

**DEPARTMENT OF COMMERCE****Bureau of Industry and Security**

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**Publication of a Report on the Effect of Imports of Transformers and Transformer Components on the National Security: An Investigation Conducted Under Section 232 of the Trade Expansion Act of 1962, as Amended****AGENCY:** Bureau of Industry and Security, Commerce.**ACTION:** Publication of a report.

**SUMMARY:** The Bureau of Industry and Security (BIS) in this notice is publishing a report that summarizes the findings of an investigation conducted by the U.S. Department of Commerce (the “Department”) pursuant to Section 232 of the Trade Expansion Act of 1962, as amended (“Section 232”), into the effect of imports of transformers and transformer components on the national security of the United States. This report was completed on October 15, 2020 and posted on the BIS website in July 2021. BIS has not published the appendices to the report in this notification of report findings, but they are available online at the BIS website, along with the rest of the report (*see the ADDRESSES section*).

**DATES:** The report was completed on October 15, 2020. The report was posted on the BIS website in July 2021.

**ADDRESSES:** The full report, including the appendices to the report, are available online at <https://www.bis.doc.gov/index.php/documents/section-232-investigations/2790-redacted-goes-report-20210723-ab-redacted/file>.

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**SUPPLEMENTARY INFORMATION:****The Effect of Imports of Transformers and Transformer Components on the National Security**

*U.S. Department of Commerce, Bureau of Industry and Security, Office of Technology Evaluation*

Final Report

October 15, 2020

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**I. Executive Summary**

On May 4, 2020, U.S. Secretary of Commerce Wilbur Ross announced he would initiate an investigation into whether laminations for stacked cores for incorporation into transformers, stacked and wound cores for incorporation into transformers, electrical transformers, and transformer regulators are being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security. Secretary Ross officially initiated this investigation on May 11, 2020, in response to inquiries and requests from multiple Members of Congress, a grain-oriented steel manufacturer, and producers of power and distribution transformers.

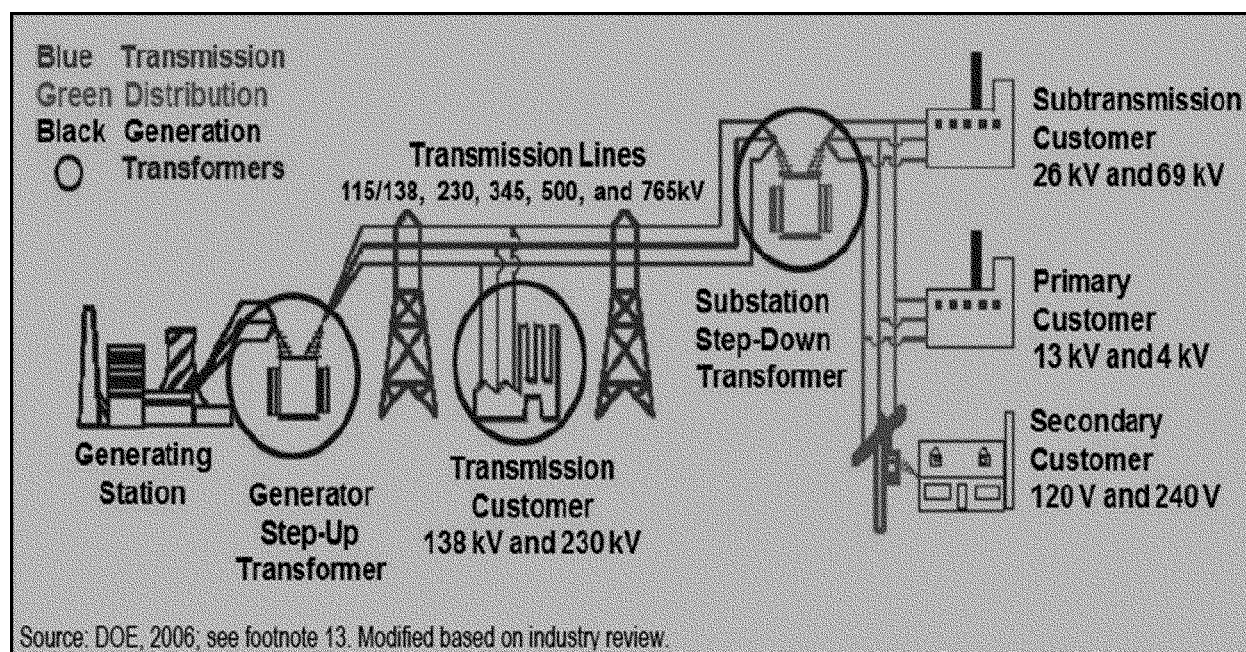
On May 19, 2020, the Department of Commerce (Department) published a **Federal Register** Notice (*See Appendix C—Federal Register*, 85 FR 29926) announcing the initiation of the investigation and inviting interested parties to submit written comments, opinions, data, information, or advice relevant to the investigation. The Department received 79 public comments and 30 rebuttal comments from a wide range of interested parties, including industry participants, representatives of state and local governments, foreign governments, and

trade associations. A summary of the public comments received is included in Appendix D.

In addition, the Department surveyed (*See Appendix E*) 87 U.S. companies identified as participating in production or distribution of electrical steel, laminations and stacked and wound cores for transformers, power and distribution transformers, and voltage regulators. Survey responses provided the Department with detailed industry information that is otherwise not publicly available and was necessary to conduct a thorough analysis for this investigation.

The Department consulted with the Department of Defense (including the Office of Industrial Policy and Defense Logistics Agency) regarding methodological and policy questions that arose during the investigation. Given the vital role that these products play in the energy sector and the critical infrastructure of the country, the Department also consulted with the Departments of Energy (Office of Electricity) and Homeland Security. In addition, the Department consulted with the Office of the United States Trade Representative, given the trade implications of any actions taken with regard to imports of these products.

The products subject to this investigation are essential inputs to the manufacture and functioning of transformers, as well as the finished transformers themselves. In particular, this investigation focuses on *transformers and transformer components (i.e., laminations and cores) for which the crucial input is grain-oriented electrical steel (GOES)*. Transformers are critical assets used to step-up and step-down power voltages throughout the electrical grid. As such, they are fundamental to the efficient transmission and distribution of electricity across the bulk-power system of the United States. The U.S. electricity grid supplies residential, commercial, and industrial customers, as well as the power required to support military and defense installations, including bases, arsenals, and laboratories. A simplified schematic of the role of transformers in the electrical grid is presented below.



In addition to transmission and distribution, transformers are used widely in major industrial sectors such as mining, manufacturing, and chemical processing. Large commercial users of transformers include hospitals, hotels, office buildings, and airports. Sophisticated military equipment, such as fighter jets and naval vessels, relies on transformers of various types and capacities to provide the correct voltage within subsystems. Due to its importance for certain defense applications, the Defense Logistics Agency has included GOES among its requests for inclusion in the National Defense Stockpile.

Large Power Transformers (LPTs) are among the most critical elements of the United States Bulk-Power System (BPS), which was the subject of an emergency declaration issued by President Trump on May 1, 2020. Executive Order 13920 (E.O. 13920 or Bulk Power Executive Order), titled "Securing the United States Bulk-Power System," noted that as the backbone of our Nation's energy infrastructure, the BPS is fundamental to national security, emergency services, critical infrastructure, and the economy.<sup>1</sup> The President determined that the unrestricted foreign supply of electrical equipment constitutes an unusual and extraordinary threat to the national security, foreign policy, and economy of the United States. The President also determined that the evolving threats facing our critical infrastructure have highlighted supply

chain risks and the need to ensure the availability of secure components from American companies and other trusted sources.<sup>2</sup>

The global transformer industry is dominated by large multinational companies that offer a wide product range and benefit from economies of scale. In addition to these large global players, in the United States there are also a number of smaller domestic companies that manufacture transformers of various power-handling capacities. Many manufacturers have established production facilities in locations that allow them to take advantage of lower labor costs and environmental standards. Mexico, in particular, has become a significant player in transformer manufacturing.

#### A. GOES

Grain-oriented electrical steel (GOES) is a critical material essential to the performance of transformers and accounts for a significant portion of the cost of transformer production (about 25 percent based on responses to the Department survey). AK Steel, Inc., a subsidiary of Cleveland Cliffs Inc., is the sole U.S. domestic producer of GOES, which it manufactures at facilities in Zanesville, Ohio, and Butler, Pennsylvania. While still a leader in the domestic market, AK Steel's electrical steel operations are not profitable, in part due to years of pressure from lower cost imports.<sup>3</sup> The CEO of Cleveland

Cliffs, Inc., has stated that it may shut down the two unprofitable plants at which GOES is manufactured. If AK Steel's GOES operations were to close, the United States would lack the ability to produce transformers of any power handling capacity without relying on foreign sources for the key material that is essential to their operation and efficiency.

The threat to national security posed by imports of GOES (among other steel products) was addressed by a Section 232 investigation conducted in 2017, which resulted in the 2018 imposition of 25 percent tariffs on imports of steel products from most countries. As a result, imports of GOES in 2019 were dramatically lower than in 2018 (down 56 percent). [TEXT REDACTED]

[TEXT REDACTED].<sup>4</sup> Moreover, many transformer companies, in public comments or survey responses, indicated concern over AK Steel's capabilities and capacity to supply a full range of GOES products, especially the higher grades that are increasingly in demand due to current DOE energy standards for distribution transformers as well as general market trends toward energy efficiency.

#### 1. Transformer Components (Laminations and Cores)

This investigation sought to evaluate the status of domestic production and the impact of imports for key subcomponents of transformers, namely laminations for stacked cores for

<sup>1</sup> <https://www.whitehouse.gov/presidential-actions/executive-order-securing-united-states-bulk-power-system/>.

<sup>2</sup> <https://www.energy.gov/articles/president-trump-signs-executive-order-securing-united-states-bulk-power-system>.

<sup>3</sup> AK Steel Public Comments.

<sup>4</sup> Department of Commerce, Section 232 Investigation into Impact of Steel Imports on National Security, 2018.

incorporation into transformers, stacked cores for incorporation into transformers, and wound cores for incorporation into transformers.

Arguably the most important part of a transformer is its core, which is made up of thin layers of laminations, usually made of GOES. Cores may have varying designs and specifications, but their function is generally to facilitate the magnetic field necessary for the induction of voltages between the two windings (*i.e.*, in order to “step-up” or “step-down” the power voltage). The layered composition helps reduce the core’s energy losses. Transformer lamination and core producers make up the primary customer base for GOES suppliers such as AK Steel.

However, over the past few years, there has been a marked decline in the domestic manufacturing of laminations and cores (both in-house by transformer companies and by independent producers), and a movement of production offshore (especially to Canada and Mexico). The United States has become highly dependent on foreign sources for these critical transformer components.

A corollary to the movement of lamination and core manufacturing out of the United States is the decline of the domestic market for AK Steel’s GOES. Although not the only factor, the tariffs imposed on imports of electrical steel under Section 232 have raised material costs for lamination and core manufacturers, affecting their ability to compete, because electrical steel accounts for a large percentage of the cost of these items [TEXT REDACTED].

In 2019, laminations with a total value of \$40.2 million were sourced by surveyed companies. Of this \$40.2 million, less than 12 percent came from domestic suppliers. This implies an import penetration level of 88% for laminations. In the years immediately prior, there was a dramatic increase in imports of these products—from \$18 million in 2017 to \$33 million in 2019—which displaced U.S. production. Over 95 percent of these imports came from Canada (68 percent) and Mexico (29 percent).

A similar situation exists with regard to stacked and wound cores. Based on survey data, imports account for about 75 percent of wound core purchases by surveyed transformer companies in 2019. With regard to stacked cores, imports accounted for 54 percent of purchases by respondents. [TEXT REDACTED]. However, this firm reported that it shut down core production in February 2020 due to its inability to compete with imports. [TEXT REDACTED]. With the exit of the

leading domestic non-captive supplier, future imports of stacked cores will also likely exceed 80 percent of purchases, with China serving as a major source.

Imports of transformer cores (stacked and wound) rose from \$22 million in 2015 to \$167 million in 2019—a 650 percent increase—again with Canada (52 percent) and Mexico (45 percent) accounting for more than 95 percent of the total. Since domestic demand for laminations and cores has not increased in parallel with the increase in imports, the surge in imports represents displaced domestic production. Moreover, neither Mexico nor Canada has indigenous production capability for GOES. While Japan is the leading source of GOES for these countries, they also import some of this material from China and Russia.

### B. Transformers

This investigation evaluated the status of the domestic transformer industry in several categories: Liquid-filled distribution transformers and small power transformers, medium power transformers, LPT, dry-type transformers, and voltage regulators.

Distribution transformers (both liquid-dielectric as well as dry-type), and small and medium power transformers are used extensively in the U.S. electrical grid—millions are installed and operating. This investigation found that domestic industrial production and capabilities in these sectors is generally adequate. In the liquid-dielectric categories, imports account for less than a quarter of apparent consumption, and companies in this sector are largely financially sound and competitive in the market, based on responses to the BIS industry survey. While import penetration is currently relatively low, survey participants indicated competitiveness challenges, especially from Mexico and China. Survey respondents also mentioned workforce issues, such as difficulty finding and attracting qualified labor, as a concern.

Imports play a major role in the dry-type transformer sector, and leading U.S.-based producers also have overseas production facilities. Countries with low cost labor—including China, Indonesia, and Mexico—are major sources of imported dry-type transformers. Despite relatively strong domestic production capabilities, an in-depth analysis of suppliers found a heavy dependence on foreign sources among domestic manufacturers in all transformer categories for critical components including laminations and cores and the GOES from which they are made, as described above.

This investigation found shortcomings with regard to domestic production of LPTs that are critical elements of the United States BPS. Because they serve the greatest number of customers, the failure or destruction of just a single unit can have a large impact on U.S. economic, public health, and security interests. Moreover, long procurement lead times and limited availability of spare LPT and parts have serious implications for the resiliency of critical infrastructure.

Domestic production capability falls far short of demand for the LPT segment of the industry, with imports accounting for over 80 percent of consumption. This lack of domestic production capability and the accompanying extreme dependence on imports has persisted for at least a decade, creating a critical infrastructure vulnerability, which has been raised in previous Department of Energy assessments.<sup>5</sup>

Only six companies currently manufacture LPTs in the United States; [TEXT REDACTED]. The largest domestic producer is Korean-owned Hyundai, which has publicly noted that its Alabama facility will be utilized “in maneuvering U.S. imposed anti-dumping tariff [sic] and its protectionist policies.”<sup>6</sup>

[TEXT REDACTED].<sup>7</sup> Compounding the issue, domestic LPT producers are highly dependent on foreign sources for GOES, laminations, and cores.

### C. Findings

[TEXT REDACTED]. While still a leader in the domestic market, the market has eroded due to the migration of production of transformer components (and finished transformers) out of the United States. If this manufacturer were to shut down GOES production, the United States would be completely dependent on foreign sources for material critical to the manufacture of transformers.

