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Electricity Distribution Transformers: Supply, Tariffs, and Policy Options

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SUMMARY

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Electricity Distribution Transformers: Supply, Tariffs, and Policy Options

Supply of electricity distribution transformers essential to the electric power grid has been strained in the last few years, with implications for post-disaster recovery and plans for grid expansion. Distribution transformers are located near the service connection with residences and commercial buildings or on industrial sites. The price of transformers has increased sharply since 2020, with data from the Bureau of Labor Statistics reporting the prices of both distribution transformers and large power transformers to have risen roughly 40% from 2020 to 2024 (inflation-adjusted). Coupled with the rise in prices is an increase in the time needed for suppliers to fulfill orders for distribution transformers. According to a February 2024 report by the National Laboratory of the Rockies (NLR), orders are reportedly taking two years to be fulfilled, a fourfold increase compared to pre-2022.

The U.S. Department of Energy (DOE) identified 34 original equipment manufacturers in the U.S. market for distribution transformers as of April 2024. They also estimated that 1.5 million units were shipped in 2021. An industry report from 2024 estimated it would take three to five years before sufficient new manufacturing capacity might become operational and alleviate supply issues. NLR estimates roughly half of distribution transformers are over 33 years old and nearing the end of their useful life. The U.S. electric power grid transmission expands at roughly 1% per year, and in 2023, roughly one-third of grid investments went toward distribution infrastructure, implying a need for additional distribution transformers.

The United States imports 25% to 30% of distribution transformers chiefly from Taiwan, Canada, and Mexico. Some domestic transformers are made using imported components such as the electrical core that facilitates the crucial voltage transformation, of which between half and three-quarters are imported for incorporation into assembled domestic transformers. Those cores that are instead made domestically obtain 95% of their steel from one domestic supplier. Importation is possible, but imported electrical "steel articles" are subject to 50% tariffs as of August 15, 2025. There are some flexibilities in the supply picture. Manufacturers could choose to increase their production of electrical steel for cores, if willing to reduce their output of other products. Current federal programs provide incentives for expanding production capacity, and several manufacturers have announced they will be utilizing these incentives—competitively awarded tax credits (Internal Revenue Code Section 48C [IRC §48C]).

Other recent domestic programs or actions include rebates for purchase of a replacement distribution transformer and a 2022 presidential determination which found that distribution transformers and grid components are "critical technology items" essential to the national defense. Bills currently in Congress, S. 448 and H.R. 4128, would expand the scope of a tax credit, Internal Revenue Code Section 45X (IRC §45X), to apply to the production costs of distribution transformers. In 2022, rural electric cooperatives and other organizations signed a letter to the House and Senate Appropriations Committees requesting $1 billion to address the "supply chain crisis."

Congress may choose to constrict, maintain, or expand statutes affecting supply of distribution transformers. Policy options include the following:

- Expanding the scope of the IRC §45X credit, a manufacturer credit of 10% the cost of producing certain electrical equipment, to include distribution transformers (S. 448 and H.R. 4128).
- Modifying the Qualifying Advanced Energy Project Credit (IRC §48C) to reserve a certain dollar amount exclusively for distribution transformers, bypassing the competitive requirement.
- Creating a virtual reserve by authorizing and funding the federal government to purchase distribution transformers up to a predetermined level (quota). If market activity does not reach the quota over a defined period of time, the government would purchase the difference as the buyer-of-last-resort.
- Using Title III of the Defense Production Act of 1950 (P.L. 81-774) to address manufacturing capacity.
- Continuing to fund research and development for new, improved transformers and periodically assessing their technological readiness and adjusting the deployment incentives.

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Introduction

Electricity *distribution transformers* are a component of the electric power grid located near the service connection with residences and commercial buildings or on industrial sites.[1] There are between 60 million and 80 million distribution transformers in service in the United States.[2] A transformer changes the input voltage of power transported via the electric grid to the end user, stepping voltage up or down as necessary to synchronize different components and stabilize the grid.[3] The parts of a transformer include a silicon-bearing, iron-alloyed steel core, wrapped by insulated electrical conductors.[4] The core performs its function by relying on the ability of this iron alloy to react with a magnetic field, a specialized property only possessed by certain materials. The assembled distribution transformers are mounted on utility poles and pads and secured in cabinets or underground vaults, operate continuously, and have lifetimes of several decades.[5]

In 2023, roughly one-third of grid investments went toward distribution infrastructure.[6] Of this, the Edison Electric Institute estimates, investor-owned utilities invested about one-quarter in component replacement and one-quarter in expansion.[7] The National Laboratory of the Rockies (NLR, formerly the National Renewable Energy Laboratory [NREL]) estimates between 1.4 million and 2.4 million distribution transformer units are added or replaced each year.[8] The U.S. electric power grid transmission expands at roughly 1% per year.[9]

Electric utilities firms profess a need for assured access to large numbers of transformers for preventative maintenance, grid expansion, or rapid replacement following natural hazard events.[10]

[1] Sometimes known as distribution power transformers (DPTs). See CRS Insight IN12179, *DOE's Proposed Regulation on Electricity Distribution Transformers*, by Martin C. Offutt; and CRS In Focus IF12253, *Introduction to Electricity Transmission*, by Ashley J. Lawson.

[2] National Renewable Energy Laboratory (NREL) [now National Laboratory of the Rockies (NRL)], *Major Drivers of Long-Term Distribution Transformer Demand*, NREL/TP-6A40-876, February 2024.

[3] See CRS Insight IN12179, *DOE's Proposed Regulation on Electricity Distribution Transformers*, by Martin C. Offutt; and CRS In Focus IF12253, *Introduction to Electricity Transmission*, by Ashley J. Lawson.

[4] U.S. Department of Energy (DOE), *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Distribution Transformers*, April 2024, p. 3-58, https://www.regulations.gov/document/EERE-2019-BT-STD-0018-0165.

[5] DOE, "DOE Finalizes Energy Efficiency Standards for Distribution Transformers That Protect Domestic Supply Chains and Jobs, Strengthen Grid Reliability, and Deliver Billions in Energy Savings," press release, April 4, 2024, https://www.energy.gov/articles/doe-finalizes-energy-efficiency-standards-distribution-transformers-protect-domestic.

[6] Edison Electric Institute (EEI), "Industry Capital Expenditures," 2024, p. 2, https://web.archive.org/web/20250630212252/https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Finance-And-Tax/Industry-Capital-Expenditures.pdf.

[7] EEI, "Industry Capital Expenditures," 2024, p. 6. Grid maintenance and expansion can include numerous types of components, not only distribution transformers.

[8] NREL, *Distribution Transformer Demand: Understanding Demand Segmentation, Drivers, and Management Through 2050*, NREL/FS-6A40-92076, November 2024, p. 2, https://www.nrel.gov/docs/fy25osti/92076.pdf.

[9] A. White et al., *Pathways to Commercial Liftoff: Innovative Grid Deployment*, DOE, April 2024, p. 14, https://www.energy.gov/articles/doe-releases-new-report-accelerating-deployment-grid-solutions-lower-costs-and-improve.

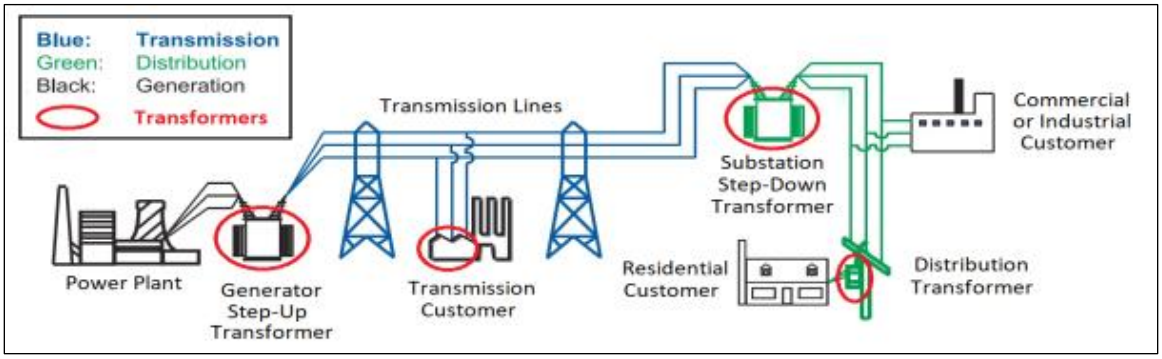
[10] B. Plumer, "Why Restoring Power After Helene Is Complicated," *New York Times*, October 1, 2004. Electric utilities are generally those firms engaged in production and/or distribution of retail electricity. Federal Energy Regulatory Commission, *Glossary*, August 31, 2020, https://www.ferc.gov/about/what-ferc/about/glossary.

