impacted by these changes, and whether those changes impact NOPR's cost/benefit analysis.

Relatedly, low-income and traditionally disadvantaged neighborhoods on average have higher load factors and less ability to participate in the energy transition. With the increased costs of NOES transformers, capital constrained utilities are going to be able to rebuild fewer miles of distribution, thereby potentially hindering the Justice-40 goals of the federal government. Furthermore, if NOES transformer costs slow the ability of utilities to upgrade the infrastructure in some Justice-40 communities, those communities will be bypassed for Inflation Reduction Act grants for communities that are ready to absorb the additional load.

Other

Other areas requiring careful study are:

- Pole loading with GOES versus NOES for the various classes of wood poles;
- The tendency of AMTs, because they are much thinner, for the foil to rip through the slitting process, and ways avoid this tearing of the foil;
- The relatively high noise levels (up to 90 dB at 20 feet) from issues with uneven gaps in the coils of AMT, as well studies on the medical impacts of this kind of problem;
- The decreased normal life of AMT compared to GOES; and
- AMT's increased brittleness compared to GOES.

DOE Questions

Additionally, the NOPR listed 50 questions on which DOE was seeking comment. Based on the NOPR document, these questions are under-explored and/or researched. While each of these questions may not require a definitive answer prior to final rulemaking, many of the questions concern matters that are essential to any reasoned technical and economic justification analysis for the proposed revised efficiency standards. Indeed, as discussed in these comments, further information in response to at least some of these questions is likely to show that the proposed standards are not economically justified. APPA urges DOE to address many of these questions prior to issuing any final rule. Among the issues requiring further research and inquiry are:

- Whether the proposed definition better aligns with industries understanding on input and output voltages;
- Whether the proposed amendment would impact products that are serving distribution applications, and if so, the number of distribution transformers impacted by the proposed amendment;
- The proposed definition of "submersible" distribution transformer, as well as the impact that submersible characteristics have on distribution transformer efficiency; and
- Challenges that would exist if designing a distribution transformer, which uses amorphous electrical steel in its core, for data center applications and whether data center transformers have been built that use amorphous electrical steel in their cores.

Conclusion

APPA appreciates the opportunity to comment on DOE's proposed revised efficiency standards for distribution transformers. For the reasons set forth above, APPA respectfully submits that the NOPR's proposed efficiency standards and the analyses cited to support them would not comport with EPCA requirements. Importantly, the proposed efficiency standards would worsen already critical distribution transformer supply shortages. APPA urges DOE to reconsider the NOPR or delay the implementation until the transformer supply base is strengthened enough to increase supply, reduce costs, and greater diversity of component suppliers exists. If the DOE continues to consider the proposed efficiency standards, it should revise the cost justification analysis, taking into account the issues identified by APPA and other commenters. Such a revised analysis is likely to show that the proposed standards are not economically justified. At a minimum, DOE should consider restricting any revised efficiency standards to pad-mount and overhead transformers and to exclude vault, submersible, and other special installation transformers.

Respectfully submitted,

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