There is insufficient or no domestic production capability for certain grades and qualities of GOES that are increasingly in demand to meet efficiency standards for distribution transformers as well as general market trends toward more efficient transformers using higher grades of GOES.

The United States lacks sufficient capacity to produce transformer cores

<sup>5</sup> “Large Power Transformers in U.S. Electric Grid”, Department of Energy, Office of Electricity and Energy Reliability, June 2012 [https://www.energy.gov/sites/prod/files/Large%20Power%20Transformer%20Study%20-%20June%202012\\_0.pdf](https://www.energy.gov/sites/prod/files/Large%20Power%20Transformer%20Study%20-%20June%202012_0.pdf).

<sup>6</sup> <http://hhiamerica.com/about/sub04.htm>.

<sup>7</sup> [TEXT REDACTED].

and laminations, which are the key components in transformers. Transformer manufacturers in the United States rely on foreign sources (especially Canada and Mexico) for these critical components to meet over 75 percent of (non-captive) demand.

The United States is also highly dependent on foreign-sourced transformers, most significantly for the LPTs that form the backbone of the BPS.

Based on the overwhelming dependence of domestic transformer manufacturers on foreign sources, the Secretary finds that transformer laminations, stacked cores and wound cores are being imported into the United States in such quantities and under such circumstances as to threaten to impair the national security. In addition, LPTs are being imported into the United States in such quantities and under such circumstances as to threaten to impair national security. This dependence on imports leaves the United States with insufficient production capability for LPTs to meet the needs of the critical energy infrastructure of the United States.

## II. Legal Framework

### A. Section 232 Requirements

Section 232 of the Trade Expansion Act of 1962, as amended, provides the Secretary with the authority to conduct investigations to determine the effect on the national security of the United States of imports of any article. It authorizes the Secretary to conduct an investigation if requested by the head of any department or agency, upon application of an interested party, or upon his own motion. *See* 19 U.S.C. 1862(b)(1)(A).

Section 232 directs the Secretary to submit to the President a report with recommendations for “action or inaction under this section” and requires the Secretary to advise the President if any article “is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security.” *See* 19 U.S.C. 1862(b)(3)(A).

Section 232(d) directs the Secretary and the President to consider, in light of the requirements of national security and without excluding other relevant factors, the domestic production needed for projected national defense requirements and the capacity of the United States to meet national security requirements. *See* 19 U.S.C. 1862(d).

Section 232(d) also directs the Secretary and the President to “recognize the close relation of the economic welfare of the Nation to our national security, and . . . take into

consideration the impact of foreign competition on the economic welfare of individual domestic industries” by examining whether any substantial unemployment, decrease in revenues of government, loss of skills or investment, or other serious effects resulting from the displacement of any domestic products by excessive imports, or other factors, results in a “weakening of our internal economy” that may impair the national security.<sup>8</sup> *See* 19 U.S.C. 1862(d).

Once an investigation has been initiated, Section 232 mandates that the Secretary provide notice to the Secretary of Defense that such an investigation has commenced. Section 232 also requires the Secretary to do the following:

- (1) “Consult with the Secretary of Defense regarding the methodological and policy questions raised in [the] investigation;”
- (2) “Seek information and advice from, and consult with, appropriate officers of the United States;” and
- (3) “If it is appropriate and after reasonable notice, hold public hearings or otherwise afford interested parties an opportunity to present information and advice relevant to such investigation.”<sup>9</sup> *See* 19 U.S.C. 1862(b)(2)(A)(i)–(iii).

As detailed in the report, all of the requirements set forth above have been satisfied.

In conducting the investigation, Section 232 permits the Secretary to request that the Secretary of Defense provide an assessment of the defense requirements of the article that is the subject of the investigation. *See* 19 U.S.C. 1862(b)(2)(B). Upon completion of a Section 232 investigation, the Secretary is required to submit a report to the President no later than 270 days after the date on which the investigation was initiated. *See* 19 U.S.C. 1862(b)(3)(A). The report must:

- (1) Set forth “the findings of such investigation with respect to the effect of the importation of such article in such quantities or under such circumstances upon the national security;”
- (2) Set forth, “based on such findings, the recommendations of the Secretary for action or inaction under this section;” and
- (3) “If the Secretary finds that such article is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security

<sup>8</sup> An investigation under Section 232 looks at whether imports threaten to impair the national security, rather than looking at unfair trade practices as in an antidumping investigation.

<sup>9</sup> Department regulations (i) set forth additional authority and specific procedures for such input from interested parties, *see* 15 CFR 705.7 and 705.8, and (ii) provide that the Secretary may vary or dispense with those procedures “in emergency situations, or when in the judgment of the Department, national security interests require it.” *Id.*, § 705.9.

. . . so advise the President.” *See* 19 U.S.C. 1862(b)(3)(A).

All unclassified and non-proprietary portions of the report submitted by the Secretary to the President must be published. *See* 19 U.S.C. 1862(b)(3)(B).

Within 90 days after receiving a report in which the Secretary finds that an article is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security, the President shall:

- (1) “Determine whether the President concurs with the finding of the Secretary;” and
- (2) “If the President concurs, determine the nature and duration of the action that, in the judgment of the President, must be taken to adjust the imports of the article and its derivatives so that such imports will not threaten to impair the national security” *See* 19 U.S.C. 1862(c)(1)(A).

### B. Discussion

While Section 232 does not specifically define “national security,” both Section 232 and the implementing regulations at 15 CFR part 705 contain non-exclusive lists of factors that the Secretary must consider in evaluating the effect of imports on the national security. Congress, in Section 232, explicitly determined that “national security” includes, but is not limited to, “national defense” requirements. *See* 19 U.S.C. 1862(d).

The Department has determined that “national defense” includes both the defense of the United States directly and the U.S. “ability to project U.S. military capabilities globally.”<sup>10</sup> The Department also concluded that “[i]n addition to the satisfaction of national defense requirements, the term ‘national security’ can be interpreted more broadly to include the general security and welfare of certain industries, beyond those necessary to satisfy national defense requirements, which are critical to the minimum operations of the economy and government.”<sup>11</sup> The Department deemed these certain industries as “critical industries.”<sup>12</sup> This report applies these interpretations of the terms “national defense” and “national security,” in defining “critical industries.” In doing so, this report considers 16 critical infrastructure sectors identified in Presidential Policy

<sup>10</sup> Department of Commerce, Bureau of Export Administration; *The Effect of Imports of Iron Ore and Semi-Finished Steel on the National Security*; Oct. 2001 (“2001 Report”).

<sup>11</sup> *Id.*

<sup>12</sup> *Id.*



Directive 21.<sup>13</sup> Section 232 directs the Secretary to determine whether imports of any article are being made “in such quantities” or “under such circumstances” that those imports “threaten to impair the national security.” See 19 U.S.C. 1862(b)(3)(A). Accordingly, either the quantities or the circumstances, standing alone, may be sufficient to support an affirmative finding.

The statute does not prescribe a threshold or a standard for when “such quantities” of imports are sufficient to threaten to impair the national security, nor does it define the “circumstances” that might qualify.

Likewise, the statute does not require a finding that the quantities or circumstances are impairing the national security. Instead, the threshold question under Section 232 is whether those quantities or circumstances “threaten to impair the national security.” See 19 U.S.C. 1862(b)(3)(A). This demonstrates that Section 232 may be used to prevent a threatened impairment to the national security from occurring before the national security is actually impaired.

Section 232(d) contains a list of factors for the Secretary to consider in determining if imports “threaten to impair the national security”<sup>14</sup> of the United States, and this list is mirrored in the implementing regulations. See 19 U.S.C. 1862(d) and 15 CFR 705.4. While the list provided by Congress in Section 232 provides mandatory factors for the Secretary to consider, it is not exhaustive.<sup>15</sup> Congress’ illustrative list is focused on the ability of the United States to maintain the domestic capacity to provide the articles in question as needed to maintain the national security of the United States.<sup>16</sup> Congress split the

list of factors into two equal parts using two separate sentences. The first sentence focuses directly on “national defense” requirements, thus making clear that “national defense” is a subset of the broader term “national security.” The second sentence focuses on the broader economy and expressly directs that the Secretary and the President “shall recognize the close relation of the economic welfare of the Nation to our national security.”<sup>17</sup> See 19 U.S.C. 1862(d).

In addition to “national defense” requirements, two of the factors listed in the second sentence of Section 232(d) are particularly relevant in this investigation. Both are directed at how “such quantities” of imports threaten to impair national security. See 19 U.S.C. 1862(b)(3)(A). In administering Section 232 to “[determine] whether such weakening of our internal economy may impair the national security,” the Secretary and the President are required to “take into consideration the impact of foreign competition on the economic welfare of individual domestic industries,” as well as to and analyze whether there exist “serious effects resulting from the displacement of any domestic products by excessive imports.” See 19 U.S.C. 1862(d). In certain key product categories, imports of transformers and transformer components accounted for over 80 percent of U.S. consumption in 2019. In the case of transformer cores and laminations, imports have substantially displaced domestic production of these items. Because these products are the primary market for GOES, the displacement of domestic production by imports also threatens threaten the financial viability of the only remaining domestic producer of GOES.

Two other factors included in the statute that are also particularly relevant to this investigation are “loss of skills” and “loss of investment.” See 19 U.S.C. 1862(d). As imports of GOES have increased, losses of U.S. GOES production capacity have caused a

decline in the skilled workforce needed for the GOES manufacturing process. Additionally, as a result of their impact on the revenues of U.S. producers, these imports have mitigated investment in U.S. GOES production facilities, precluding future sustainable development of domestic GOES production. Similarly, these imports also create a disincentive for needed investment in U.S. GOES production facilities; without this investment, future production of domestic GOES is not sustainable. These factors are illustrative of a “weakening of the internal economy [that] may impair the national security” as defined in Section 232.

### III. Investigation Process

#### A. Initiation of Investigation

On May 4, 2020, the Secretary of Commerce announced that he would initiate an investigation into whether laminations for stacked cores for incorporation into transformers, stacked and wound cores for incorporation into transformers, electrical transformers, and transformer regulators are being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security.<sup>18</sup> Laminations and cores made of GOES are critical transformer components, and transformers are a key element for distribution of all types of energy—including solar, nuclear, wind, coal, and natural gas—across the country. The decision to launch an investigation under Section 232 of the Trade Expansion Act of 1962, as amended (19 U.S.C. 1862), followed inquiries and requests from multiple Members of Congress, a GOES manufacturer, and producers of power and distribution transformers.

On May 11, 2020, the Department officially initiated the investigation. Pursuant to Section 232(b)(1)(b), the Department notified Secretary of Defense Mark T. Esper of the investigation and requested Department of Defense participation as it relates to methodology, policy questions, and national defense requirements for these products. Additionally, given that the products subject to this investigation are used extensively in the electrical grid and critical infrastructure of the United States, the Department also notified Secretary of Energy Dan R. Brouillette and Acting Secretary of Homeland Security Chad F. Wolf. Finally, the Secretary notified United States Trade Representative Robert E. Lighthizer,

<sup>13</sup> Presidential Policy Directive 21, *Critical Infrastructure Security and Resilience* (Feb. 12, 2013) (“PPD-21”).

<sup>14</sup> 19 U.S.C. 1862(b)(3)(A).

<sup>15</sup> See 19 U.S.C. 1862(d) (“the Secretary and the President shall, in light of the requirements of national security and without excluding other relevant factors . . .” and “serious effects resulting from the displacement of any domestic products by excessive imports shall be considered, without excluding other factors . . .”).

<sup>16</sup> This reading is supported by Congressional findings in other statutes. See, e.g., 15 U.S.C. 271(a)(1) (“The future well-being of the United States economy depends on a strong manufacturing base . . .”) and 50 U.S.C. 4502(a) (“Congress finds that—(1) the security of the United States is dependent on the ability of the domestic industrial base to supply materials and services . . . (2)(C) to provide for the protection and restoration of domestic critical infrastructure operations under emergency conditions . . . (3) . . . the national defense preparedness effort of the United States government requires—(C) the development of domestic productive capacity to meet—(ii) unique technological requirements . . . (7) much of the

industrial capacity that is relied upon by the United States Government for military production and other national defense purposes is deeply and directly influenced by—(A) the overall competitiveness of the industrial economy of the United States; and (B) the ability of industries in the United States, in general, to produce internationally competitive products and operate profitably while maintaining adequate research and development to preserve competitiveness with respect to military and civilian production; and (8) the inability of industries in the United States, especially smaller subcontractors and suppliers, to provide vital parts and components and other materials would impair the ability to sustain the Armed Forces of the United States in combat for longer than a short period.”).

<sup>17</sup> *Accord* 50 U.S.C. 4502(a).

<sup>18</sup> Department of Commerce Press Release, May 4, 2020.

noting that Department staff will consult with counterparts in the Office of the United States Trade Representative regarding methodological and policy questions that arise during the investigation. (See Appendix A).

On May 19, 2020, the Department published a **Federal Register** Notice (See Appendix C—**Federal Register**, 85 FR 29926) announcing the initiation of the investigation to determine the effect of imports of Laminations for Stacked Cores for Incorporation into Transformers, Stacked Cores for Incorporation into Transformers, Wound Cores for Incorporation into Transformers, Electrical Transformers, and Transformer Regulators on the national security. The notice also announced the opening of the public comment period.

### B. Public Comments

In the **Federal Register** Notice announcing the investigation, the Department invited interested parties to submit written comments, opinions, data, information, and advice relevant to the criteria listed in Section 705.4 of the National Security Industrial Base Regulations (15 CFR 705.4) as it affects the requirements of national security, including the following:

(a) Quantity of the articles subject to the investigation and other circumstances related to the importation of such articles;

(b) Domestic production capacity needed for these articles to meet projected national defense requirements;

(c) The capacity of domestic industries to meet projected national defense requirements;

(d) Existing and anticipated availability of human resources, products, raw materials, production equipment, facilities, and other supplies and services essential to the national defense;

(e) Growth requirements of domestic industries needed to meet national defense requirements and the supplies and services, including the investment, exploration, and development, necessary to assure such growth;

(f) The impact of foreign competition on the economic welfare of any domestic industry essential to our national security;

(g) The displacement of any domestic products causing substantial unemployment, decrease in the revenues of government, loss of investment or specialized skills, and productive capacity, or other serious effects;

(h) Relevant factors that are causing or will cause a weakening of our national economy; and

(i) Any other relevant factors, including the use and importance of the Products in critical infrastructure sectors identified in Presidential Policy Directive 21 (Feb. 12, 2013) (for a listing of those sectors see <https://www.dhs.gov/cisa/critical-infrastructure-sectors>).