The Nature of Transformers and Their Role in the Electric Grid

Transformers vary in physical size, location in the network's topology, and voltage step they effect (see **Figure 1**). Distribution transformers are but one type of transformer and one of many types of grid components.[11] (See **Figure 1**, bottom right, circled in red.) Congress has defined distribution transformers in terms of the input voltage (34.5 kilovolts or less), the output voltage (600 volts or less), and the operating frequency (60 Hertz or cycles per second).[12] The definition excludes device-specific transformers that are not general-purpose. The Department of Energy (DOE) has further added electrical capacity ratings for distribution transformers, and the current definitions set this at no more than 5,000 kilovolt-amperes (kVA).[13] According to DOE, distribution substation transformers, which are the bridge between transmission and distribution, would typically not be included within this definition because the output voltage would exceed 600 volts.[14] (See **Figure 1**, top right, circled in red.)

Figure 1. Electric Power Grid: Transformers

Distribution transformers appear in lower right



Source: Adapted by CRS from U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, April 2004, Figure 2.1. CRS Insight IN12048, *Electric Power Transformers: Supply Issues*, by Paul W. Parfomak.

Distribution transformers do not present the same challenge to electric grid security as large power transformers, which serve many thousands of customers and are a single-point vulnerability, meaning just one component failure can affect a large number of users. The consequence (i.e., extent) of a power blackout due to failure of a single distribution transformer is relatively much smaller.[15] A DOE-funded journal article surmised nonetheless that older

[11] In DOE's definition, grid components can include grid infrastructure (e.g., wooden poles), transmission systems, and power transformers; distribution transformers, switchgear, etc.; and electrical circuits and power electronics. DOE Office of Manufacturing and Energy Supply Chains, *Defense Production Act: Request for Information*, October 2022, https://www.energy.gov/mesc/defense-production-act-request-information.

[12] 42 U.S.C. §6291(35)(A). Section 135 of the Energy Policy Act of 2005 (P.L. 109-58) amended the Energy Policy and Conservation Act (P.L. 94-163) to add distribution transformers as a type of commercial equipment subject to energy conservation standards. DOE subsequently amended the definition to include a description of power capacities, measured in volt-amperes. 10 C.F.R. §431.192 and DOE, "Energy Conservation Program: Test Procedures for Distribution Transformers," 71 *Federal Register* 24972, April 27, 2006.

[13] 10 C.F.R. §431.192.

[14] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 89 *Federal Register* 29877, April 22, 2024.

[15] U.S. Government Accountability Office (GAO), *Electricity Grid: DOE Could Better Support Industry Efforts to Ensure Adequate Transformer Reserves*, GAO-23-106180, August 2023, p. 2, https://www.gao.gov/products/gao-23-106180.

distribution transformers were more likely to fail owing to degraded insulation; the article further noted that the heat from wildfires could accelerate such failures.[16] High temperatures can trigger explosions in distribution transformers, as can short circuits or lightning strikes.[17]

Context of This Report

The distribution transformers that serve the power grid, while numerous, are vulnerable to periodic failure as they near the end of their useful life or suffer the effects of natural hazards leading to widespread damage or failure.[18] The creation of an assured supply of transformers encounters a tension between the need for sufficient inventory to replace the existing transformer stock and aspirations to expand the power grid.

The supply chain for distribution transformers has certain vulnerabilities or bottlenecks and is experiencing upward pressures on price, leading to either greater importation or longer wait times for delivery of orders. Industry groups representing electric utilities and home builders refer to a "supply chain crisis;"[19] a federal advisory committee foresees the possibility of economic disruption;[20] and a DOE-convened roundtable tied a lack of manufacturing capacity to ongoing shortages.[21] More recently, an industry consultancy estimated that wait times for distribution transformers had decreased to 30 weeks by the second quarter of 2025.[22]

Report Framework

This report considers policy options for improving the supply of distribution transformers within a framework of economic costs and benefits, or advantages and disadvantages, and the implications for grid resilience and the price of the components themselves. Other perspectives, not considered in this report, include industrial policy, such as the onshoring of manufacturing capacity, and national security benefits, such as might accrue from maximizing domestic supply of distribution transformers.

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[16] S. Vahedi et al., "Wildfire and Power Grid Nexus in a Changing Climate," *Nature Reviews Electrical Engineering*, vol. 2 (March 24, 2025), pp. 225-243.

[17] ABB, "Overcoming Urban Power Distribution Challenges with Technology Innovations," 2012, p. 2, ABB-456-WPO_urban-substations_FINAL.pdf. Liquid-filled transformers, one of the three categories of distribution transformers DOE regulates, include an electrical core immersed in a nonconducting, electrically insulating oil that has favorable cooling characteristics (i.e., heat conduction). DOE, *Technical Support Document*, p. 3-51.

[18] An academic study found 73% of counties it studied experienced outages due to weather events in the years 2018 to 2020, with outages defined as lasting at least 8 hours and affecting 0.1% of customers. Vivian Do et al., "Spatiotemporal Patterns of Individual and Multiple Simultaneous Severe Weather Events Co-occurring with Power Outages in the United States, 2018–2020," *PLOS CLIMATE*, vol. 4, no. 1 (January 22, 2025), p. e0000523.

[19] Letter from Jim Matheson, National Rural Electric Cooperative Association (NRECA), et al. to Sen. Patrick Leahy et al., November 18, 2022, https://s3.documentcloud.org/documents/23466298/transformershortage.pdf. The letter called on Congress to appropriate $1 billion in support of the distribution transformer supply chain.

[20] National Infrastructure Advisory Council (NIAC), *Addressing the Critical Shortage of Power Transformers to Ensure Reliability of the U.S. Grid*, June 2024, p. 17, https://www.cisa.gov/sites/default/files/2024-09/NIAC_Addressing%20the%20Critical%20Shortage%20of%20Power%20Transformers%20to%20Ensure%20Reliability%20of%20the%20U.S.%20Grid_Report_06112024_508c_pdf_0.pdf.

[21] DOE, *Defense Production Act to Accelerate Domestic Manufacturing and Adoption of Clean Energy Technologies: Summary of Roundtables and RFI Responses*, DOE/MESC-0102, March 2023, p. 8, https://www.energy.gov/sites/default/files/2023-04/DOE%20DPA%20Roundtables%20and%20RFI%20Executive%20Summary%20FINAL%203-21-23.pdf.

[22] Wood Mackenzie, *Untangling the US Transformer Supply Chain Crisis*, July 2025, p. 3, https://www.woodmac.com/press-releases/power-transformers-and-distribution-transformers-will-face-supply-deficits-of-30-and-10-in-2025/.

Market for Distribution Transformers

Publicly available information on the size of the U.S. market for distribution transformers is limited. DOE estimated that 1.5 million distribution transformers were shipped by manufacturers in 2021.[23] For 2024, an industry analysis estimated the size of the market for distribution transformers in North America to be $12.4 billion annually.[24] A second industry analysis estimates the market for distribution transformers in North and South America will reach $27.7 billion in 2028 (2024 dollars).[25]

Market Participants

The market for distribution transformers includes utilities and commercial and industrial users on the demand side and manufacturers on the supply side. Other market participants, such as parts suppliers and foreign manufacturers, are discussed later. The electric power utility industry includes investor-owned utilities, municipal authorities, electric cooperatives, and other entities. Among electric utilities, over 90% purchase their distribution transformers directly from manufacturers, though rural electric cooperatives are an exception. The remainder, especially rural utilities and electric cooperatives, purchase through distributors, repair shops, and electrical contractors.[26] Among commercial and industrial owners, the distribution chain is different and goes through distributors.[27] Generally speaking, electric utilities and commercial and industrial customers purchase different types of transformers.[28]

Recent Supply Picture

The price of transformers has increased sharply, with data from the Bureau of Labor Statistics reporting the producer price index of distribution transformers and large power transformers to have risen roughly 40% from 2020 to 2024 (inflation-adjusted).[29] For the segment from 2021 to 2023, DOE attributes the rise in transformer prices to increased demand following the 2020-era pandemic slowdown.[30]

Coupled with the rise in transformer prices is an increase in the time needed for suppliers to fulfill orders for distribution transformers. According to a February 2024 report by NLR, orders were

[23] DOE (2024), *Technical Support Document*, p. 9-8. DOE uses shipments as a proxy for aggregate sales since the latter are not readily available. See discussion at DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 89 *Federal Register* 29949, April 22, 2024, note 167.

[24] Global Marketing Insights, *North America Distribution Transformer Market Size*, August 2023, https://www.gminsights.com/industry-analysis/north-america-distribution-transformer-market.

[25] GlobalData, "Global Transformers Market to Reach $51.33 Billion in 2028, Led by the Asia-Pacific Region, Forecasts GlobalData," press release, June 18, 2024, https://www.globaldata.com/media/power/global-transformers-market-to-reach-51-33-billion-in-2028-led-by-the-asia-pacific-region-forecasts-globaldata/.

[26] DOE, *Technical Support Document*, p. 3-27.

[27] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 88 *Federal Register* 1769, January 11, 2023.

[28] Electric utilities purchase almost all only liquid-filled transformers. Commercial and industrial are more likely to own dry-type transformers. DOE, *Technical Support Document*, pp. 3-27, 6-2, and 7-1.

[29] U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Machinery and Equipment: Power and Distribution Transformers, Except Parts, https://fred.stlouisfed.org/series/WPU11740999.

[30] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 89 *Federal Register* 29905, April 22, 2024.

reportedly taking two years to be fulfilled, a fourfold increase compared to pre-2022.[31] Work by a consultancy, while agreeing with NLR that a two-year wait time prevailed in 2024, estimated that wait times for distribution transformers had decreased to 30 weeks by the second quarter of 2025.[32]

In an April 2024 notice, DOE identified 34 original equipment manufacturers in the U.S. market for distribution transformers.[33] An industry report estimated it would take three years to five years before anticipated new manufacturing capacity could come online and be able to alleviate supply issues.[34]

A study by the Government Accountability Office (GAO) found suppliers of distribution transformers were concerned with two key issues limiting manufacturing capacity: the size of existing factories and the need to hire and train additional workers.[35]

Drivers of Demand

Electric utilities replace distribution transformers as part of preventive maintenance, grid expansion, and rapid replacement following natural hazard events.[36] Regarding expansion, NLR estimates that installed distribution transformer capacity (measured in watts of rated electrical capacity) could more than triple by 2050 to satisfy economy-wide demand.[37] Regarding natural hazards, the linkage between demand for transformers and weather events may be illustrated by the after-effects of hurricanes. A utility in Mississippi saw 10,000 transformers and 30,000 power poles damaged and in need of replacement following Hurricane Katrina (2005), according to a report by an industry-affiliated organization.[38]

Maintaining Inventories of Transformers

According to an industry group, utilities maintain access to inventories of hundreds of transformers for contingency planning and business continuity to mitigate the risk of severe weather events.[39] Though the transformers would be held back from normal use, the market would in theory respond to the occasional need to replenish the reserve. From the perspective of a utility, maintaining an inventory of transformers ties up working capital, but, because such inventory may not meet the criterion of "used and useful equipment," the utility may not be able

[31] NREL, *Major Drivers of Long-Term Distribution Transformer Demand*.

[32] Wood Mackenzie, *Untangling the US Transformer Supply Chain Crisis*, p. 3.

[33] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 89 *Federal Register* 30034, April 22, 2024.

[34] I. Schwartz and K. Jacobs, "4 Years into a Difficult Transformers Market in the US, Is There a Potential End in Sight?" Wood Mackenzie, June 27, 2024, https://www.woodmac.com/news/opinion/4-years-into-a-difficult-transformers-market-in-the-us-is-there-a-potential-end-in-sight/.

[35] GAO, *Electricity Grid*, p. 11. H.R. 4105, the Veterans Energy Transition Act of 2025, would authorize grants for eligible entities providing jobs for "separating members, veterans, and spouses to obtain employment in the energy industry," including for work on certain equipment enumerated in the bill as critical, including transformers.

[36] B. Plumer, "Why Restoring Power After Helene Is Complicated," *New York Times*, October 1, 2004.

[37] NREL, *Major Drivers of Long-Term Transformer Demand*, p. 7.

[38] E. Kelly, "Electric Co-ops Hit Hard by Hurricane Helene Face Tough Task of Rebuilding," NRECA, October 7, 2024, https://www.electric.coop/electric-co-ops-hit-hard-by-hurricane-helene-face-tough-task-of-rebuilding.

[39] EEI, *Spare Equipment and Grid Resilience*, August 1, 2023, https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Reliability-and-Emergency-Response/Spare-Equipment-and-Grid-Resilience-Programs.pdf; and NREL, *Distribution Transformer Demand*, p. 6.

to charge customers and, therefore, may not see a return on investment, depending on its regulator.[40]

The larger entities in the business of supplying electric power keep their own inventories of distribution transformers, using their buying power to negotiate pricing. Entities that are not as large, including electric cooperatives, may band together to form parts-supply cooperatives. For example, United Utility Supply, a supply cooperative formed as a pooled resource to make available large numbers of grid components in a short time frame, is headquartered in Kentucky and maintains an inventory of about 10,000 transformers.[41] The firm shipped several hundred pad- and pole-mounted distribution transformers in the first few days following Hurricane Helene in 2024 and keeps such inventory in five locations.[42] GAO notes that small utilities may not be able to absorb the administrative burden of participating in equipment sharing.[43]

Imports and Supply Chain

One firm estimated in 2023 that roughly 25% to 30% of finished distribution transformers (all core types) were imported and that the majority originated from Mexico, Canada, and Taiwan.[44]

Imported parts may include a steel core, made of stacked laminations of thin rectangular steel shapes, wrapped by insulated electrical conductors or "windings" made of copper or aluminum that carry the electrical current.[45]

Imports of finished cores rose significantly between 2016 and 2019, from $29 million to $205 million (inflation-adjusted 2024 dollars), according to a 2021 study by the Department of Commerce; together, Mexico and Canada were responsible for roughly 95% of the 2019 total.[46] The Department of Commerce noted that this increase in imports had displaced domestic production. An industry analysis, noting the rise in imports of finished cores after 2018, attributed this to efforts to bypass import duties manufacturers might otherwise pay on raw materials in order to reduce their costs for making the assembled transformers.[47]

Another supply chain method relies on using imported specialty steel and then manufacturing the electrical cores domestically. Manufacturers of distribution transformers do not typically use this option. Writing in 2024, DOE suggested this was because of the prevailing tariff on "steel

[40] The principle of "used and useful" applies to which equipment a utility can bill to its customers. See, for example, Federal Energy Regulatory Commission, *Energy Primer: A Handbook of Energy Market Basics*, staff report, April 2020, https://www.ferc.gov/news-events/news/ferc-staff-issues-2024-energy-primer-handbook-energy-market-basics.

[41] E. Kelly, "Electric Co-ops Hit Hard."

[42] E. Kelly, "Electric Co-ops Hit Hard"; and United Utility Supply, *United Utility Supply*, 2025, https://uus.coop/c/products.

[43] GAO, *Electricity Grid*, pp. 19, 24.

[44] A. Fayyaz and S. Saeed, "Watts Happening: A Comprehensive Look at Americas Distribution Transformer Market," November 1, 2023, https://ptr.inc/watts-happening-a-comprehensive-look-at-americas-distribution-transformer-market/.

[45] DOE, *Technical Support Document*, pp. 3-50, 3-58. Aluminum can be easier to machine and is less costly than copper, but copper can have more favorable electrical properties. DOE, *Technical Support Document*, p. 4-3. The particular cores described in the text are known as *stacked cores* because of the laying, one upon another, of the laminations. *Wound cores* operate on the same physical principles but the form of the core is different, comprised of a flat tape or foil of electrical steel that is wrapped into the shape of a cylinder or flattened cylinder.

[46] Department of Commerce (DOC), "Publication of a Report on the Effect of Imports of Transformers and Transformer Components on the National Security: An Investigation Conducted Under the Trade Expansion Act, as Amended," 86 *Federal Register* 64608, November 18, 2021.

[47] Wood Mackenzie, *Untangling the US Transformer Supply Chain Crisis*, p. 6.

articles," discussed below, which made this steel uncompetitive.[48] Cleveland-Cliffs Inc., the dominant U.S. maker of the steel used in transformers, recently asserted that manufacturers of cores in Canada and Mexico were "using steel melted and poured outside of North America."[49]

Steel and Its Relevance to Transformer Supply

Supply and International Trade

DOE states in a 2024 notice that the manufacturing of distribution transformers entails either the use of imported steel or the purchase of steel from the sole domestic manufacturer.[50] DOE's May 2023 critical materials assessment identified electrical steel in general as a "near-critical material."[51] Currently, the type of steel used for transformer cores is grain-oriented electrical steel, or "GOES." GOES is a specialty steel with desirable electrical and magnetic properties. Large power transformers, another part of the electric grid, also use GOES.[52] By one estimate, 95% of transformer cores in the United States are constructed using GOES.[53] The supply of electrical steel must satisfy demand for electrical steel from other grid components as well, and all such components can compete with one another for manufacturing capacity from the same plant.[54]

In 2020, two Members of Congress wrote a letter to President Trump urging him to address what they perceived to be "unfairly traded imports" of "minimally transformed" GOES, citing "laminations, cores, and core assemblies" made using steel originating outside the United States.[55] A subsequent letter, in which the two Members were joined by a further 23 Representatives, requested that the President extend existing tariffs on steel products to cores and laminations (i.e., derivative products) under Section 232 of the Trade Expansion Act of 1962, as amended (19 U.S.C. §1862), discussed in the next section.[56]

[48] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 89 *Federal Register* 29889, April 22, 2024. A 2018 presidential proclamation issued the 25% tariff on "steel articles." See Proclamation 9705 of March 8, 2018, "Adjusting Imports of Steel into the United States," 83 *Federal Register* 11625, March 15, 2018. The steel articles generally included steel rather than parts or products made from steel.

[49] Cleveland-Cliffs Inc., "Cleveland-Cliffs Applauds New Section 232 Tariff Coverage of Electrical Steel and Stainless Steel Derivative Products," press release, August 18, 2025, https://www.clevelandcliffs.com/news/news-releases/detail/679/cleveland-cliffs-applauds-new-section-232-tariff-coverage.