At the request of several parties, and in light of the global pandemic, the initial public comment period, as well as the rebuttal period, were extended ten additional days. The department provided an additional 24 days to submit public comments, with an additional time period provided for the submission of rebuttals to such comments as well. The final deadline for the submission of rebuttals to the public comments July 24, 2020.

The Department received 82 written comments concerning this investigation, 79 of which were responsive on *Regulations.gov* for public review. Parties that submitted comments included members of industry, representatives of state and local governments, foreign governments, and other concerned groups.

All 79 comments were available for response during the rebuttal period. Thirty-four rebuttal comments from industry participants and other stakeholders were received and 30 were responsive and were posted on *Regulations.gov* for public review. All of the appropriate comments and rebuttals were reviewed and factored into the investigative process. These responsive public comments received are summarized in Appendix D, along with a link to the *Regulations.gov* docket (BIS-2020-0015), where comments can be viewed in full.

### C. Information Gathering and Data Collection Activities

Because this investigation commenced during a pandemic during which, many public and private sector organizations were shut down or operating under limited conditions, the Department decided not to hold a public hearing for this investigation. In lieu of a public hearing, the Department issued mandatory surveys (See Appendix E) to 87 companies or divisions of companies identified as participating in the production or distribution of electrical steel, laminations and stacked and wound cores for transformers, and power and distribution transformers. Survey responses were received from most of the major participants in the domestic transformer supply chain. The surveys collected both qualitative and quantitative information.

These mandatory surveys were conducted pursuant to Section 705 of the Defense Production Act (DPA) of 1950, as amended (50 U.S.C. 4555), and collected data on imports, exports, production, capacity utilization, employment, operating status, global competition, and financial information. The resulting aggregate data provided the Department with detailed industry

information that is otherwise not publicly available, which was necessary to conduct a thorough analysis for this investigation.

Information furnished in the survey responses is deemed confidential and will not be published or disclosed except in accordance with Section 705 of the DPA.<sup>19</sup>

### D. Interagency Consultation

The Department consulted with the Department of Defense (including the Office of Industrial Policy and Defense Logistics Agency) regarding methodological and policy questions that arose during the investigation. Given the vital role that these products play in the energy sector and the critical infrastructure of the country, the Department also consulted with the Departments of Energy (Office of Electricity) and Homeland Security. In addition, the Department consulted with the Office of the United States Trade Representative, given the trade implications of any actions with regard to imports of these products.

The Department also consulted with other U.S. government agencies with expertise and information regarding the domestic and global transformer and GOES industries, including the Department's International Trade Administration and the U.S. International Trade Commission.

### E. Product Scope of the Investigation

The scope of this investigation includes laminations for incorporation into stacked cores, stacked cores for incorporation into transformers, wound cores for incorporation into transformers, electrical transformers, and transformer regulators. While GOES is not the direct subject of this investigation, because it is the primary material used in laminations, stacked cores, and wound cores, it is included in the scope of products addressed in this report. Products were examined in accordance with the Harmonized Tariff Schedule of the United States (HTS) up to the ten-digit level. The products and their associated HTS code are provided in Figure 1 below.

<sup>19</sup> Section 705 of the DPA prohibits the publication or disclosure of this information unless the President determines that withholding such information is contrary to the interest of the national defense. Unless or until such a determination is made, information will not be shared with any non-government entity in other than aggregate form.

FIGURE III–1—PRODUCT SCOPE OF THE INVESTIGATION

10 digit HTS	Product description
7226.19.1000 .....	Non-Oriented Electrical Steel (NOES) (300–600mm).
7226.19.9000 .....	Non-Oriented Electrical Steel (NOES) (<300mm).
7225.11.0000 .....	Grain-Oriented Electrical Steel (GOES) (>600mm width).
7226.11.1000 .....	Grain-Oriented Electrical Steel (GOES) (300–600mm).
7226.11.9030 .....	Grain-Oriented Electrical Steel (GOES) (<300mm; <.25mm thick).
7226.11.9060 .....	Grain-Oriented Electrical Steel (GOES) (<300mm; >.25mm thick).
8504.90.9634 (Post 2016), 8504.90.9534 (2015) .....	Transformer Laminations (Stacked).
8504.90.9638 (Post 2016), 8504.90.9538 (2015) .....	Transformer Cores (Stacked).
8504.90.9642 (Post 2016), 8504.90.9542 (2015) .....	Transformer Cores (Wound).
8504.21.0020 .....	Liquid-Dielectric Transformer Under 50KVA.
8504.21.0040 .....	Liquid-Dielectric Transformer 50–100KVA.
8504.21.0060 .....	Liquid-Dielectric Transformer 100–500KVA.
8504.21.0080 .....	Liquid-Dielectric Transformer 500–650KVA.
8504.22.0040 .....	Liquid-Dielectric Transformer 650–2,500KVA.
8504.22.0080 .....	Liquid-Dielectric Transformer 2,500–10,000KVA.
8504.23.0041 .....	Liquid-Dielectric Transformer 10,000–60,000KVA.
8504.23.0045 .....	Liquid-Dielectric Transformer 60,000KVA–100,000KVA.
8504.23.0080 .....	Liquid-Dielectric Transformer Over 100,000KVA.
8504.32.0000 .....	Dry-Type/Other Transformer 1–16KVA.
8504.33.0020 .....	Dry-Type/Other Transformer 16–50KVA.
8504.33.0040 .....	Dry-Type/Other Transformer 50–500KVA.
8504.34.0000 .....	Dry-Type/Other Transformer Over 500KVA.
9032.89.4000 .....	Voltage Regulators.

Source: United States International Trade Commission and U.S. Department of Commerce, Bureau of Industry and Security.

#### IV. Description of the Products Subject to the Investigation

The products subject to this investigation are those that are critical to the manufacture and functioning of transformers, as well as the transformers themselves. In particular, this investigation focuses on *transformers and transformer components for which the crucial input is GOES*.

*Transformers* are passive devices that change (or transform) the voltage or electrical current level using a magnetic circuit. They are used to either increase (step-up) or decrease (step-down) voltage to ensure the correct voltage for a specific electricity use application. Transformers are available with a wide range of power-handling capabilities, typically measured in kilo-volt-amperes (kVA), from less than one kVA, to more than 100,000 kVA (which can also be expressed as 100 mega-volt-amperes where 1 MVA = 1,000 kVA). LPTs can be several stories tall and weigh hundreds of tons, while transformers for consumer products may be small enough to fit in your hand. No matter the size, the basic purpose of any transformer is to transform electrical power from one voltage to another.

There are many ways in which transformers can be categorized. Common industry terminology may classify by specific type (autotransformer, instrument

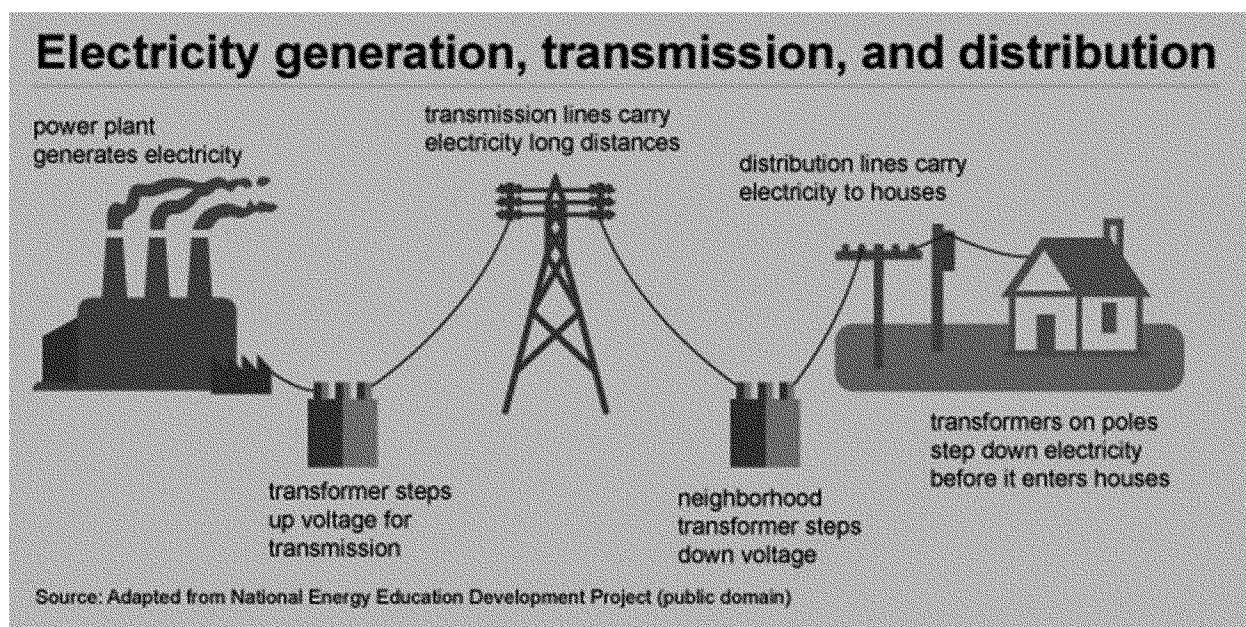
transformer), current type (direct or alternating), function (step-up, step-down), core type (shell-form or core-form), or type of installation (pole-mounted, pad-mounted, underground). The size of a transformer can be measured by the input voltage (in kilovolts), the output voltage (in kilovolts), or the load capacity (measured by kilovolt amperes). This report will generally classify transformers based on their power load handling capacity (in kVA) as well as their type of dielectric insulation (liquid or dry). These categorizations were chosen because they correspond with the way in which the U.S. Census Bureau collects information on imports of these items. Transformers of most power-handling capacities are subject to this investigation. The exception is very small transformers (under 1 kVA), such as those typically used in conjunction with power cables for consumer electronics including laptops and cell phones, as these generally do not use electrical steel cores.

The most ubiquitous use of transformers is in the electrical grid, where they are used by electric utilities and power producers for the transmission and distribution of electricity from power generation plants to residential, commercial, and industrial customers. In addition to the electrical grid, large industrial users

such as mines and major manufacturing, and chemical plants, as well as large commercial users including hospitals, hotels, office buildings, and airports may connect directly to the transmission grid and utilize their own transformers to take advantage of lower marginal costs.

Transformers are crucial equipment used throughout the electrical grid. Power leaves the generator and enters a transmission substation located at the power plant. This transmission substation uses LPTs to “step-up” the generator’s voltage to extremely high voltages (155 kV to 765 kV volts) for efficient transmission over long distances (up to 300 miles). For the electricity to be used by commercial, industrial, or residential users, it must be “stepped-down” by transformers to distribution voltages (less than 10 kV; a standard line voltage is 7.2 kV at a substation). From there, the electricity is distributed locally via overhead or sunk power lines before it is further stepped-down by smaller transformers (such as pole mounted units) to the 240 volts that is standard household electrical service. Additionally, as noted above, some large commercial and industrial users may connect directly at substation transmission levels. The diagram below presents a simplified depiction of the use of transformers in the electrical grid.

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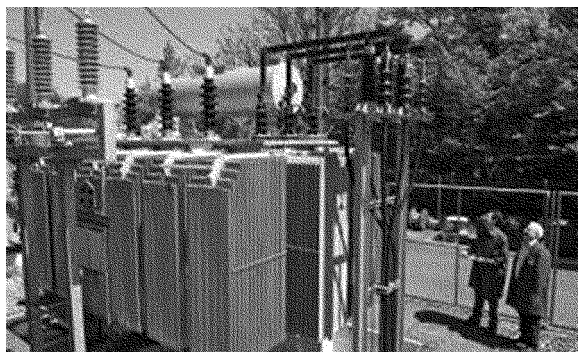


### A. Types of Transformers

LPTs generally have power-handling capacities above 100,000 kVA (100 MVA) and are used to step-up the

voltage up to extremely high levels at power generation sites for efficient transmission over long distances. They are used again at substations to step-down the voltage for more local

distribution. LPT are also used by manufacturing sectors that require high voltages in their production processes, such as steel mills.



*Small and medium power transformers*, which generally have power handling capacities from 5,000 kVA to 100,000 kVA, are also used extensively throughout the electrical grid. They are available in a wide range of voltage ratings and power handling capacities, to meet the specific needs of consumers. For example, they are used at substations and at industrial facilities.

*Distribution transformers* (up to 5,000 kVA) are used to further step-down the voltage at substations to deliver electricity to customers. Distribution transformers provide the final voltage transformation in the electrical grid. While they are energized for 24 hours a

day, their load fluctuates throughout the day with changing energy demands.

Also located along the electric grid are banks of *voltage regulators*, which are used to compensate for voltage fluctuation during power distribution. Voltage regulators play an important role in light of the increasing use of distributed energy resources such as solar and wind, which are intermittent.

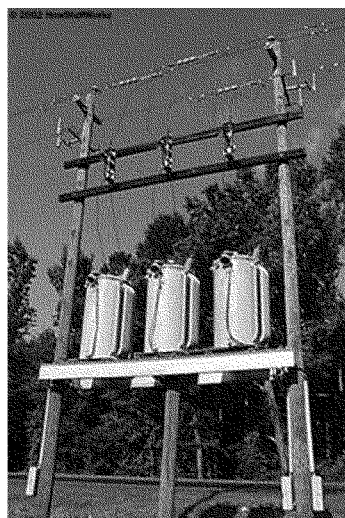
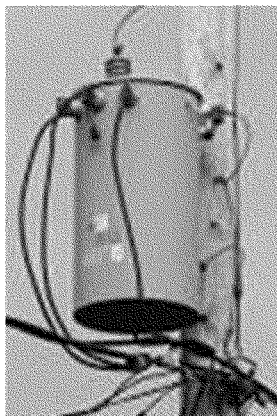
Transformers can be classified by the material used in core-insulation (e.g., “Liquid-dielectric” or “Dry-Type”). Cooling is important because transformers generate heat and pose potential fire or explosion hazards.

*Liquid-dielectric transformers* consist of the transformer core placed in a metal sealed container filled with mineral oil, which serves as a coolant and insulator.

*Dry-type transformers* have a metal housing for insulation but are cooled by air convection or fans, or may be encased in resin. Oil-filled liquid transformers are generally more efficient than dry-type, which are more limited in their power-handling capacity and size. However, oil-filled transformers require more maintenance, and because the liquid may be flammable or toxic, dry-type may be more preferable in public spaces.

## Pole Mounted

## Distribution Transformer



## Transformer Regulators

Dry-type transformers are commonly used in light industrial and commercial applications; some are used indoors or underground. They are often used in cases in which liquid-dielectric transformers present unacceptable environmental, explosion, or fire hazards.

Specialized transformers perform specific functions in the electric grid. For example, *instrument transformers* step-down currents and voltages for accurate and reliable measurement by secondary equipment such as meters, protection relays, and other devices. Another specialized type of transformer is the *autotransformer*, which is used in power transmission systems to interconnect systems operating at different voltage; this type of transformer can also be used as a voltage regulators.

Transformers have been in use for over 100 years (Westinghouse built the first reliable commercial transformer in 1886) and are becoming more complex as they evolve to become part of the

growing interconnected “smart grid.”<sup>20</sup> The smart grid is an automated network with a two-way flow of energy and information that is capable of monitoring and controlling energy metrics between the power plant and the end user, as well as at the many points in between. To function as part of the smart grid, transformers must be able to communicate in real time, be capable of extensive customer interaction, feature remote digital monitoring, and have the ability to self-diagnose and repair malfunctions.

#### B. Transformer Construction

Regardless of their size or application, all transformers work through electromagnetic induction, a process in which a coil of wire magnetically induces a voltage into another coil of wire in close proximity to it. The basic structure of a transformer is two coils of copper wire: The “primary winding”

and the “secondary winding.” The primary winding takes the power into the transformer, and the secondary winding delivers the power from the transformer. The difference in voltage between the primary and secondary windings is achieved by differences in the number of coil turns in each winding.<sup>21</sup>

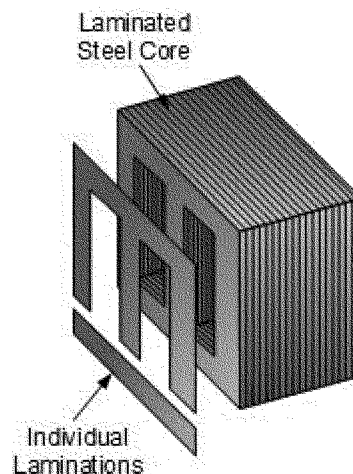
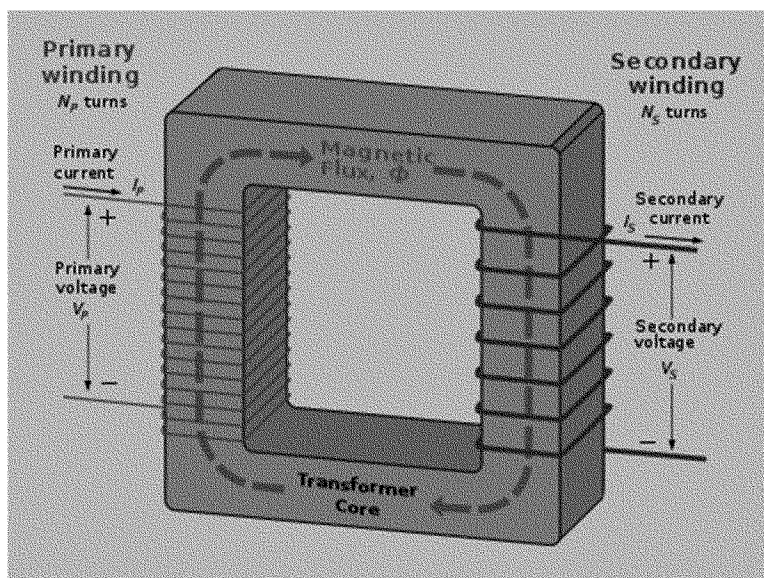
The two windings are not in direct contact with one another, but rather are each wound around a closed magnetic circuit that forms the *core* of the transformer. The core is not solid, but is made up of thin layers, or *laminations*, usually made of GOES. This layered composition helps reduce energy losses (eddy flow and hysteresis) within the core. Core laminations are the main material input in an electrical transformer and can account for up to 50 percent of a transformer’s cost.<sup>22</sup>

<sup>21</sup> <https://circuitdigest.com/tutorial/transformer-basics>.

<sup>20</sup> <https://global.abb/group/en/about/history/heritage-brands/westinghouse>.

<sup>22</sup> <https://www.worldofsteel.com/Types%20of%20CRGO.html>.





Electrical transformers are typically produced with either *stacked* or *wound cores*. Stacked cores are most often used in larger distribution and power transformers, while wound cores are used in small and medium distribution transformers that step-down the voltage from the transmission line and provide power. In either case, GOES is the most common material used.

When used in *stacked cores*, GOES is sheared or stamped into individual laminations, which are then stacked together to form the core. Stacked laminations often resemble letters of the alphabet, including C, E, L, U, and I shapes. Commonly used core shapes include E-I, E-E, L, and U-I. When used in *wound cores*, a continuous length of GOES is wound around a mandrel multiple times to form the core. Copper windings (electricity conductors) are wrapped around both stacked and wound cores.

Transformers can be produced in “single-phase” or “three-phase” models. A single-phase transformer has one primary and one secondary set of windings, while a three-phase transformer has three primary and secondary windings around three core limbs. Most commercial electric power applications use three-phase transformers, while lower voltage and distribution level transmissions use single-phase transformers.

There are two typical configurations for the core and windings of a transformer: *Core-form* and *shell-form*. In core-form, the windings are in a cylindrical shape around the legs of the core. In shell-form, the windings are wrapped around the center of the core.

Core-form transformers are the most widely used because they are generally simpler in design and less expensive than shell-form transformers. Shell-form transformers typically use more electrical steel and are more resistant to short circuit offering an advantage for extra high voltage applications. For this reason, they are often used in industrial applications, such as steel mills, where short circuits are common.

### C. Electrical Steel <sup>23</sup>

As noted in the above description of transformer construction, the key material used in the core of most transformers is GOES; this application accounts for the majority of GOES consumption. The magnetic properties of electrical steel are integral to the primary function of transformers, *i.e.*, converting voltage from one level to another.

Electrical steel is a flat-rolled silicon alloy. The benefits of adding silicon to steel include increased electrical resistivity, high permeability, and low hysteresis loss. There are two types of electrical steel: GOES, also known as Cold-Rolled Grain Oriented Steel (abbreviated CRGO), and non-grain-oriented electrical steel (NOES), also known as Cold-Rolled Non-Grain Oriented Steel (abbreviated CRNGO).

GOES is the most energy efficient type of electrical steel used to transport and transform mechanical energy to electrical energy. Its primary application

is in transformers where energy or core loss is critical (particularly large and medium-sized electrical power and distribution transformers). In contrast, NOES is more commonly used in electric motors and generators, as well as in some smaller transformers.

GOES is milled to yield exceptionally good magnetic properties. It can be sold in sheets or strips in fully processed form (annealed by the manufacturer) or semi-processed (requiring further heat treatment by purchaser). GOES, which typically contains approximately 3.2 percent by weight of silicon, is manufactured using specialized rolling and annealing (heat treatment) processes, which produces grain structures uniformly oriented in the rolling (lengthwise) direction of the steel sheet. Compared with NOES, this uniformly oriented grain structure permits the GOES steel sheets to conduct a magnetic field with a higher degree of efficiency in the direction of rolling.

### 1. Types of GOES

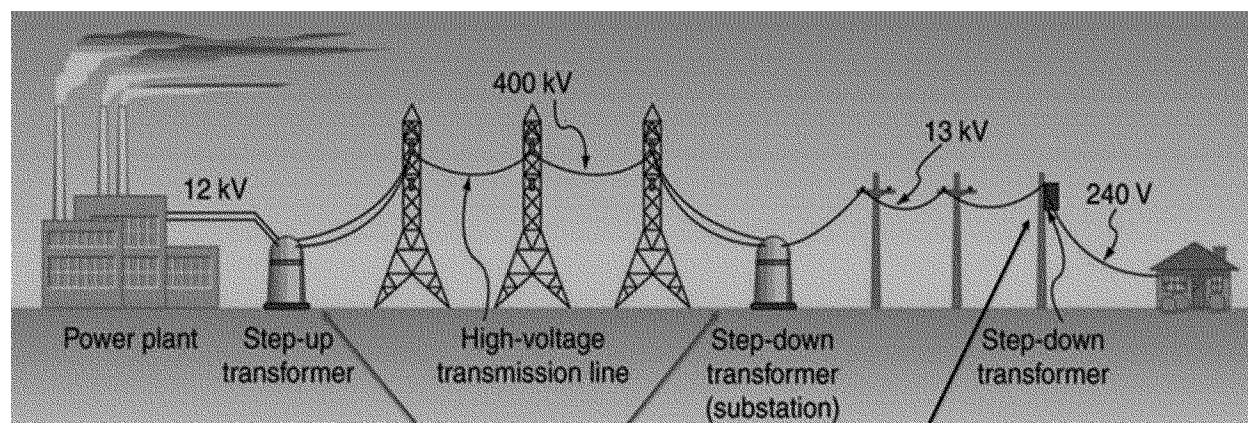
GOES is produced in compliance with specifications issued by standards organizations and various proprietary specifications. For example, *conventional GOES* is available in standard gauges (thicknesses), ranging from 0.007 inch (0.18 mm) through 0.0138 inch (0.35 mm), and *high-permeability GOES* is found in two standard thicknesses (0.23 mm and 0.27mm). Conventional products in the standard thicknesses are often referred to as U.S. or American Iron and Steel Institute grades M2 through M6. Thinner gauge GOES is often preferred

<sup>23</sup> This section draws from USITC's report, Grain-Oriented Electrical Steel From the People's Republic of China, the Czech Republic, Germany, Japan, the Republic of Korea, Poland, and the Russian Federation: Initiation of Antidumping Duty Investigations, 78 FR 65283 (October 31, 2013).

because thinner laminations yield lower core losses in transformers, despite the added cost for both the steel and the manufacturing of the transformer core. Within each type of GOES, magnetic characteristics may vary, with producers manufacturing the same product with differing average core losses.

In addition to differences in thickness, GOES is produced with varying levels of magnetic permeability, distinguished by the size and orientation precision of the grains within the steel. Conventional GOES has smaller but less precisely oriented grains, while high-permeability GOES

has more precisely oriented but larger grains. High-permeability products allow a transformer to operate at a higher level of flux (flow) density than conventional products, thus permitting a transformer to be smaller and have lower energy operating losses.



## High permeability GOES

## Regular GOES

High permeability GOES is also produced as a domain-refined (surface-treated) type that has even lower core loss at high flux density. Domain refinement occurs by using laser scribing, mechanical scribing or electrolytic etching to scribe thin lines onto the surface of the steel, which subdivides larger-oriented grains into smaller ones to produce “domain-refined GOES” (DR-GOES). GOES that undergoes laser scribing does not retain its enhanced magnetic characteristics when it is annealed (heat treated) to relieve internal stresses. As a result, laser-scribed GOES (or “non-heat-proof GOES”) is not suitable for producing wound-core transformers, which require superior core-loss properties but must undergo heat treatment to relieve internal stresses (which increase core losses) accumulated from the manufacturing process. By contrast, domain-refined GOES produced by mechanical scribing or electrolytic etching (“heat-proof” or “permanent” DR-GOES”) retains its enhanced magnetic characteristics, even though stress-relief treatment. There is no known production of mechanically scribed or electrolytically-etched heat-proof GOES in the United States.

### 2. Amorphous Metal

Amorphous metal transformer cores are an alternative to traditional cores made from GOES. Amorphous metal, called metglas, is an alloy of iron that

includes boron, silicon, and phosphorous in the form of thin foil. Produced using rapid solidification of molten alloy (at a rate of about one million degrees Celsius per second), it differs from GOES in that it has a random rather than a crystalline structure. While more expensive than GOES on a per kilogram basis and more labor intensive to form into cores, the material has the potential to reduce costs in the long run for utilities over the life of the transformer. Compared to cores made from GOES, core losses from eddy currents can be 70–80 percent lower in transformers with amorphous metal cores, reducing their operating costs and improving their energy efficiency. Amorphous metal is most often used in industrial and distribution transformers with power handling capacities in the 50 to 1000 kVA range.

### D. Transformer Construction

The typical transformer manufacturing process consists of the following steps:

1. *Engineering and design:* Design is complex, balancing the costs of raw materials (copper, steel, and cooling oil), electrical losses, manufacturing labor hours, plant capability constraints, and shipping constraints.

2. *Core building:* The core is the most critical component of a transformer, and it requires both a highly trained and skilled workforce and a supply of GOES.

3. *Windings production and assembly of the core and windings:* Windings are

predominantly copper and have an insulating material.

4. *Drying operations:* Excess moisture must be removed from the core and windings because moisture can degrade the dielectric strength of the insulation.

5. *Tank production:* A tank must be completed before the winding and core assembly finish the drying phase so that the core and windings do not reabsorb moisture.

6. *Final assembly:* The final assembly must be done in a clean environment; even a tiny amount of dust or moisture can deteriorate the performance of a transformer.

7. *Testing:* Testing is performed to ensure the accuracy of voltage ratios, verify power ratings, and determine electrical impedances.

## V. Importance for Critical Infrastructure and National Security

### A. Critical Energy Infrastructure

The Cybersecurity and Infrastructure Security Agency (CISA) has identified 16 critical infrastructure sectors whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof.<sup>24</sup> One of these 16 sectors is the Energy Sector. CISA has

<sup>24</sup> <https://www.cisa.gov/critical-infrastructure-sectors>.

determined that the U.S. energy infrastructure fuels the economy of the 21st century. Without a stable energy supply, health and welfare are threatened, and the U.S. economy cannot function. In fact, CISA notes that, among the sixteen sectors, the Energy Sector is *uniquely* critical because it provides an “enabling function” across all critical infrastructure sectors. The energy infrastructure is divided into three interrelated segments: Electricity, oil, and natural gas. Items subject to this investigation form the backbone of the electricity segment.

The U.S. electricity segment contains more than 9,700 power plants with 1,200 gigawatts capacity, sourced by coal, petroleum, natural gas, nuclear, hydroelectric, and renewable energy sources such as wind and solar.<sup>25</sup> The number of power plants has increased significantly in recent years, due primarily to the expansion of solar and wind power generation. The electricity generated by the plants is processed along hundreds of thousands of miles of high voltage transmission lines and millions of miles of local distribution lines through transformers subject to this investigation. In addition to plant-generated power, there is an evolution of sorts where distributed energy resources are allowing energy resources such as solar, wind, and energy storage, to be owned and operated at the customer level. However, the vast majority of electric power is in plant-generated and delivered via traditional means to consumers.

In its Energy-Sector Specific Plan, CISA notes that the failure of U.S. power infrastructure, and specifically LPTs, could present a vulnerability to the electric grid. CISA further expresses concern that the United States heavily depends on overseas manufacturers to meet its demand for LPTs and that the supply and procurement of LPTs can be challenging because it can take more than 12 months to replace an LPT due to its long and complex procurement process and the uniqueness in construction for the specific voltages and currents at the intended substation.<sup>26</sup>

While the electrical grid, especially at the BPS level,<sup>27</sup> has operated at a high-

level of reliability, there is a growing concern that the ever-expanding list of threats, which could be physical and/or cyber-related in nature, further increases the grid’s vulnerability and the need for enhanced security. In addition to their long manufacturing and acquisition lead time, LPTs pose unique vulnerabilities because of transformer’s susceptibility to the serious and evolving threats and hazards. Single or multiple failures of LPTs are becoming a significantly greater concern to grid reliability.