[50] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 89 *Federal Register* 29899, April 22, 2024.

[51] DOE, *Critical Materials Assessment*, July 2023, p. xiv, https://www.energy.gov/sites/default/files/2023-07/doe-critical-material-assessment_07312023.pdf; and DOE, "Notice of Final Determination on 2023 DOE Critical Materials List," 88 *Federal Register* 51792, August 4, 2023.

[52] DOE Office of Policy, *Electric Grid Supply Chain Review: Large Power Transformers and High Voltage Direct Current Systems*, DOE/OP-0004, February 24, 2022, p. 8, https://www.energy.gov/sites/default/files/2022-02/Electric%20Grid%20Supply%20Chain%20Report%20-%20Final.pdf.

[53] Brian Dabbs, "Meet the Metal That Could Transform the Grid," *Energywire*, June 22, 2023.

[54] DOE, *Electric Grid Supply Chain Review*, p. viii.

[55] Rep. Troy Balderson, "Balderson Urges Trump to Protect AK Steel, the Last Remaining Electrical Steel Producer in U.S.," press release, March 6, 2020, https://balderson.house.gov/news/documentsingle.aspx?DocumentID=1487. AK Steel was subsequently acquired by Cleveland-Cliffs.

[56] U.S. Rep. Mike Kelly, "Kelly, Kaptur, and Balderson Lead Bipartisan Group of Lawmakers Urging President Trump to Preserve American Electrical Steel Industry," press release, April 15, 2020, https://kelly.house.gov/media/press-releases/kelly-kaptur-and-balderson-lead-bipartisan-group-lawmakers-urging-president.

Tariffs

Tariffs levied on imported goods have been used to protect certain domestic industries and as an instrument of foreign policy.[57] In 2018, President Trump imposed a 25% tariff on electrical steel from most trading partners.[58] Of the GOES imported into the United States, as of 2020, 85% came from South Korea.[59] In February 2025, President Trump removed the exemptions from the tariffs for certain countries (e.g., Mexico, Australia, Canada).[60] The action also eliminated exemptions for South Korean steel that were the result of negotiations between the U.S. and South Korean governments in 2018.[61] By one estimate, the quota, when in place, would have allowed roughly three-quarters of South Korea's steel exports, by weight, to the United States to be free from tariffs, relative to 2017 levels.[62] DOE found that the rise in price of transformers correlated with the rise in price of GOES, starting in 2021.[63]

On June 3, 2025, President Trump increased the Section 232 tariffs on steel and aluminum to 50% and expanded the number of derivative products covered by the tariff; for derivative products, the tariff would "apply only to the steel and aluminum contents of imported products."[64] On August 15, 2025, the Commerce Department announced that the 50% tariff on steel and aluminum imports would include derivative products in distribution transformers, including the electrical core and the laminations.[65] For certain copper products, President Trump placed a 50% tariff on August 1, 2025; such copper products may be used in the windings of transformers and in other electrical and electronic devices.[66]

[57] CRS In Focus IF11030, *U.S. Tariff Policy: Overview*, by Christopher A. Casey.

[58] CRS Insight IN12519, *Expanded Section 232 Tariffs on Steel and Aluminum*, by Kyla H. Kitamura and Keigh E. Hammond.

[59] DOE, *Electric Grid Supply Chain Review*, p. 15.

[60] Proclamation 10896 of February 10, 2025, "Adjusting Imports of Steel into the United States," 90 *Federal Register* 9817, February 18, 2025.

[61] Proclamation 9740 of April 30, 2018, "Adjusting Imports of Steel into the United States," 83 *Federal Register* 20683, May 7, 2018; and U.S. Customs and Border Patrol, *Korea Steel Annual Limits*, QB 18-120, May 22, 2018, https://www.cbp.gov/trade/quota/bulletins/qb-18-120-korea-steel-annual-limits.

[62] J. Schott and L. Lu, *Korea Steel Deal Means More US Steel Barriers Lie Ahead*, Peterson Institute for International Economics, March 28, 2018, https://www.piie.com/blogs/trade-and-investment-policy-watch/korea-steel-deal-means-more-us-steel-barriers-lie-ahead.

[63] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 89 *Federal Register* 29905, April 22, 2024.

[64] White House, "Fact Sheet: President Donald J. Trump Increases Section 232 Tariffs on Steel and Aluminum," press release, June 3, 2025, https://www.whitehouse.gov/fact-sheets/2025/06/fact-sheet-president-donald-j-trump-increases-section-232-tariffs-on-steel-and-aluminum/. The press release noted that tariffs on steel imported from the United Kingdom would remain at 25% depending on the status of the U.S.-UK Economic Prosperity Deal, with U.S. implementation of certain aspects of the deal subsequently announced on June 16, 2025. Under the deal, the United States is to establish a tariff-rate quota for steel from the United Kingdom at most-favored-nation rates, conditioned on the United Kingdom meeting U.S. requirements for steel supply chain security. See Executive Order 14309 of June 16, 2025, "Implementing the General Terms of the United States of America-United Kingdom Economic Prosperity Deal," 90 *Federal Register* 26419 (June 23, 2025).

[65] DOC, "Adoption and Procedures of the Section 232 Steel and Aluminum Tariff Inclusions Process," 90 *Federal Register* 40326, August 19, 2025.

[66] CRS Insight IN12614, *Section 232 National Security Tariffs on Copper Imports*, by Kyla H. Kitamura; and Proclamation 10962 of July 30, 2025, "Adjusting Imports of Copper into the United States," 90 *Federal Register* 37727, August 5, 2025. For discussion of copper in distribution transformers, see DOE, *Technical Support Document*, p. 4-6.

Possible Additions to Domestic Supply of Steel

Manufacturers have some flexibility to repurpose existing production capacity toward GOES, as well as other types of electrical steel, and manufacturers have stated in the past to DOE that some GOES capacity was being directed toward electrical steel needed for electric vehicles.[67] According to a 2022 DOE report, one steelmaker—Big River Steel, owned by U.S. Steel—could upgrade its production to supply GOES.[68] DOE noted other GOES sources exist in Russia, China, and the European Union.

While GOES is the dominant electrical steel in transformers, another type of steel, known as amorphous steel, has desirable magnetic properties as well. Japanese-owned Metglas has a domestic plant in South Carolina that produces amorphous steel. Hitachi Energy, according to DOE, imports amorphous steel from China to its plant in Quebec, Canada, for use in transformer manufacture.[69] An industry report listed the major amorphous steel producers outside the United States as being in Japan, China, and the European Union.[70] (See further discussion of amorphous steel in the section "Energy Conservation Standards and Implications for Supply.")

News of a possible further source of transformer core steel may be gleaned from an announcement by U.S. Steel, in October 2023, of the launch of its new electrical steel product line—InduX, with the ability to produce 200,000 tons annually at its electric arc furnace steelmaking facility in Osceola, AR.[71] The company claims the product line possesses magnetic properties suitable for transformers, although the majority of the capacity would be allocated toward "non-oriented" electrical steels for use in electric vehicles and motors.[72]

Recent Executive Branch Actions

Changes to Tariffs on Copper and Steel and Its Derivative Products[73]

As noted above, there is currently a 50% tariff on steel imports that includes electrical steel and derivative products used in distribution transformers, such as the core and laminations.[74] Certain

[67] DOE, *Technical Support Document*, p. 12-6.

[68] DOE, *Electric Grid Supply Chain Review*, p. viii.

[69] DOE, *Technical Support Document*, p. 3-18.

[70] 360 Research Reports, *Global Amorphous Metal Transformers Market Research Report 2022*, June 11, 2022, https://www.360researchreports.com/global-amorphous-metal-transformers-market-21064941.

[71] United States Steel Corporation, "U.S. Steel Celebrates Launch of New Electrical Steel Line with Ribbon Cutting in Osceola, Arkansas," press release, October 12, 2023, at https://investors.ussteel.com/news-events/news-releases/detail/648/u-s-steel-celebrates-launch-of-new-electrical-steel-line.

[72] United States Steel Corporation, "Statement of Rich Fruehauf, Senior Vice President and Chief Strategy & Sustainability Officer to the Congressional Steel Caucus," June 7, 2023, https://mrvan.house.gov/sites/evo-subsites/mrvan.house.gov/files/evo-media-document/u.s.-steel-corporation-testimony-2023.pdf.

[73] Kyla Kitamura, CRS Analyst in International Trade and Finance, contributed to this section.