As a result of these concerns, several efforts by the federal government and electric utility industry have been initiated and are underway. For example, the North American Electric Reliability Corporation (NERC) issued the NERC-CIP-14 Standard in 2015, requiring transmission asset owners to apply risk assessments to identify and protect transmission stations and substations, as well as their associated primary control centers. Instability, uncontrolled separation, or cascading failure within an interconnected transmission system could result if these assets were rendered inoperable or damaged as a result of a physical attack.

In addition, the Fixing America’s Surface Transportation Act [Pub. L. No. 114–94 (FAST Act)], signed into law in December 2015, requiring the DOE to establish a plan for a Strategic Transformer Reserve that could be tapped in the event of a major disruption to the electric grid.<sup>28</sup> DOE’s responsive recommendation is that a voluntary industry-based approach would be more feasible and effective than a national, Government-owned stockpile of transformers. The DOE report, however, noted the lack of domestic capacity to produce LPT and the extreme dependence on foreign suppliers, especially for high-voltage transmission (>345 kV).<sup>29</sup>

President Trump signed Executive Order 13920 (E.O. 13920), titled “Securing the United States Bulk-Power System,” on May 1, 2020.<sup>30</sup> The President determined that the unrestricted foreign supply of BPS electric equipment constitutes an unusual and extraordinary threat to the national security, foreign policy, and economy of the United States.

In this Executive Order, the President declared that threats to the BPS by foreign adversaries constitute a national emergency. He also found that as it serves as the backbone of our Nation’s

energy infrastructure, the BPS is fundamental to national security, emergency services, critical infrastructure, and the economy. Transformers subject to E.O. 13920 include substation transformers, substation voltage regulators, and instrument transformers, which are key elements of the BPS. The E.O. notes that the BPS is a target of those seeking to commit malicious acts against the United States and its people, including malicious cyber activities, because a successful attack on the U.S. BPS would present significant risks to the economy and human health and safety and would render the United States less capable of acting in defense of itself and its allies.

While BPS electric equipment supplied by potential adversaries raises immediate concerns, the Secretary of Energy has also noted that evolving threats facing our critical infrastructure have only served to highlight the supply chain risks and the need to ensure the availability of secure components from American companies and other trusted sources.<sup>31</sup> DOE is currently undertaking a rulemaking effort, in consultation with other agencies, to implement the authorities delegated to the Secretary of Energy in E.O. 13920. E.O. 13920 authorizes the Secretary of Energy to (1) prohibit any acquisition, importation, transfer, or installation of BPS electric equipment by any person or with respect to any property to which a foreign adversary or an associated national thereof has any interest, that poses an undue risk to the BPS, the security or resiliency of U.S. critical infrastructure or the economy, or U.S. national security; (2) establish and publicize criteria for recognizing particular equipment and vendors in the BPS electric equipment market as “pre-qualified” for future transactions and to apply these criteria to establish and publish a list of pre-qualified equipment and vendors; (3) in consultation with heads of other agencies, to identify existing BPS electric equipment in which a foreign adversary or associated national thereof has an interest that poses an undue risk to the BPS, the security or resiliency of U.S. critical infrastructure or the U.S. economy, or U.S. national security, and develop recommendations to identify, isolate, monitor, or replace this equipment as appropriate; and (4) establish a Task Force on Federal Energy Infrastructure Procurement Policies Related to National Security, which will focus on the coordination of Federal Government

<sup>25</sup> EIA, Electric Power Annual, Table 4.1.

<sup>26</sup> <https://www.cisa.gov/sites/default/files/publications/nipp-ssp-energy-2015-508.pdf>.

<sup>27</sup> The North American Electric Reliability Corporation defines the bulk-power system to consist of all generation components and transmission system elements generally operating at 100 KV or higher. See: [https://www.nerc.com/pa/Stand/Project%20201017%20Proposed%20Definition%20of%20Bulk%20Electri/bes\\_phase2\\_reference\\_document\\_20140124\\_llh.pdf](https://www.nerc.com/pa/Stand/Project%20201017%20Proposed%20Definition%20of%20Bulk%20Electri/bes_phase2_reference_document_20140124_llh.pdf).

<sup>28</sup> <https://www.congress.gov/114/plaws/publ94/PLAW-114publ94.pdf>.

<sup>29</sup> DOE Transformer Reserve Study, 2017.

<sup>30</sup> <https://www.federalregister.gov/documents/2020/05/04/2020-09695/securing-the-united-states-bulk-power-system>.

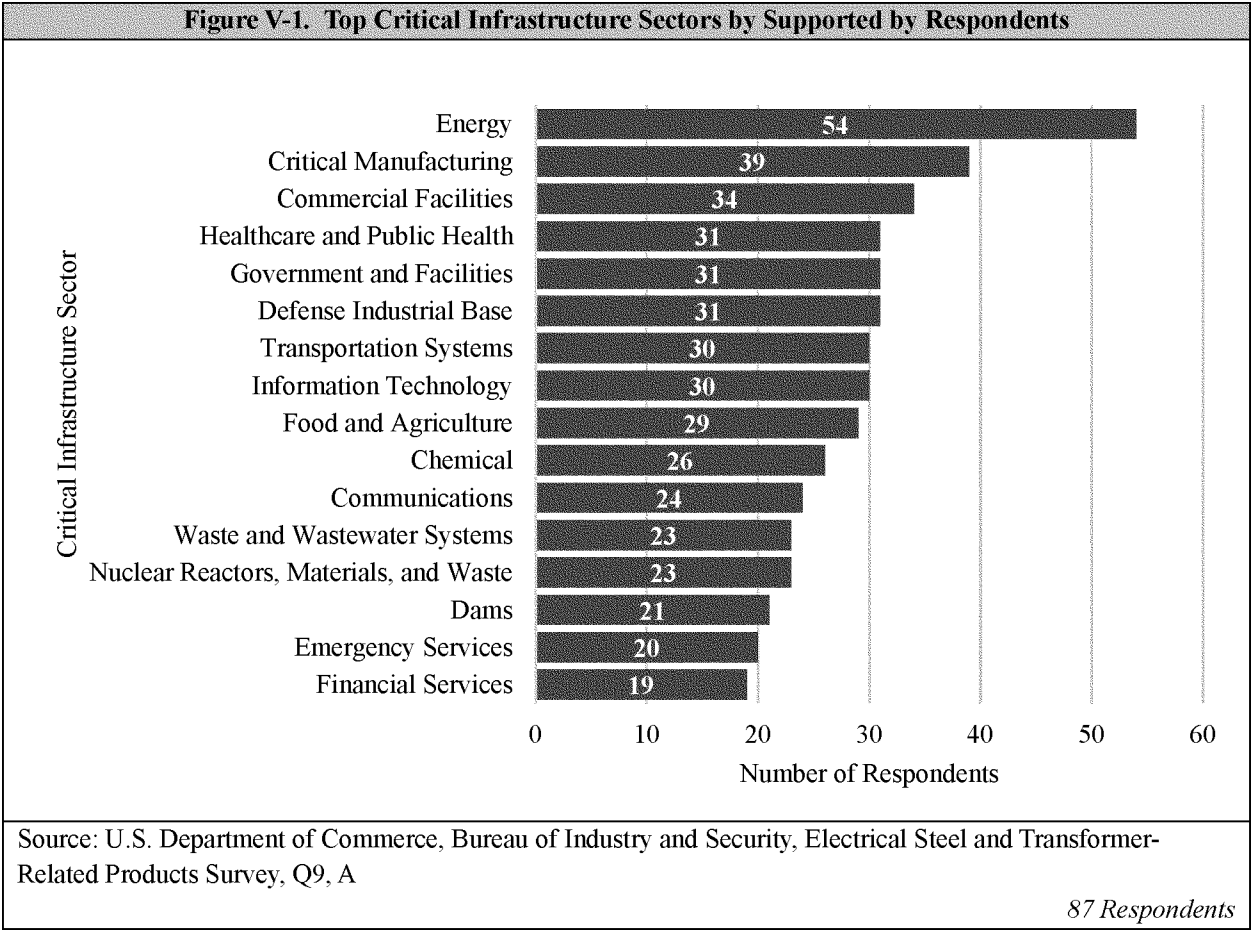
<sup>31</sup> <https://www.energy.gov/articles/president-trump-signs-executive-order-securing-united-states-bulk-power-system>.

procurement of energy infrastructure, the sharing of risk information and risk management practices, and the development of recommendations for implementation to the Federal Acquisition Regulatory Council (FAR Council). DOE and the Department will coordinate efforts to ensure consistency of rules and supporting program activities.

1. Role of Transformer Manufacturers in Critical Infrastructure

As part of its survey of industry conducted for this investigation, the Department requested survey recipients to provide information on which of the 16 critical infrastructure sectors their products support. Respondents indicated support for all 16 sectors, with the Energy Sector (not surprisingly) indicated most frequently. As mentioned above, the Energy Sector is

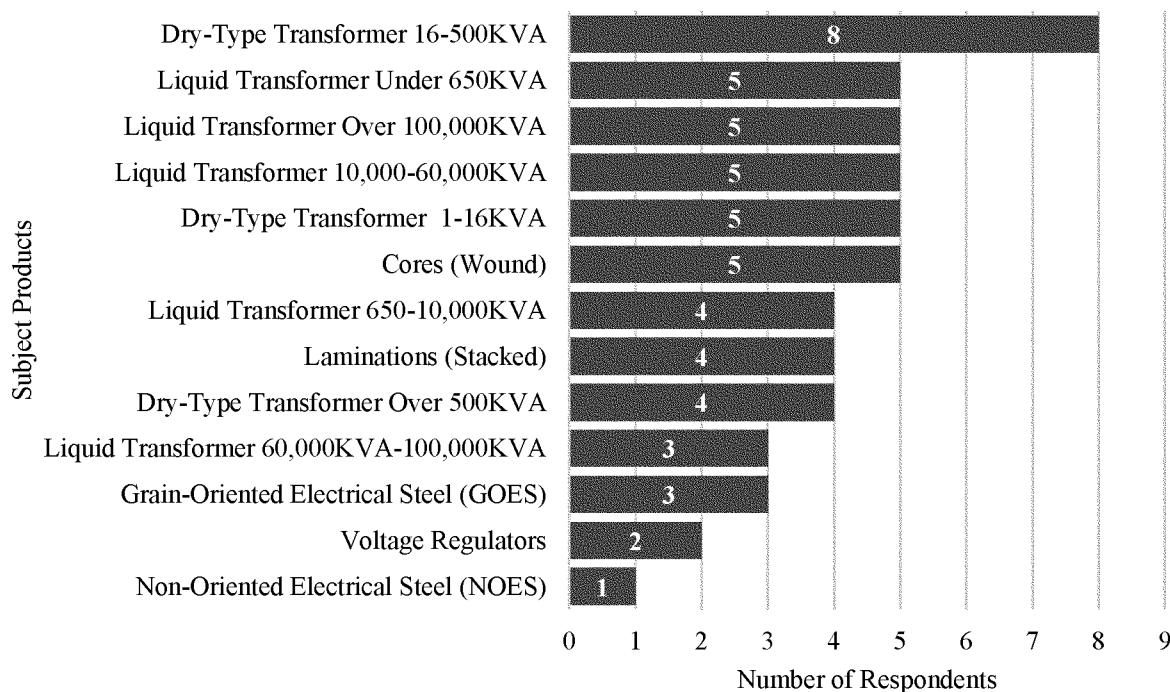
unique among the 16 sectors because it provides an “enabling function” across all critical infrastructure sectors, and survey responses validated this fact. Other critical infrastructure sectors that received numerous mentions by survey respondents were critical manufacturing, commercial facilities, Government facilities, information technology, chemical sector, defense industrial base, and food and agriculture (see Figure V–1).



By product, all categories were again cited as providing support to critical technology sectors (see Figure V–2).

Most frequently mentioned were dry-type transformers 16–500 kVA, followed by liquid-dielectric transformers 60–100

MVA, and liquid-dielectric transformers under 650 kVA.

**Figure V-2. Energy Sector – Top Electrical Steel and Transformer-related Products by Respondent Support**

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q9, A

54 Respondents

### B. National Security/Defense Requirements

In today's technology-dependent environment, energy requirements are inseparable from the Department of Defense's (DOD) mission requirements, whether discussing weapons platforms or the installations and systems that support those capabilities around the globe. As such, energy resilience, which enables the capabilities of weapons platforms, facilities, and equipment, is a critical investment that must be part of the DOD's research, acquisition, operations, and sustainment conversations.<sup>32</sup>

DOD is the largest single energy-consuming entity in the United States, both within the Federal Government and as compared to any single private-sector entity. DOD operational and installation energy consumption represents approximately 80 percent of total Federal energy consumption, more than sixteen times the total energy consumption of the next closest Federal agency (the United States Postal

Service).<sup>33</sup> In FY 2018, DOD spent approximately \$3.49 billion on installation energy, of which \$2.5 billion was for electricity used to power, heat, and cool buildings.

The U.S. electrical grid, primarily under the ownership and control of private organizations, supplies the power required to support DOD installations, including military bases, arsenals, and laboratories. This supply is a key part of the "Defense Critical Electric Infrastructure," which is defined as any electrical infrastructure in the 48 contiguous States or the District of Columbia that serves a facility designated by the Secretary of Energy as critical to the defense of the United States and vulnerable to a disruption of the supply of electric energy provided to such a facility by an external provider, but that is not owned or operated by the owner or operator of such facility.<sup>34</sup> In 1998, with the issuance of Defense Reform Initiative #49, the military services were directed

to privatize their utility systems. The Department of Defense's Defense Logistics Agency Energy acts as the procurement agency for contracting with utilities for this purpose.<sup>35</sup>

The Department of Defense operates 500 installations worldwide, with nearly 300,000 buildings covering 1.9 billion square feet. Energy needed to power these fixed installations accounts for nearly 30 percent of DoD's total energy use, and the installations rely extensively on transformers of various power handling capacities to distribute electricity at the appropriate voltage level.<sup>36</sup>

As noted above, DOD relies primarily on commercial power to support its installations. Commercial power supplies can be threatened by a variety of events, ranging from natural hazards and physical attacks on infrastructure (including transformers), to cyber-attacks on networks and Supervisory Control and Data Acquisition (SCADA) systems. Disruption of power could affect critical DOD missions involving power projection, defense of the

<sup>32</sup> Id., p. 32.

<sup>34</sup> <https://www.federalregister.gov/documents/2018/10/29/2018-23459/critical-electric-infrastructure-information-new-administrative-procedures>.

<sup>35</sup> <https://archive.defense.gov/dodreform/drids/drid49.html>.

<sup>36</sup> DOD AEMMR.

<sup>32</sup> Department of Defense Annual Energy Management and Resilience Report (AEMMR) for Fiscal Year 2018, <https://www.acq.osd.mil/eie/Downloads/IE/FY%202018%20AEMR.pdf>.



homeland, or operations conducted at installations in the United States directly supporting warfighting missions overseas.

DOD's efforts to improve the energy resilience of its installations mainly focuses on backup power *generation* to compensate when the commercial grid experiences a disruption. However, emergency power generation assets are ineffective if the surrounding *distribution* system is unable to convey power between the generation asset and final point of use. Therefore, DOD may also pursue upgrading distribution system equipment, including transformers and power lines, as a standalone solution if backup generation is already adequate or as an integrated solution when new backup power generation assets are implemented.

In addition to their vital role in the electricity grid to supply power to military installations, transformers also play an essential role in supporting military operations. Sophisticated military equipment, such as missiles, fighter jets, and naval vessels, rely on transformers of various types and capacities to provide the correct voltage within subsystems. Additional military applications include tactical displays and field operations equipment such as mobile power supplies and reconnaissance equipment. In addition to reliability and durability, military transformers must meet defense specifications (Mil Spec) and often must

be designed and manufactured to withstand extreme environmental conditions, such as high humidity, salt spray, sand, high altitude, shock, and vibration. Military transformers may be specially encapsulated to withstand these types of harsh conditions.

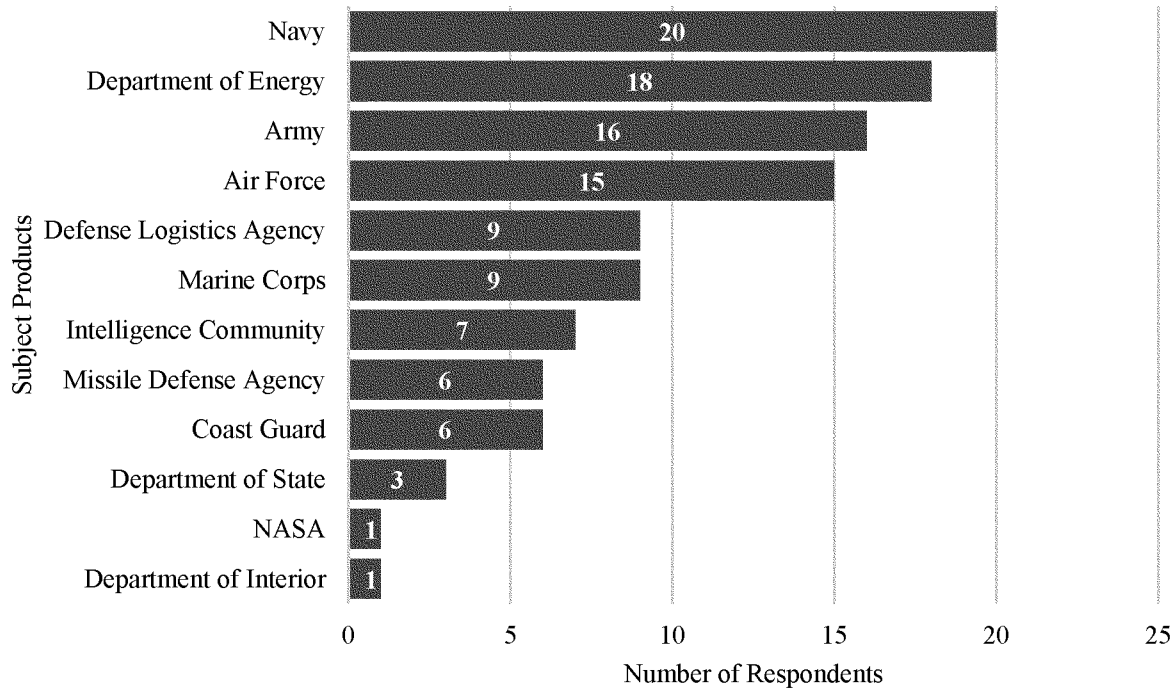
[TEXT REDACTED].

Due to its importance for certain defense applications, the Defense Logistics Agency (DLA) has included GOES among its requests for inclusion in the National Defense Stockpile. In their Fiscal Year 2019 Report to Congress on Stockpile Requirements, DLA Strategic Materials identified a potential shortfall for GOES of approximately [TEXT REDACTED]. Per the Strategic and Critical Materials Stock Piling Act (50 U.S.C. 98 *et seq.* Sec 14 (b)), shortfalls are estimated under national emergency planning assumptions consisting of "a military conflict scenario consistent with the scenario used by the Secretary of Defense in budgeting and defense planning purposes." In other words, shortfall amounts are calculated based on surge requirements for the military engaging in conflict, taking into consideration weapons and munitions lost and expended during the conflict in an environment of reduced foreign availability of supplies of strategic and critical materials. If United States' sole domestic source of GOES were to cease production, DLA's estimated shortfalls would be larger. DLA Strategic Materials recommended a [TEXT REDACTED].

The stockpile recommendation is lower than the estimated requirement due to competing stockpile needs and budget constraints.

In the industry survey conducted as part of this investigation, the Department queried participants as to whether their products were provided, directly or indirectly, for U.S. defense systems, installations, or known defense end-uses. The majority of survey respondents were unable to provide specific information in this regard because most defense-related sales are indirect; instead, respondents noted that their products (especially liquid-dielectric transformers) are used to provide power in the national grid that supplies power to military bases. Most of those that responded to the question with specifics reported that only a small percentage of sales, about 1–3 percent, involved defense-related uses. Moreover, in most cases, this was just an estimate, as survey respondents typically did not have insight into the ultimate end use of their products.

However, some survey respondents were able to provide precise information on defense and military uses for their products. These respondents supported every branch of the military, as well as the Department of Energy/National Labs, the DLA, the State Department, NASA, the Department of Defense's Missile Defense Agency, and the U.S. Intelligence Community.

**Figure V-3. National Defense – Top USG Agencies by Respondent Support****\*\*\*Note: Respondents may support more than one USG agency**

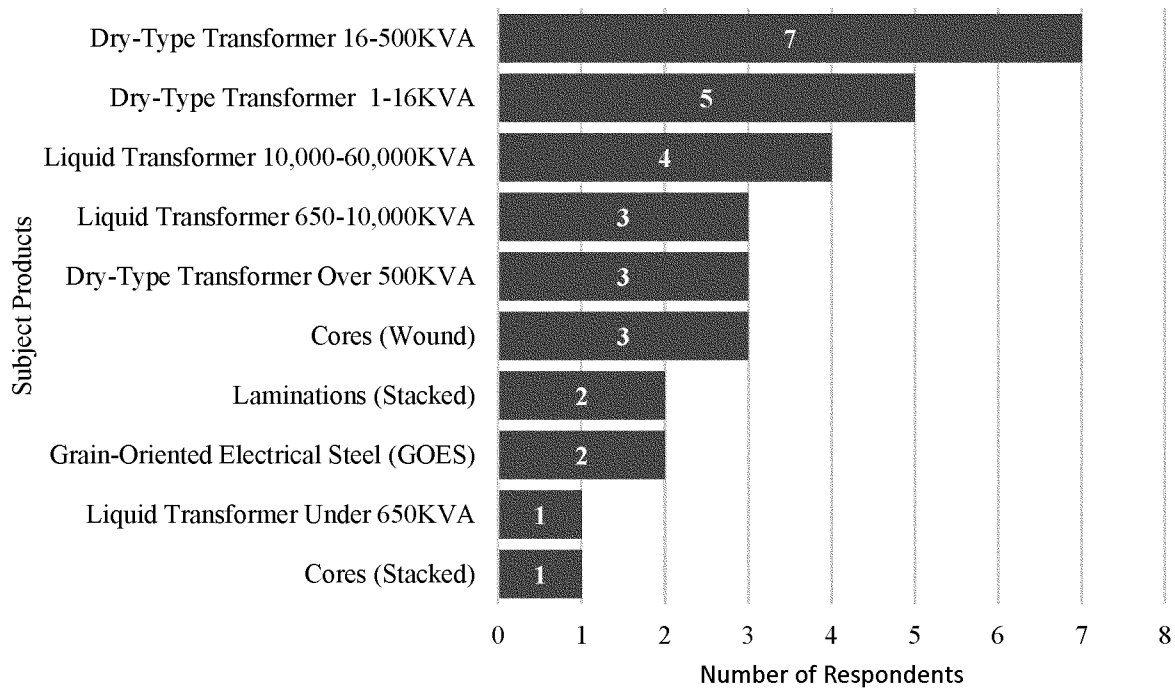
Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q8, B

*22 Respondents*

Based on survey responses, dry-type transformers (particularly of higher power handling capacities) are suitable

for inside installations and thus play an important role in direct defense

applications such as onboard radars, missiles, ships, and aircraft.

**Figure V-4. Defense Industrial Base Sector – Top Electrical Steel and Transformer-related Products by Respondent Support**

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q9, A

31 Respondents

No respondent attributed sales of voltage regulators, non-oriented electrical steel, liquid-dielectric transformer 60,000–100,000 kVA, or liquid-dielectric transformer over 100,000 kVA to direct defense industrial base support.

[TEXT REDACTED].

[TEXT REDACTED].<sup>37</sup> [TEXT REDACTED].

## **VI. United States' and Global Markets for GOES, Transformers and Transformer Components**

### **A. GOES Market**

The market for GOES is dominated by transformers, particularly LPTs, which

<sup>37</sup> <https://new.abb.com/news/detail/64657/abb-completes-divestment-of-power-grids-to-hitachi>.

can weigh over 400 tons, and GOES constitutes a significant portion of this weight. Although large transformers by sheer size incorporate more GOES by weight, the market for them is small in terms of units. In contrast, smaller transformers, such as distribution transformers, utilize less GOES by weight, but they are sold in much greater volumes and so also provide a significant market for GOES.

A recent report by a market research firm estimated that the global market for GOES will reach \$20.8 billion by 2025, with a compounded annual growth rate (CAGR) of 5.8 percent. The average annual growth rate in the United States is estimated to be 4.6 percent over the next five years (adjusted downward from 5.7 percent due to the impacts of

COVID-19); the market in China will grow at 9.5 percent.<sup>38</sup>

AK Steel is the sole remaining U.S. supplier of GOES. Another domestic producer, Allegheny Technologies, Inc. (ATI) stopped production of GOES in 2016. However, industry reports indicate that Big River Steel (Osceola, AR), a manufacturer of non-grain oriented steel, intends to produce high quality GOES in the future, including high permeability grades (such as Hi-B).<sup>39</sup>

Outside of the United States, there are 13 manufacturers of GOES, as listed in Figure VI-1.

<sup>38</sup> [https://www.reportlinker.com/p05798466/Global-Electrical-Steel-Industry.html?utm\\_source=GNW](https://www.reportlinker.com/p05798466/Global-Electrical-Steel-Industry.html?utm_source=GNW).

<sup>39</sup> <https://bigriversteel.com/products/electrical/>.

**Figure VI-1. Manufacturers of GOES Outside the United States**

<b>Company Name</b>	<b>Country of Manufacture</b>
Baowu Iron & Steel Co., Ltd	China
Anshan Iron & Steel Group Corp.	China
Hebei Shougang Iron & Steel Co., Ltd.	China
TISCO	China
JFE Steel Corporation	Japan
Nippon Steel & Sumitomo Metal Corp. (NSSMC)	Japan
ThyssenKrupp Electrical Steel GmbH	France/Germany
ThyssenKrupp	India
StalProdukt	Poland
GO Steel Frydek Mistek A.S. (Purchased by StalProdukt from Arcelor Mittal in 2018) <sup>40</sup>	Czech Republic
Novolipetsk Steel (NLMK)	Russia
Aperam	Brazil
POSCO	South Korea
Source: DLA Report	

[TEXT REDACTED].<sup>41</sup>

A limited number of these global suppliers, such as those from Japan and

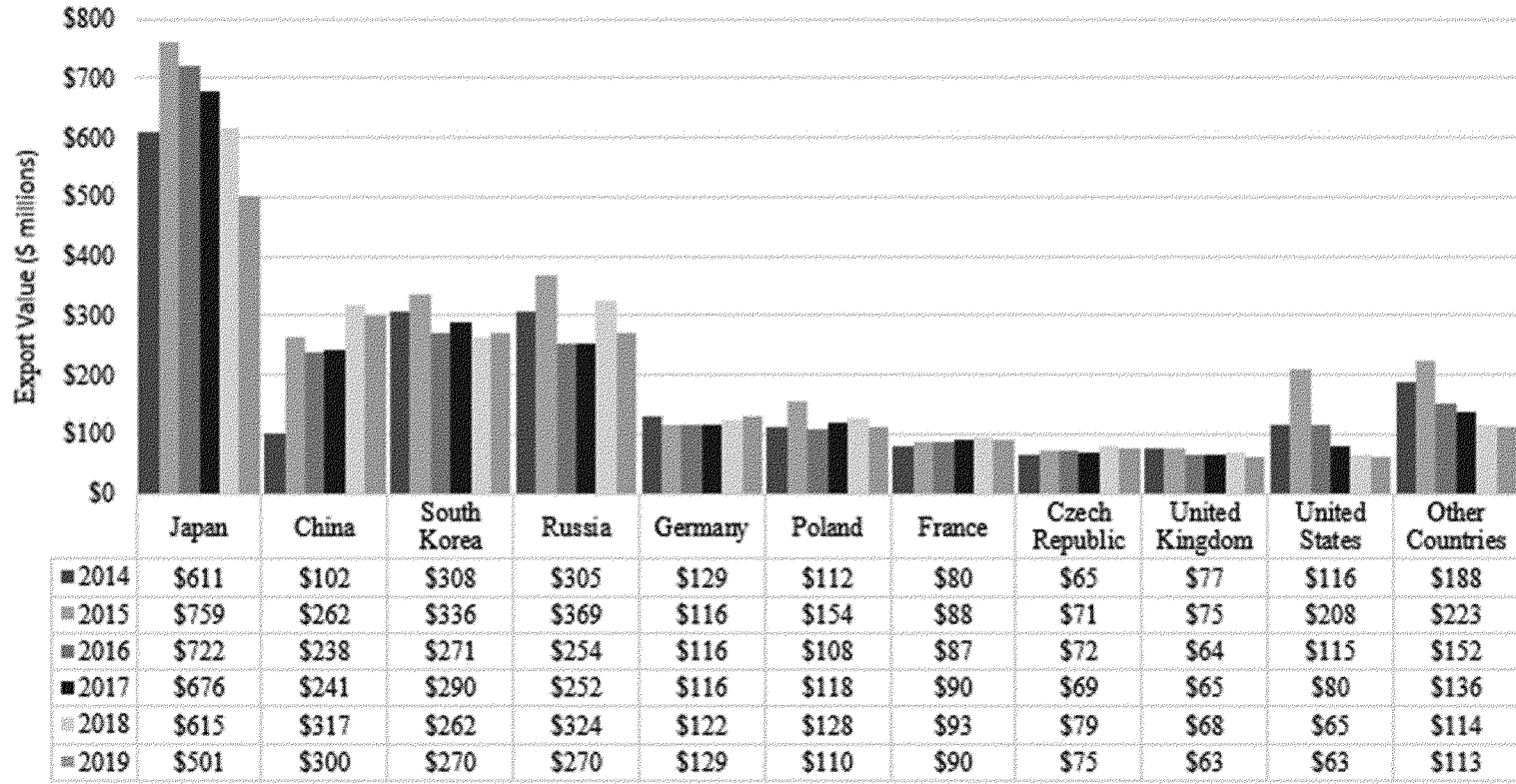
South Korea, are capable of producing the high permeability GOES that the market is demanding in response to current DOE standards. China is the world's largest producer of GOES but

much of its production is consumed internally, and Chinese firms have not dominated export markets.