[74] White House, "Fact Sheet: President Donald J. Trump Increases Section 232 Tariffs on Steel and Aluminum," press release, June 3, 2025, https://www.whitehouse.gov/fact-sheets/2025/06/fact-sheet-president-donald-j-trump-increases-section-232-tariffs-on-steel-and-aluminum/; and DOC, "Adoption and Procedures of the Section 232 Steel and Aluminum Tariff Inclusions Process," 90 *Federal Register* 40326, August 19, 2025.

copper products, including those used in electrical and electronic devices, are also subject to a 50% tariff.[75]

The larger question of how the current tariff regime will affect firms that employ electrical steel, transformer subassemblies, and finished transformers is unknown. A Section 232 investigation by the Department of Commerce found that laminations, stacked cores, and wound cores were being imported "in such quantities and under such circumstances as to threaten to impair U.S. national security."[76] This finding has not yet led to any trade action. In the course of its investigation, the Department of Commerce surveyed firms who noted supply shortages and increased costs due to tariffs.[77]

Defense Production Act of 1950[78]

The Defense Production Act of 1950 (DPA; P.L. 81-774) provides the President with authority to "shape national defense preparedness programs and to take appropriate steps to maintain and enhance the domestic industrial base."[79] Title III of the DPA gives the President the means to provide financial assistance to private industry in order to "create, maintain, protect, expand, or restore domestic industrial base capabilities essential for the national defense."[80]

On June 6, 2022, then-President Biden made a determination pursuant to Section 303 (50 U.S.C. §4533) stating that "transformers and electric power grid components are industrial resources, materials, or critical technology items essential to the national defense."[81] In August 2022, Section 30001 of P.L. 117-169, known as the Inflation Reduction Act of 2022 (IRA), appropriated $500 million to carry out the DPA. There is no evidence that any of this funding has been allocated to transformers and electric power grid components. DOE allocated $250 million of the funding appropriated in P.L. 117-169 to electric heat pumps,[82] and the remaining $250 million was allocated to the Department of Defense (DOD). (DOD is "using a secondary Department of War designation" under Executive Order 14347 dated September 5, 2025.) DOD stated that the

[75] Proclamation 10962 of July 30, 2025, "Adjusting Imports of Copper into the United States," 90 *Federal Register* 37727, August 5, 2025. The copper products included wires such as those used in transformer windings. See A. Home, "US Copper Mountain Still Growing After December Import Surge," Reuters, February 27, 2026, https://www.reuters.com/markets/commodities/us-copper-mountain-still-growing-after-december-import-surge-2026-02-27/.

[76] DOC, "Publication of a Report on the Effect of Imports of Transformers and Transformer Components on the National Security: An Investigation Conducted Under the Trade Expansion Act, as Amended," 81 *Federal Register* 64609, November 18, 2021.

[77] DOC, "Publication of a Report on the Effect of Imports of Transformers and Transformer Components on the National Security," 81 *Federal Register* 64638.

[78] For further description of the Defense Production Act, see CRS Report R43767, *The Defense Production Act of 1950: History, Authorities, and Considerations for Congress*, by Alexandra G. Neenan.

[79] 50 U.S.C. §4502.

[80] 50 U.S.C. §4533.

[81] Presidential Determination No. 2022-19 of June 6, 2022, "Presidential Determination Pursuant to Section 303 of the Defense Production Act of 1950, as Amended, Transformers and Electric Power Grid Components," 87 *Federal Register* 35079, June 9, 2022.

[82] DOE, "Biden-Harris Administration Announces $250 Million to Accelerate Electric Heat Pump Manufacturing Across America," press release, April 22, 2023, https://www.energy.gov/articles/biden-harris-administration-announces-250-million-accelerate-electric-heat-pump.

funding would be allocated to expand capabilities for critical minerals production for large-capacity batteries and other purposes.[83]

DOE Fact-Finding and Analysis

Following the presidential determination under the DPA, DOE began a series of outreach activities including a request for information (RFI), posted in October 2022, "to inform how the Defense Production Act (DPA) authority provided to DOE through Presidential Determinations could best be used."[84] In summarizing this outreach, DOE noted that industrial participants favored government incentives to increase production capacity of GOES and of electrical steel generally.[85]

DOE has also joined with industry CEOs "to identify the challenges facing the energy sector and what solutions could help to address this issue."[86] For example, DOE formed a Supply Chain Tiger Team with the Electricity Subsector Coordinating Council (ESCC), a contact group for CEOs from the electric power industry.[87] The team determined that distribution transformers were a crucial supply constraint for the electric power system.[88]

One DOE assessment of large power transformer devices, which have some parts and materials in common with distribution transformers, suggests that a domestic market that can meet at least 50% of demand would be secure.[89] However, there is no universally agreed upon level of importation of distribution transformers that would be considered too risky.

Other DOE Activities and Programs on Distribution Transformers

Various federal programs and incentives have either addressed, impacted, or analyzed the supply of distribution transformers in terms of its adequacy and reliability.

Energy Conservation Standards and Implications for Supply

DOE regulates the energy efficiency of distribution transformers using authority under the Energy Policy and Conservation Act (P.L. 94-163), as amended. Congress first required DOE to set legally binding energy conservation standards for distribution transformers in the Energy Policy Act of 1992 (P.L. 102-486), requiring that such standards "would be technologically feasible and economically justified, and would result in significant energy savings."[90] DOE makes periodic

[83] Office of the Under Secretary of War, Acquisition and Sustainment, "Summary of DPAP Awards Funded via Inflation Reduction Act for Critical Mineral Production," press release, November 7, 2024, https://www.acq.osd.mil/news/office-news/asda/2024/Summary-of-DPAP-Awards-Funded-via-Inflation-Reduction-Act.html.

[84] DOE, "Defense Production Act: Request for Information," press release, October 4, 2022, https://www.energy.gov/mesc/defense-production-act-request-information.

[85] DOE, *Defense Production Act*, p. 8.

[86] DOE Office of Policy, "DOE Actions to Unlock Transformer and Grid Component Production," press release, October 20, 2022, https://www.energy.gov/policy/articles/doe-actions-unlock-transformer-and-grid-component-production.

[87] DOE Office of Electricity, "DOE and Industry Team Up to Keep the Lights on for America," press release, February 22, 2024, https://www.energy.gov/oe/articles/doe-and-industry-team-keep-lights-america. Similarly, H.R. 5067, the Empowering Electric Grid Reliability Act, would have established a task force to study supply chains for electric grid components related to electricity distribution.

[88] DOE Office of Electricity, "DOE and Industry Team Up to Keep the Lights on for America," February 22, 2024, https://www.energy.gov/oe/articles/doe-and-industry-team-keep-lights-america.

[89] DOE, *Electric Grid Supply Chain Review*, p. 43.

[90] 42 U.S.C. §6317(a)(1).

revision to its standards, and, in the case of distribution transformers, initiated this with a request for information on June 18, 2019, and concluded with final revisions to the distribution transformer standards on April 22, 2024.[91] This rulemaking sparked a discussion on the adequacy of supply of electrical steel, the material needed for the transformer's electrical core.

At the proposed rule stage, DOE issued a notice on January 11, 2023, that, if finalized, would have raised the minimum efficiency standards to a degree that might require switching to a new type of "amorphous" steel for the electrical core, according to DOE.[92] Forty-seven Senators wrote a letter to Energy Secretary Granholm on June 1, 2023, urging DOE to "finalize a rule that does not exacerbate the shortage in distribution transformers."[93] At an April 20, 2023, hearing of the Senate Committee on Energy and Natural Resources, Senator Hyde-Smith asked Secretary Granholm about the impact of the proposed standard, asking whether users might expect "long lead times, up to 2 to 4 years and more," owing to "more expensive and limited types of steel" needed to comply with the standard.[94]

The standards DOE finalized on April 22, 2024, were less stringent than in the January 11, 2023, proposed rule and are not expected to necessitate switching to amorphous steel but, at the same time, would not address any issues with the current supply of GOES.[95] Certain firms have cited supply chain challenges related to the availability of GOES.[96] As discussed above, GOES has been the dominant material in distribution transformer cores.

H.R. 4626, the Home Appliance Protection and Affordability Act, would prevent DOE from revising the regulations for distribution transformers.[97] H.R. 4856, the Revitalizing America's Housing Act, included a section 103, "Relieving strain from shortages of transformers," that would have restricted DOE's choice of proposed efficiency levels to the two least stringent levels contemplated in the January 11, 2023, proposal.[98]

[91] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 84 *Federal Register* 28239, June 18, 2019; and DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 89 *Federal Register* 29834, April 22, 2024.

[92] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 88 *Federal Register* 1722, January 11, 2023. DOE previously had found that "amorphous [steel] is the lowest-loss grade and a practical necessity to reach the very highest efficiency levels." DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 84 *Federal Register* 28242, June 18, 2019, note 6.

[93] U.S. Congress, Senate Committee on Energy and Natural Resources, "ICYMI: Manchin Leads Bipartisan Effort to Protect Domestic Electric Power Supply Chain," press release, June 2, 2023, https://www.energy.senate.gov/2023/6/icymi-manchin-leads-bipartisan-effort-to-protect-domestic-electric-power-supply-chain.

[94] U.S. Congress, Senate Committee on Energy and Natural Resources, *Full Committee Hearing to Examine the President's Budget Request for the U.S. Department of Energy for Fiscal Year 2024*, 118th Cong., 2nd sess., April 20, 2023.

[95] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 89 *Federal Register* 29834, April 22, 2024.

[96] Sonal Patel, "Reconsider Distribution Transformer Efficiency Standards, Power Groups Urge DOE," *Power*, February 16, 2023.