[TEXT REDACTED]

<sup>40</sup> <http://www.corpin.cz/en/arcelorgosteel.html>.

<sup>41</sup> [TEXT REDACTED]

**Figure VI-2. 2014-2019 Export Statistics of HTSD Code 7225.11 – Flat-Rolled Silicon Electrical Steel 600 Mm or More Wide, Grain-Oriented**

Source: Global Trade Atlas, retrieved on July 6, 2020

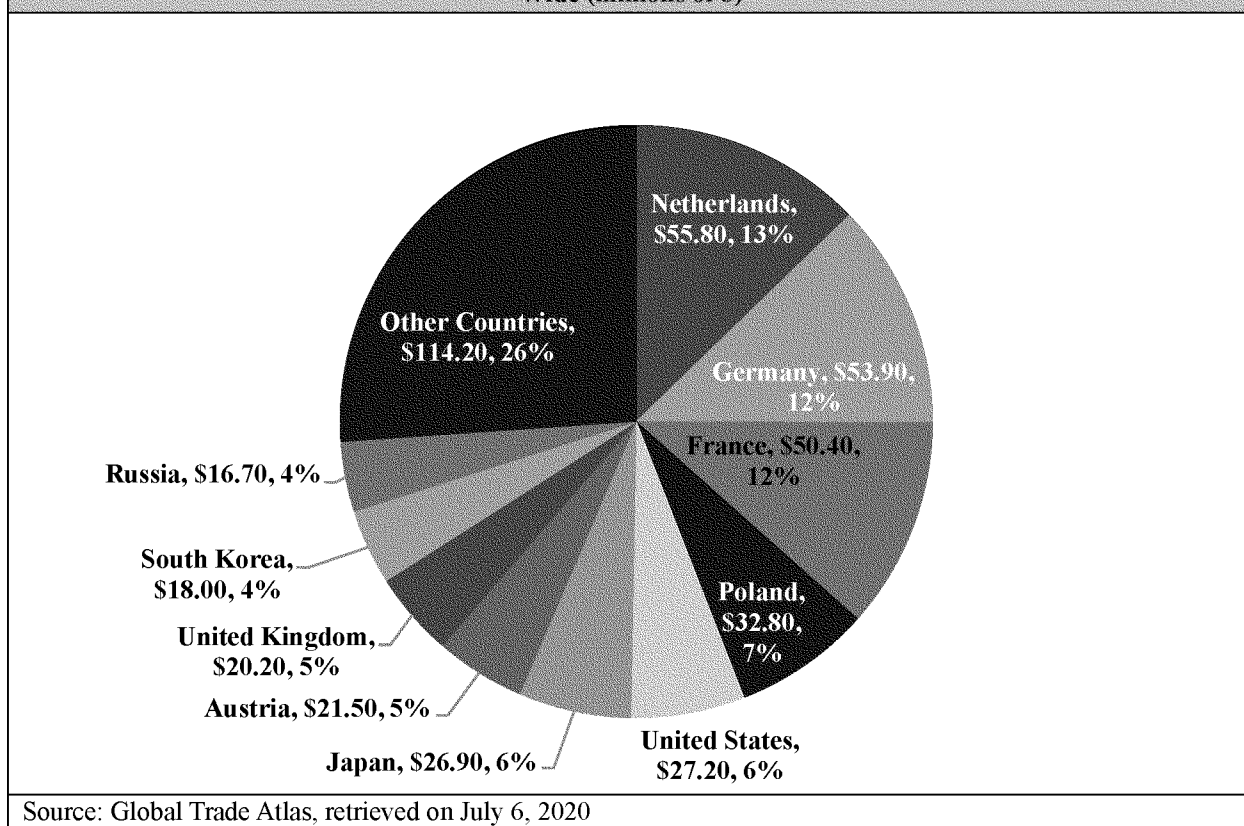
For GOES <600 Mm in width, the total trade in 2019 was \$437.6 million,

much smaller than GOES ≥600 Mm in

width, and the major players were mainly European countries.



**Figure VI-3 2019 Export Statistics of HTS Code 7226.11 – Grain-Oriented Electrical Steel Under 600 Mm Wide (millions of \$)**



#### *B. Transformer Laminations and Cores*

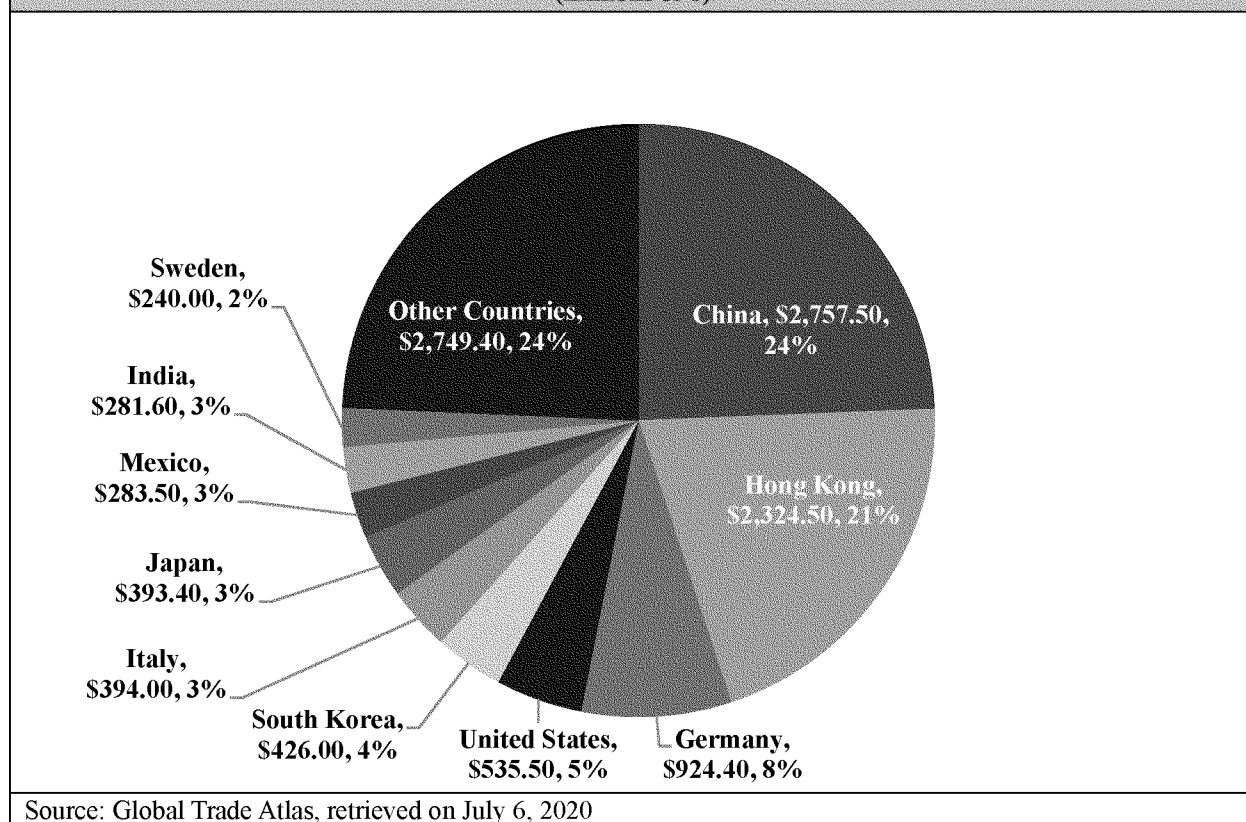
Most of the major global transformer companies produce laminations and cores for internal consumption, although manufacture of these items does not necessarily occur in the same facility in which they are consumed. However, there are also companies that manufacture these products for transformer producers. Lamination and core manufacturers tend to be small companies that produce specialized products, and there is little information available on them as a distinct industry sector.

Based on data available from GTAA, the biggest players in the world export market for the category including transformer parts (laminations and cores but also products not subject to this investigation)<sup>42</sup> is China, including Hong Kong. In 2019, of the total \$11.3

<sup>42</sup> Note: At the 6 digit HTS level for which global trade data are available, this category (8504.90) includes parts and components unrelated to transformers (e.g., parts of static converters and inductors). There is no way to determine how much of this trade is transformer laminations and cores. Therefore, this information should be considered indicative of general trading patterns only.

billion of trade of transformer parts, China exported \$2.8 billion and Hong Kong exported \$2.3 billion; together, China and Hong Kong accounted for 44.9 percent of the total trade. Germany was second, with exports of \$924.4 million. Although Canada and Mexico are the main sources for U.S. imports of transformer cores and laminations, neither country is significant actors in global exports: Mexico ranked 8th with \$283.5 million and Canada ranked 12th with \$184.0 million.

**Figure VI-4. 2019 Top 10 Exporters for HTS Code 8504.90 – Parts of Electrical Transformers (millions of \$)**



The leading destination for China's exports of transformer parts was the United States with \$282.4 million total imports in 2019, followed by India with \$256.9 million. The leading destination for Hong Kong's exports of transformer parts during the same year was also the United States with \$152.6 million, followed by Germany with \$77.9 million.

### C. Global and U.S. Transformers Market

[TEXT REDACTED]. Typical customers are companies in electricity generation, transmission, and distribution industries. End-use customers also include energy-intensive industries such as mining, chemical manufacturing, and steel and pulp/paper mills, as well as large commercial facilities.

The global transformer industry has undergone numerous mergers, acquisitions, consolidations over the past several decades, resulting in fewer, larger players that offer a wider product range and are able to benefit from economies of scale. During the consolidation process, many manufacturers moved their production offshore (e.g., Mexico, India, Colombia), taking advantage of lower labor costs, lower labor and environmental

standards, and access to local markets with rapidly increasing demands for electricity.<sup>43</sup> Mexico, in particular, has become a significant player in transformer manufacturing; among the global transformer manufacturers with production facilities in Mexico [TEXT REDACTED].

In addition to these large global players, in the United States there are a number of smaller companies that manufacture transformers of various power-handling capacities. These include [TEXT REDACTED].

In its most recent market assessment, Global Market Insights estimated the global transformer market to reach \$80 billion by 2024, assuming a CAGR of 6.5 percent. Key markets for transformers are those with rising electricity demands and investments in power distribution infrastructure—namely, the Asia/Pacific region, Africa, and the Middle East. The greatest market potential is in emerging markets such as these; 15 percent of the world's population does not yet have access to electricity.<sup>44</sup>

<sup>43</sup> Large Power Transformers and the U.S. Electric Grid, DOE, 2014.

<sup>44</sup> Draws from <http://www.firstresearch.com/industry-research/Transformer-Manufacturing.html> (Dun & Bradstreet).

In contrast, the U.S. market is mature, and demand for transformers is largely based on upgrades and replacements of aging infrastructure, including efforts to install smart grids to increase energy efficiency. The average transformer in the United States is 38 years old, with 70 percent of U.S. transformers older than 25 years.<sup>45</sup> New transformers are also needed to distribute electricity from the growing number of renewable energy generation plants. With over 9,000 power plants, 1.2 terawatts of power generating capacity, and 360,000 miles of high voltage transmission lines, the United States remains one of the largest markets for transformers.

Trade data available through GTA show the major players by country in export markets for transformers of various power handling capacities. While only available at broad (6 digit HTS) product categories, these data are useful to show the relative global export market sizes and which countries dominate exports in each broad segment.

Among all transformer categories, the product with the greatest value of world exports is the liquid-dielectric transformers with a handling capacity of

<sup>45</sup> DOE LPT Study, 2014 update.

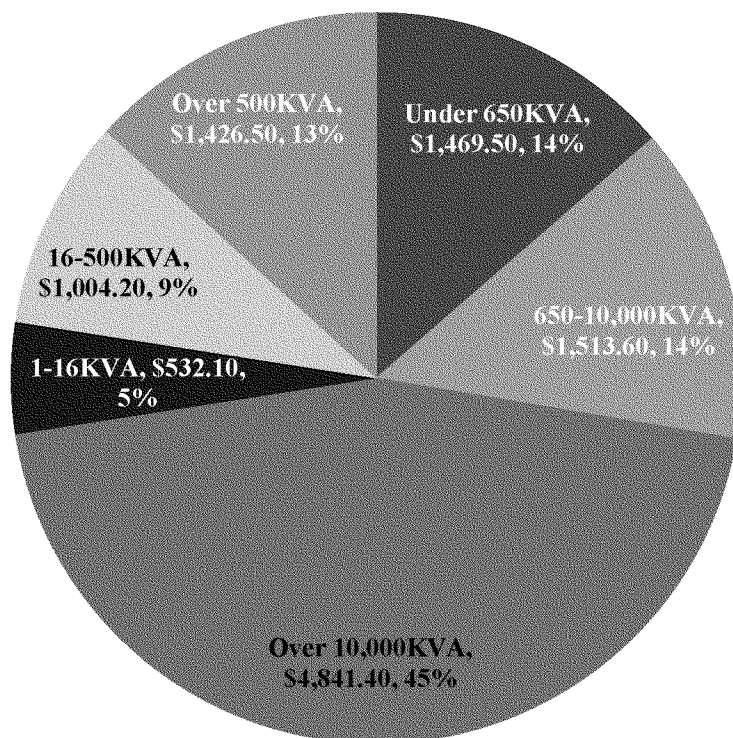
more than 10,000 kVA (HTS 8504.23). This category includes large power transformers, as well as medium sized power transformers and larger distribution transformers. It accounted for nearly 45 percent of total world trade in transformers, based on average annual value of global exports over the

2014–2019 period. In this category, China is the top exporter with an average annual export value of \$893.9 million, followed by South Korea with \$635.9 million, and Germany with \$371.8 million.

For liquid-dielectric transformers with smaller power handling capacities

(distribution transformers, HTS 8504.21 and 8504.22), as well as mid-sized dry-type transformers (HTS 8504.32 and 8504.33), Mexico is a major exporter. Virtually all of Mexico's transformer exports are destined for the United States.