[97] H.R. 4626 passed the House on February 24, 2026, and on February 25, 2026, was received in the Senate and referred to the Committee on Energy and Natural Resources.

[98] DOE, "Energy Conservation Program: Energy Conservation Standards for Distribution Transformers," 88 *Federal Register* 1722, January 11, 2023. Of the three subclasses of distribution transformers it regulates, DOE finalized one of them at the second-least-stringent level and one of them at the third-least-stringent level. For the third subclass of distribution transformers, the levels were not directly comparable between the proposed rule (88 *Federal Register* 1795, Table V.1) and the final rule (89 *Federal Register* 29834, April 22, 2024, Table V.2).

Research and Development

Research and development (R&D) could lead to improvements related to distribution transformers in two ways: by improving the distribution transformer itself, or by improving the manufacturing processes, with the latter leading to enhanced supply through greater productivity.

R&D on the transformer can lead to a few outcomes. If the R&D leads to a new commercial product, then the device could be less expensive than the incumbent it replaces, or it could perform better (e.g., be more reliable, more durable, more energy-efficient), or both. In the first outcome, the benefit of the R&D could be as simple as the before-and-after situation in which a utility pays less for a service (transformed voltage) than it would have before.[99] Prior to the advent of the new, improved transformer, the utility had been willing to accept a higher market price. Consumers would benefit to the extent the utility passes along any savings in its rates.

Another possibility could occur when an innovative, improved product provides additional utility beyond the incumbent product and thereby increases demand, leading to greater sales volume.[100] For example, smart distribution transformers, though not currently in deployment, would offer control and optimization of other services, such as the charging load of an electric vehicle.[101]

R&D could lead to new products which, while having a lower cost of ownership or better lifetime and reliability, have a higher purchase price ("first cost") that can deter buyers. In such cases, governments or utilities can offer incentives (e.g., taxes, rebates) to induce consumers and firms to purchase the newly developed device.[102]

DOE-Sponsored Transformer Research and Development

In March 2024, DOE's Office of Electricity issued a funding opportunity announcement (FOA) for up to $18 million in awards for research on "Flexible Innovative Transformer Technologies." At the time, DOE stated it would support concepts for "advanced distribution transformers," including flexible, modular, scalable, hybrid, or solid state transformers. In December 2024, DOE announced nine award finalists for a total of approximately $20 million, with DOE's Office of Cybersecurity, Energy Security, and Emergency Response contributing $2 million toward the total.[103] DOE funded projects on solid state transformers, which could increase reliability and "put intelligence" on the grid in support of next-generation transmission and distribution concepts.[104]

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[99] Jack Hirshleifer et al., *Price Theory and Applications*, 7th ed. (Cambridge University Press, 2005), pp. 206-207. As the authors note, analyzing the policies in this way by comparing two different equilibriums ("comparative statics") does not account for the dynamics of the market. For an application of this method to energy technology, see National Research Council (NRC), *Prospective Evaluation of Applied Energy Research and Development at DOE (Phase One): A First Look Forward* (National Academies Press, 2005).

[100] Hirshleifer et al., *Price Theory and Applications*, p. 207, describes the welfare gain that occurs due to the shift in demand enabled by innovation, accruing to both the buyer (utility) and the seller (manufacturer).

[101] International Renewable Energy Agency, "Smart Distribution Transformers: Overview of the Status and Impact of the Innovation," https://www.irena.org/Innovation-landscape-for-smart-electrification/Power-to-mobility/11-Smart-distribution-transformers.

[102] NRC, *Energy Research at DOE: Was It Worth It?* (National Academy Press, 2001), p. 27.

[103] DOE Office of Electricity, "Energy Department Advances U.S. Electric Grid Resilience and Reliability with New Transformer and Silicon Carbide Packaging Projects," press release, December 3, 2024, https://www.energy.gov/oe/articles/energy-department-advances-us-electric-grid-resilience-and-reliability-new-transformer; and NRC, *Energy Research at DOE*, p. 156.

[104] Sonal Patel, "The Solid-State Shift: Reinventing the Transformer for Modern Grids," *Power*, January 2, 2025. The (continued...)

Manufacturing Research and Development

R&D on manufacturing can expand supply by increasing productivity, that is, achieving greater output with the same inputs or *factors* (e.g., energy, raw materials). Increases in productivity can be an incremental improvement to an existing process (e.g., making it use less energy) or a new method of production that may use smaller quantities of materials.[105] A report by the National Infrastructure Advisory Council,[106] a DOE advisory committee, called for such improvements in transformer manufacturing efficiency.[107] Even if available, however, manufacturers might delay changes to production until they renew the production line; so long as a production line is still within its book life or recovery period, the manufacturer would not want to forgo revenues by prematurely closing it down. More likely is that a manufacturer would incorporate new technology when making new capital investments.[108] The House Appropriations Committee called for increasing the efficiency of the manufacture of distribution transformers in H.Rept. 119-213, which accompanied the Energy and Water Development and Related Agencies Appropriations Act, 2026 (H.R. 4553).[109]

Government Financial Incentives in Statute

Internal Revenue Code §48C and Possible Impact on Manufacturing Capacity

The Qualifying Advanced Energy Project Credit (Internal Revenue Code Section 48C [IRC §48C]) is a competitive tax program providing up to 30% credit for investments in qualifying advanced energy projects. The American Recovery and Reinvestment Act of 2009 (ARRA; P.L. 111-5), Section 1302(b), created IRC §48C and authorized a program for "investment in advanced energy property."[110] ARRA provided $300 million in credit authority.[111] IRA Section 13501(a) expanded the credit authority by $10 billion.

Several categories of property are eligible for the credit, including Clean Energy Manufacturing and Recycling Projects for "grid equipment for electricity delivery," which includes distribution transformers.[112]

concept of an intelligent or smart grid is discussed at International Renewable Energy Agency, "Smart Distribution Transformers: Overview of the Status and Impact of the Innovation," https://www.irena.org/Innovation-landscape-for-smart-electrification/Power-to-mobility/11-Smart-distribution-transformers. Smart distribution transformers, for example, could provide remote monitoring and control of local load conditions, such as those due to vehicle charging, to allow the grid to adapt.

[105] Such an advance confers advantages such as lowering the part count of the product or the waste of raw materials. NRC, *Energy Research at DOE*, p. 118.

[106] The Council was created by executive order in 2001. Executive Order 13231, "Critical Infrastructure Protection in the Information Age," 66 *Federal Register* 53063, October 18, 2001.

[107] NIAC, *Addressing the Critical Shortage of Power Transformers*, p. 17.

[108] NRC, *Energy Research at DOE*, pp. 26, 105.

[109] H.R. 4553 was not enacted. For discussion of the DOE appropriation for FY2026, see CRS In Focus IF13118, *DOE Energy Efficiency and Renewable Energy (EERE) Appropriations, FY2026*, by Martin C. Offutt and Lexie Ryan.

[110] H.Rept. 111-16, p. 644.

[111] H.Rept. 111-16, p. 646.

[112] Internal Revenue Service (IRS), "Initial Guidance Establishing Qualifying Advanced Energy Project Credit Allocation Program Under Section 48C(e) [Notice 2023-18], Appendix A: Qualifying Advanced Energy Projects," *Internal Revenue Bulletin: 2023-10*, March 6, 2023, https://www.irs.gov/irb/2023-10_IRB#NOT-2023-18.

The Internal Revenue Service (IRS) released allocations for the first round of credits provided by the IRA totaling $4 billion on March 29, 2024.[113] The IRS awarded the second round of allocations, $6 billion, on January 10, 2025.[114] Any applications for §48C credits for transformer projects would have competed with applications for all types of qualifying advanced energy projects, with the "most meritorious projects" receiving an allocation of some of the tax credit.[115]

Four transformer makers who received some of the credit allocation have disclosed details of their §48C proposals.[116] The voluntarily disclosed projects related to distribution transformers include the following:[117]

- Eaton Corporation (credit allocation: $13,278,300) will address, among other purposes, increasing the production at its Waukesha, WI, facility of medium voltage liquid-immersed transformers for distribution utilities.
- Prolec GE USA (credit allocation: $7,980,000) is expanding its Shreveport, LA, facility to produce substation and pad-mounted distribution transformers for industrial and renewable energy applications and has plans to add a third production line.

An additional two projects concern transformers more generally:

- Eaton Corporation (credit allocation: $1,326,060) is investing $22 million at the Waukesha, WI, facility for increased production capacity of three-phase transformers for utility and other applications.
- Siemens Energy (credit allocation: $18,311,511) is investing $150 million in the construction of a large power transformer production facility.

The above projects could increase the ability of the manufacturer to produce more transformers, though any change in market price and quantity would be subject to demand for the transformers, tariffs on imports including of components and steel, and other factors as discussed above.

Rebates for Purchase of Distribution Transformers (Expired)

Division J of the Infrastructure Investment and Jobs Act (IIJA; P.L. 117-58) appropriated $10 million to provide rebates for the replacement of distribution transformers, a program authorized in Section 1006 of the Energy Act of 2020 (Division Z of the Consolidated Appropriations Act of 2020, P.L. 116-260). The categories eligible for rebates included two of the three transformer categories DOE regulates.[118] DOE implemented the program up until December 31, 2023, when the authorization provided in Section 40555 of the IIJA expired.[119] The program offered rebates toward the purchase of new transformers provided that (1) the old, to-be-replaced transformer

[113] Department of the Treasury, "Anchoring Clean Energy Manufacturing Investments in Coal Country and Beyond," May 16, 2024, https://home.treasury.gov/news/featured-stories/anchoring-clean-energy-manufacturing-investments-in-coal-country-and-beyond.

[114] Department of the Treasury, "U.S. Department of the Treasury and IRS Announce $6 Billion in Tax Credit Allocations for the Second Round of the §48C Qualifying Advanced Energy Project Tax Credit," press release, January 10, 2025, https://home.treasury.gov/news/press-releases/jy2779.

[115] Department of the Treasury, "U.S. Department of the Treasury and IRS Announce $6 Billion in Tax Credit Allocations."

[116] Participants in the tax credit program are not obligated to disclose their participation. DOE MESC, "Applicant Self-Disclosed 48C Projects."

[117] DOE MESC, "Applicant Self-Disclosed 48C Projects."

[118] These were liquid-immersed distribution transformers and medium voltage dry-type distribution transformers.

[119] ICF, "Energy Efficient Transformer Rebates," https://doerebates.my.site.com/rebatesold/s/transformer-rebates.

was less efficient than (i.e., did not comply with) the energy conservation standards that were in effect as of December 27, 2020 (see "DOE Fact-Finding and Analysis" above); and (2) the old transformer was manufactured during certain years.[120] The payout was determined by the savings in power consumption (watts) of a new transformer relative to the installed transformer and could range from roughly $60 to over $10,000 per transformer.[121]

The program thus targeted existing stock. Utilities would replace distribution transformers that, while not end-of-life, could still be replaced and save energy.[122] The rebate policy's criteria singled out installed units that were less energy-efficient. The rebates did not apply to the purchase of distribution transformers to expand a utility's physical distribution network. Purely from an energy consumption perspective, the replacement of transformers could be beneficial. A 1998 DOE study estimates that replacing all transformers at 35 years could save 1% of electricity.[123] A disadvantage of the rebate is that the induced purchases would reduce the stocks available for replacement, post-hurricane, or for grid expansion, making it unlikely the rebate policy would address adequacy of supply.

A potential benefit of extending this policy could accrue from reduced peak load—that is, a reduction in the amount of electric power generated at the most intense time of day.[124] Over time, planners could see the improved efficiency of the grid as an opportunity to forgo capital costs of additional power plants or energy storage.[125] A congressionally mandated study by the National Research Council on the benefits of energy R&D characterized such a reduction as a security benefit because it would reduce the probability of disruptions in supply.[126] A United Nations study finds improved distribution and large power transformers could reduce the need for electric power plants by 5%.[127]

Selected Policy Options

If Congress finds urgency in the issues related to adequacy of supply of distribution transformers, Congress could choose from among several legislative options. Congress may choose to constrict,

[120] For liquid-immersed distribution transformers, from 1987 to 2008, and for medium voltage dry-type distribution transformers, from 1992 to 2011.

[121] DOE MESC, *Guidance on Implementing Section 1006 of the Energy Act of 2020*, October 2023, https://www.energy.gov/sites/default/files/2023-10/Transformer%20Guidance%20October%202023.pdf.

[122] NLR estimates the size of the opportunity, estimating that roughly half of distribution transformers are over 33 years old and nearing the end of their useful life. NREL, *Distribution Transformer Demand: Understanding Demand Segmentation, Drivers, and Management Through 2050*, NREL/FS-6A40-92076, November 2024, p. 1, https://www.nrel.gov/docs/fy25osti/92076.pdf.

[123] A. Thomas et al., "Replacing Distribution Transformers: A Hidden Opportunity for Energy Savings," presented at 2002 Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, 2002, p. 3.357 of conference proceedings, https://www.eceee.org/library/conference_proceedings/ACEEE_buildings/2002/Panel_3/p3_27/.

[124] DOE, *Technical Support Document*, p. 8-26.

[125] EPA, "Part One: The Multiple Benefits of Energy Efficiency and Renewable Energy," in *Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy: A Guide for State and Local Governments*, 2018, p. I-9, https://www.epa.gov/statelocalenergy/quantifying-multiple-benefits-energy-efficiency-and-renewable-energy-guide-state; and National Association of Clean Air Agencies, *Implementing EPA's Clean Power Plan: A Menu of Options*, May 2015, p. 10-8, https://www.4cleanair.org/event_meeting_notes/implementing-epas-clean-power-plan-a-menu-of-options/.

[126] NRC, *Energy Research at DOE*, p. 103. The congressional request may be found at pp. 492-493 of H.Rept. 106-479, which accompanied the Consolidated Appropriations Act, 2000 (P.L. 106-113).

[127] Sustainable Energy for All, "SDG 7.3 - Energy Efficiency," https://www.seforall.org/goal-7-targets/energy-efficiency; and United Nations Environment Programme, *Accelerating the Global Adoption of Energy-Efficient Transformers*, U4E Policy Guide Series, 2017, p. 6.

maintain, or expand statutes affecting price and supply of distribution transformers. This section presents some selected policy options Congress could pursue. The section discusses the possible outcomes of these selected policies within a framework considering the advantages and disadvantages, including economic and fiscal benefits and costs.

Extending or Revising Tax Credits

Property Eligible for §45X Tax Credits

The Advanced Manufacturing Production Credit, created by Section 13502 of the IRA (P.L. 117-169), located at IRC Section 45X (§45X), applies to components of energy systems including wind and solar power; the inverters necessary for converting electricity into the alternating current needed for synchronizing with the grid; batteries; and certain critical minerals.[128] The beneficiaries of the tax credit include persons who produce the eligible components. The IRS issued final regulations for implementing the credit on October 28, 2024.[129]

S. 448 and H.R. 4128, both titled the Credit Incentives for Resilient Critical Utility Infrastructure and Transformers Act, or CIRCUIT Act, would expand the scope of §45X to include distribution transformers. In common with inverters, which are covered by §45X, distribution transformers provide grid services to electric utilities.

The persistent backlog discussed in "Recent Supply Picture" could indicate that utilities want to purchase a greater number of distribution transformers than manufacturers are able to produce. Utilities thus maintain access to inventories of distribution transformers as a means of ensuring they can restore power after storms. One disadvantage of maintaining these inventories, in certain regulated markets, is to tie up working capital. Further, as noted above, because such inventory does not meet the criterion of "used and useful equipment," the utility cannot charge customers, depending on the regulator. By advancing S. 448 and H.R. 4128 or similar legislation, and thereby expanding the §45X-eligible projects to include distribution transformers, Congress could help address the backlog by encouraging manufacturers to add more capacity.

Allocation of Funds for §48C Investment Tax Credit

The Qualifying Advanced Energy Project Credit (IRC §48C) is a competitive tax program providing up to 30% credit for investments in qualifying advanced energy projects. Section 48C defines certain categories of qualifying projects (IRC §48C(c)) and authorizes DOE to award certifications to qualifying energy project sponsors (IRC §48C(e)). IRA Section 13501 also sets a program cap of $10 billion. The certifications are competitively awarded, and applications for tax credits for distribution transformers must compete with a number of other type of projects. The §48C program had allocated credits up to its $10 billion cap as of January 2025.[130]

Congress could authorize a new round of awards for the credits by raising the $10 billion cap. In addition, Congress might consider reserving a certain dollar amount or percentage of the total credit cap and directing those funds exclusively toward distribution transformers, though the certification requirement would still apply.

[128] P.L. 119-21, referred to as the 2025 Budget Reconciliation Act, phased out the credit for wind energy components at the end of 2027.

[129] IRS, "Advanced Manufacturing Production Credit," 89 *Federal Register* 85798, October 28, 2024.

[130] Department of the Treasury, "U.S. Department of the Treasury and IRS Announce $6 Billion in Tax Credit Allocations."

Possible Outcomes of Changes to IRC §45X or IRC §45C

A manufacturing production tax credit, such as IRC §45X, and an investment tax credit, such as IRC §48C, could increase the quantity of goods supplied. The tax incentives—whether by increasing the return on sales of the product (§45X) or increasing investment in new or improved production lines (§48C)—could induce manufacturers to increase production capacity and ideally reduce the time necessary to fulfill orders placed by utilities. The benefit of such a supply expansion would be to reduce the risk of any possible disruption in supply of distribution transformers due to manufacturing shortfalls. Further, increased domestic supply could reduce risk of disruptions in supply by actors with market power, who might be offshore suppliers of raw material (steel) or components (electrical cores). The time needed for the supply to expand to pre-2020 levels could be three to five years.[131]

A disadvantage is the policy could be indifferent to the supply chain and national origin of components and raw materials. The §45X credit, for example, is awarded to the U.S. firm that is final assembler of the distribution transformers. Components and raw materials may be sourced from outside the United States, and these offshore suppliers might indirectly benefit from the credit. In a March 12, 2024, hearing of the Senate Finance Committee, Senator Brown expressed the concern that some of the §45X credit was going to China. Senator Brown stated that a tax credit should apply from the beginning of the supply chain, to include parts or raw materials.[132] In the 118th Congress, the American Tax Dollars for American Solar Manufacturing Act (S. 4873), sponsored by Senator Brown, would have prohibited the allowance of a §45X tax credit for components produced by a "foreign entity of concern."[133]

Creating a Virtual Reserve

DOE suggested the idea of a virtual reserve mechanism in a 2022 publication, reporting on discussions with stakeholders involved in the market for grid components.[134] Congress could create a virtual reserve by authorizing and funding the federal government to purchase distribution transformers up to a predetermined level (quota). If market activity does not reach the quota over a defined period of time, the government makes up the difference, becoming in effect the buyer-of-last-resort. A DOE advisory committee conjectures that government purchases would be triggered if the lead time required to fulfill orders were to become unacceptably long.[135]

The impact of a virtual reserve could be to increase annual production volume, the reasoning being that manufacturers would be more likely to invest in capacity expansions knowing there is a buyer. When making such purchases, the government would need to maintain and administer a physical reserve for a time until it could be depleted. The *2025 Report Card for America's Infrastructure* also recommended a national transformer inventory be kept.[136]

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[131] Wood Mackenzie, "4 Years into a Difficult Transformers Market in the US, Is There a Potential End in Sight?"

[132] U.S. Congress, Senate Committee on Finance, *American Made: Growing U.S. Manufacturing Through the Tax Code*, hearing, 118th Cong., 2nd sess., March 12, 2024; and Timothy Cama, "Sherrod Brown Working on Tweak to Energy Tax Credit," *E&E News*, March 13, 2024, https://www.eenews.net/articles/sherrod-brown-working-on-tweak-to-energy-tax-credit/.

[133] Defined at 15 U.S.C. §4651(8).

[134] DOE, *The Supply Chain Crisis Facing the Nation's Electric Grid*, December 14, 2022, https://www.energy.gov/policy/articles/supply-chain-crisis-facing-nations-electric-grid.

[135] NIAC, *Addressing the Critical Shortage of Power Transformers*, p. 19.

[136] American Society of Civil Engineers, *2025 Report Card for America's Infrastructure: Energy*, March 2025, p. 82.

The benefit of a virtual reserve is that it could eventually lead to stable and even expanded supply and transformer reserves. This, in turn, could mitigate the sort of disruption that might occur were an actor with market power to affect price or supply of raw materials or components. As in the case of the tax credits, the increased production would be expected to lower the market price, benefiting utilities by extending them a lower (i.e., better) price than they had been willing to accept previously. The manufacturers would likely benefit from selling the additional production units, since these units could be produced at a lower unit cost than the market price. The fiscal cost to the government arising from the transformer purchases could be weighed against the benefits to utilities and manufacturers.

Using Title III of DPA Authority for Manufacturing

Congress could appropriate money for the Defense Production Act of 1950 (DPA; P.L. 81-774) to be used to address manufacturing capacity of distribution transformers.[137] The National Infrastructure Advisory Council has called for use of DPA money to convert the U.S. manufacturing base for distribution transformers to more efficient production methods.[138] Among other purposes, the DPA allows the President to provide incentives to expand "industrial base capabilities" using tools such as loan guarantees, loans, purchases and purchase commitments, and other methods.[139] The impact of invoking the DPA and associated financial assistance, specifically for distribution transformers, would be to add new manufacturing capacity. Assuming no existing manufacturing capacity is retired or repurposed, the benefit might be increased supply and shorter wait times for fulfillment of orders for distribution transformers.

In the 118th Congress, H.R. 6747, the Clean Electricity and Transmission Acceleration Act of 2023, would have authorized $2.1 billion under authority of Title III of the DPA to address domestic manufacturing capacity of transformers and grid components and the steel needed to construct them.

Investing in Research and Development

Research and development could support distribution transformers in two ways: by improving the distribution transformer itself, or by improving the manufacturing processes, leading to enhanced supply through greater productivity. Congress could continue to fund R&D for new, improved transformers in a grants-making DOE program.[140] Congress could request periodic reports from DOE on the technological readiness of these new distribution transformer concepts. When the new types of distribution transformers reach the appropriate level of technological readiness, Congress could consider demonstration programs for early adoption of these devices by utilities and/or provide investment tax credits to manufacturers for new or modified production lines.

[137] Title III of the DPA gives the President the means to provide financial assistance to private industry in order to "create, maintain, protect, expand, or restore domestic industrial base capabilities essential for the national defense." 50 U.S.C. §4533.

[138] NIAC, *Addressing the Critical Shortage of Power Transformers*, pp. 16-17.

[139] 50 U.S.C. §4533. For further description of the DPA, see CRS Report R43767, *The Defense Production Act of 1950: History, Authorities, and Considerations for Congress*, by Alexandra G. Neenan.

[140] The explanatory statement to accompany P.L. 119-74, the Commerce, Justice, Science; Energy and Water Development; and Interior and Environment Appropriations Act, 2026, recommended $22.5 million for Transformer Resilience and Grid Components, equal to the appropriation for the prior two years. See table on p. H405 of Rep. Tom Cole, Explanatory Statement, *Congressional Record*, daily edition, vol. 172, no. 5 (January 8, 2026), pp. H255-H591; and DOE Office of the Chief Financial Officer, *FY 2026 Budget Justification*, vol. 4, DOE/CF-0215, May 2025, p. 43, https://www.energy.gov/cfo/articles/fy-2026-budget-justification.

The impact of improved distribution transformers could be greater reliability of the electric grid, greater durability, and improved energy efficiency. New types of distribution transformers could enable improved electricity distribution concepts by remotely monitoring and controlling electric loads such as a charging electric vehicle in the vicinity of a particular distribution transformer.[141] Further benefits could be peak load reduction, discussed above in "Research and Development," which might lead to lower capital costs for utilities as planners foresee less need for new power plants. Another possible benefit could accrue if the new technology is easier to manufacture. A disadvantage is that government-funded R&D may not lead to a commercial product to justify the government expenditure.

Summary

The benefits of government policies discussed above could be more assured supply of distribution transformers, lower prices, and a more energy-efficient power grid that might reduce the need for new power plants. **Table 1** summarizes the selected policy options. The table describes the benefits to electric utilities from increased manufacturing capacity and, where applicable, lower market prices for distribution transformers. Consumers would benefit to the extent the utilities pass along any savings in the rates they charge.

For the policy options listed, success is not assured, as outcomes would depend on utilities adopting a new technology and suppliers taking the capital risk to expand manufacturing capacity.[142] Unforeseen geopolitical events or shifts in supply of raw materials or components (electrical cores) could occur as well. The effect of policy options designed to increase additional manufacturing capacity would be latent and experience a delay of several years while the new or expanded production lines were completed.

Table 1. Summary of Selected Policy Options for Supply of Distribution Transformers

Name	Possible Outcome[a]	Anticipated Benefit	Disadvantages
Make DPTs eligible for IRC §45X Tax Credit (S. 448 and H.R. 4128)	Increase domestic supply. Lower effective price.	Decreased risk of price or supply disruptions, once additional manufacturing assets are online.	Government expenditure may exceed the value gained by electric utility and supplier. Credit may benefit offshore suppliers.
Issue another round of IRC §48C tax credits or Change Scope of IRC §48C Tax Credit to allocate more to DPTs	Increase domestic supply. Lower effective price.	Decreased risk of price or supply disruptions, once additional manufacturing assets are online.	Government expenditure may exceed the value gained by electric utility and supplier.
Virtual reserve—government is buyer-of-last-resort	Increase domestic supply.	Decreased risk of price or supply disruptions.	Fiscal cost of purchasing DPTs. Administrative cost of managing the physical reserve of government-purchased DPTs.

[141] Sonal Patel, "The Solid-State Shift: Reinventing the Transformer for Modern Grids," *Power*, January 2, 2025.

[142] DOE, *Defense Production Act*, p. 7.

Use DPA authority	Increase domestic supply.	Decreased risk of price or supply disruptions, once additional manufacturing assets are online.	Government expenditure may exceed the value gained by electric utility and suppliers.
Fund R&D	Superior, cheaper DPTs available in future.	Lower energy consumption and superior device performance, if R&D succeeds.	If R&D fails, fiscal cost not compensated by corresponding benefit of a new improved product.

Source: CRS analysis.

Notes: DPA = Defense Production Act of 1950; DPT = distribution power transformers; IRC = Internal Revenue Code; R&D = research and development.

a. The policies do not stand alone; for successful outcomes, utilities must be willing to adopt a new technology and replace old units; manufacturers would need to expand capacity. Unforeseen geopolitical events or shifts in supply of raw materials or transformer subassemblies (e.g., electrical cores) could occur and impact the benefit of some of the policies. Changes in tariffs could impact price and quantity of available transformers and/or the materials used to build them.

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