**Figure VI-5. Transformer World Trade Average Export Value by Power Handling Capacity, 2014-2019**  
(millions of \$)



Source: Global Trade Atlas, retrieved on July 29, 2020

Figure VI-6. Top Five Exporters for Dry-Type/Other Transformers by HTS Code, 2014-2019			
HTS Code	Power Handling Capacity	Country	Average Annual Export Value, 2014-2019 (\$ millions)
8504.32	1-16KVA	United States	\$70.6
		China	\$68.4
		Hong Kong	\$66.2
		Germany	\$53.5
		Mexico	\$49.0
8504.33	16-500KVA	Mexico	\$255.6
		United States	\$132.3
		China	\$71.6
		Italy	\$57.3
		Germany	\$56.3
8504.34	Over 500KVA	Germany	\$214.9
		China	\$186.7
		Italy	\$147.7
		Denmark	\$137.3
		Spain	\$93.5

Source: Global Trade Atlas, retrieved on July 29, 2020

Figure VI-7. Top Five Exporters for Liquid-Dielectric Transformers by HTS Code, 2014-2019			
HTS Code	Power Handling Capacity	Country	Average Annual Export Value, 2014-2019 (\$ millions)
8504.21	Under 650KVA	Mexico	\$198.3
		United States	\$110.5
		India	\$102.4
		China	\$99.6
		Turkey	\$79.4
8504.22	650-10,000KVA	China	\$150.5
		Mexico	\$133.8
		Turkey	\$104.6
		Switzerland	\$96.3
		Austria	\$92.6
8504.23	Over 10,000KVA	China	\$893.9
		South Korea	\$635.9
		Germany	\$371.8
		Turkey	\$321.8
		Italy	\$298.7

Source: Global Trade Atlas, retrieved on July 29, 2020

#### D. United States Transformers Market

In the United States, there are about 250 establishments involved in transformer manufacturing (including units of companies with multiple locations), with a combined annual revenue of about \$5 billion according to Global Market Insights. The National Electrical Equipment Manufacturers

Association (NEMA) is the major sector-specific trade association that represents companies in this industry. NEMA states that there are over two dozen companies and over 15,000 employees involved in transformer manufacturing in the United States.<sup>46</sup>

<sup>46</sup> NEMA Public Comments.

Transformer manufacturing is most highly concentrated in Mississippi, Wisconsin, Virginia, North Carolina, and California. The industry is highly regulated by local, state, and federal agencies for environmental protection reasons, as well as to ensure workplace safety. DOE sets energy efficiency standards for distribution transformers,

with the standards last increased to achieve stricter efficiency in 2016.<sup>47</sup>

The industry is made up of large companies, such as GE (headquartered in the United States but with most transformer manufacturing facilities abroad) and ABB (now called Hitachi ABB Power Grids), which offer a variety of transformer products to utilities and industrial customers. In addition, there are numerous small companies that manufacture specialty transformers and

niche products to industrial and consumer products customers. However, the 50 largest companies account for 90 percent of industry revenue.<sup>48</sup>

According to the Census Bureau, in 2018 (the most recent year for which data are available), the U.S. power, distribution, and specialty transformer manufacturing industry employed 19,227 people, operated in 285 locations, and totaled \$6.15 billion in

revenue. The Census Bureau classifies data using the North American Industry Classification System (NAICS) codes. Because the NAICS code representing power, distribution, and specialty transformer manufacturing is broader and more inclusive than the scope of this investigation, the data below should be interpreted to represent industry trends.

**Figure VI-8. Employment for Power, Distribution, and Specialty Transformer Manufacturing Industry (2012-2018)**

Year	Number of Locations	Number of Employees
2012	253	18,678
2013	253	19,603
2014	256	18,873
2015	246	19,289
2016	246	18,803
2017	242	18,502
2018	284	19,227

Source: United States Census Bureau

**Figure VI-9. Employment Distribution by Location Size 2018**

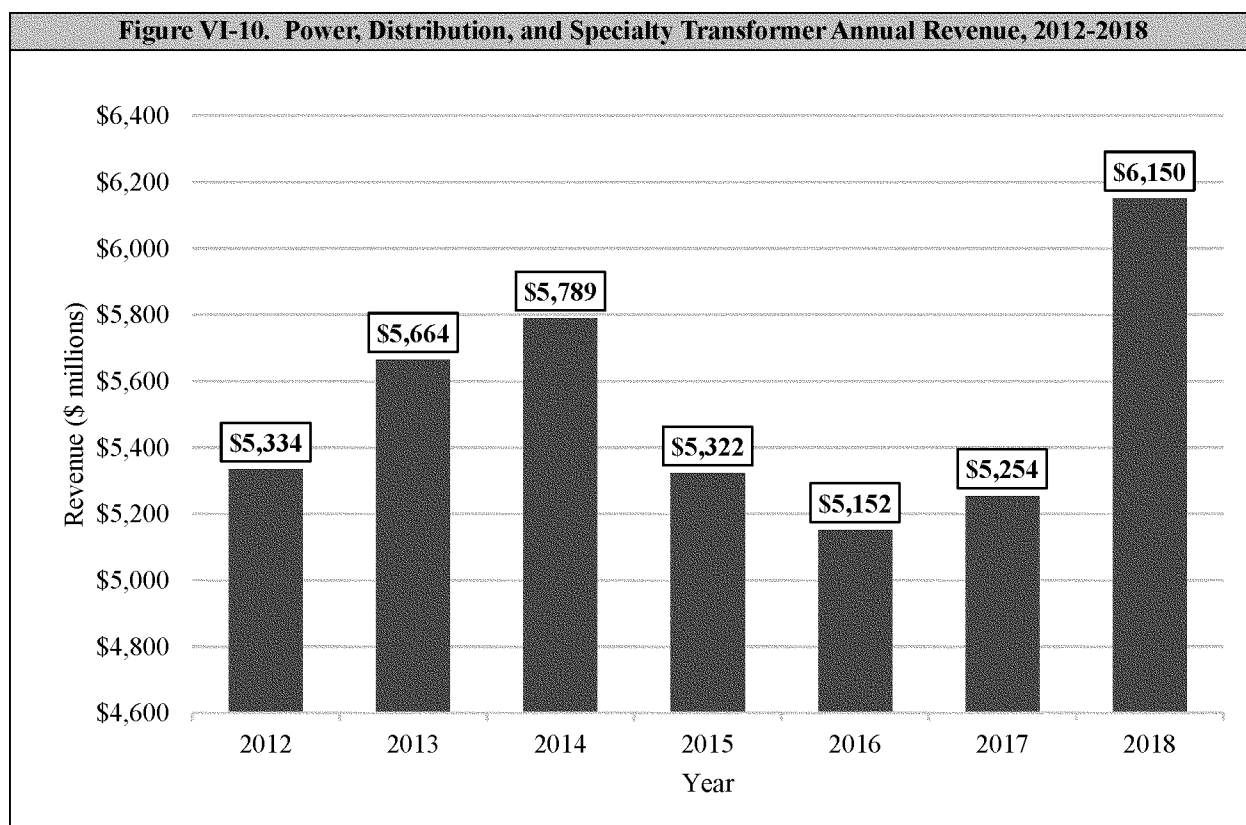
Location Size	Number of Locations	Number of Employees
< 5 employees	100	189
5 ≤ 9 employees	32	203
10 ≤ 19 employees	34	471
20 ≤ 49 employees	43	1,402
50 ≤ 99 employees	26	1,784
100 ≤ 249 employees	30	4,573
250 ≤ 499 employees	16	5,854
500 ≤ 999 employees	3	2,141

Source: United States Census Bureau

<sup>47</sup> <https://www.researchandmarkets.com/reports/4376152/transformer-manufacturing>.

<sup>48</sup> <https://www.researchandmarkets.com/reports/4376152/transformer-manufacturing>.



**BILLING CODE 3510-33-C**

Imports account for about 35 percent of the U.S. market for transformers (of all power handling capacities combined); primary sources of imports are Mexico, Canada, South Korea, and China. About 10 percent of U.S. production is exported, mainly to Mexico and Canada.

With regard to specific subsectors of the transformer industry, there are few companies worldwide that manufacture LPTs; in the United States, as previously discussed, there are six manufacturers but their capability is limited. Distribution transformers are produced by a greater number of companies, including U.S. manufacturers.

DOE has gathered extensive information about the distribution transformer market as a result of the energy conservation standards that the Energy Efficiency and Renewable Energy (EERE) Office is required to set under the Energy Conservation and Policy Act of 1975, as amended. DOE determined that there is significant domestic manufacturing of these products, finding that 75 percent of the employees who work for manufacturers that provide medium-voltage dry-type transformers are located domestically.<sup>49</sup>

<sup>49</sup> DOE, EERE, Technical Support Document (TSD), Ch. 12, Manufacturer Impact Analysis, filed in Docket No. ERE-2010-BT-STD-0048 (Apr. 2013), at 12-48.

The Edison Electric Institute (EEI), which represents investor-owned electric companies that provide power to about 220 million Americans, estimates that its members have procured about four million transformers, at a total cost of more than \$20 billion, over the last five years. The vast majority of these were distribution transformers. EEI estimates that investments in the grid will continue at similar levels in the coming years. EEI members also reported that transformers were sourced both domestically and internationally, with a majority of the reported distribution transformer purchases sourced domestically.<sup>50</sup>

## **VII. U.S. Production Capabilities, Industry Health and Competitiveness, and the Impact of Imports on National Security for Transformer Component Manufacturers**

### **A. Introduction**

This chapter evaluates the state of U.S. production capabilities, industry health and competitiveness, and the impact of imports on national security for GOES, transformer lamination, and transformer core manufacturers. In particular, it presents data on U.S. GOES production, as well as production of key transformer components

<sup>50</sup> EEI et al. Public Comments.

primarily composed of GOES: Transformer laminations, stacked cores, and wound cores.

### **B. Grain-Oriented Electrical Steel**

GOES is a highly specialized, technically challenging product that requires dedicated equipment, advanced manufacturing process know-how, and well-trained, experienced employees. This product is absolutely critical to the performance of transformers, as it is the key material used in transformer cores, which constitutes the primary market for GOES.

AK Steel is the only domestic producer of GOES.<sup>51</sup> The company, then known as Armco Steel, invented and introduced GOES products to the

<sup>51</sup> Paul J. Bough, "ATI to Permanently Close Midland, Bagdad Metal Plants," *Pittsburgh Business Times*, October 25, 2016, <https://www.bizjournals.com/pittsburgh/news/2016/10/25/ati-to-permanently-close-midland-bagdad-metals.html>. Another U.S. company, Big River Inc. (Osceola, Arkansas) has indicated an intention to enter the GOES market. The company currently produces a wide variety of non-grain oriented steels for motor laminations. It has invested in plant equipment and infrastructure to expand production to include high permeability grain-oriented electrical steels. It also has expressed interest in utilizing the facility at which Orb Steel formerly manufactured grain oriented electrical steel in the United Kingdom (owned by Tata of India, which is attempting to sell the plant). However, the company's production capacity and product range is unknown at this time so cannot be counted as domestic production capability.

market in 1926.<sup>52</sup> Another manufacturer, Allegheny Ludlum, a subsidiary of Allegheny Technologies, Inc. (ATI), ceased manufacturing of GOES in 2016, with a loss of 350 jobs. [TEXT REDACTED]<sup>53</sup>

AK Steel melts, rolls, and finishes electrical steel at its Butler Works facility in Butler, Pennsylvania (which employs about 1,300 employees; this plant also processes other rolled steel products including Non-Grain Oriented Electrical Steel) and finishes electrical steel at its Zanesville Works plant in Zanesville, Ohio (which employs about 100 employees). However, electrical steel represents only a small percentage

of AK Steel's business, accounting for [TEXT REDACTED] of revenues (the automotive industry is AK Steel's primary customer). AK Steel was acquired by Cleveland Cliffs Inc., the nation's largest producer of iron ore pellets, in March 2020.<sup>54</sup>

While still a leader in the domestic market, AK Steel's electrical steel operations are in poor financial condition, in part due to years of pressure from lower-cost foreign imports. In his testimony before the Congressional Steel Caucus in March 2020, Lourenco Goncalves, the President & CEO of Cleveland Cliffs, warned that the company would be

forced to close the Butler and Zanesville facilities, both of which are unprofitable, unless the U.S. Government were to take action to limit imports of GOES in the form of transformer laminations and cores.<sup>55</sup> If AK Steel's GOES operations were to close, the United States would lack the ability to produce transformers of any power handling capacity without relying on foreign sources for the key material that is essential to their operation and efficiency.

The charts below present the current status of AK Steel specific to several important industry measures.

[TEXT REDACTED]		
[TEXT REDACTED]. <sup>56</sup>	[TEXT REDACTED] <sup>57</sup>	[TEXT REDACTED]
[TEXT REDACTED]		
[TEXT REDACTED]. <sup>58</sup>		
[TEXT REDACTED]		
[TEXT REDACTED]		

[TEXT REDACTED].<sup>59</sup> <sup>60</sup> [TEXT REDACTED] <sup>61</sup> [TEXT REDACTED].<sup>62</sup> [TEXT REDACTED].

[TEXT REDACTED]. As a result of its inadequate investment, AK Steel says it will not be able to innovate in order to keep pace with the latest production technology or be able to meet increasingly stringent DOE efficiency standards. AK Steel states (and transformer companies validate) that the company can make high-permeability GOES products that have very low losses and are highly efficient. However, if the DOE increases its efficiency

standards to require more high-permeability GOES, AK Steel would likely need to invest in more capacity to meet U.S. demand. Under current market conditions and pricing, AK Steel claims it cannot justify investments to achieve such additional capacity.<sup>63</sup>

[TEXT REDACTED]
[TEXT REDACTED]

#### 1. U.S. GOES Production, Consumption and Import Penetration

[TEXT REDACTED].

[TEXT REDACTED]

The United States imported about 27,000 metric tons of GOES in 2019, for which Japan and Korea were the main sources. Imports of GOES in 2019 were dramatically lower than in 2018 (down 56 percent), a result of 25 percent tariffs imposed on imported GOES from most locations (Steel 232 tariffs). However, the steel tariffs did not achieve the intended result of increased production and consumption of domestic GOES.

**BILLING CODE 3510-33-P**

<sup>52</sup> <https://www.aksteel.com/our-products/electrical-steel/grain-oriented-electrical-steels>.

<sup>53</sup> [TEXT REDACTED].

<sup>54</sup> <http://www.clevelandcliffs.com/English/news-center/news-releases/news-releases-details/2020/Cleveland-Cliffs-Completes-Acquisition-of-AK-Steel/default.aspx>.

<sup>55</sup> <http://www.butlereagle.com/article/20200306/NEWS12/200309971>.

<sup>56</sup> [TEXT REDACTED].

<sup>57</sup> [TEXT REDACTED].

<sup>58</sup> [TEXT REDACTED].

<sup>59</sup> U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation on

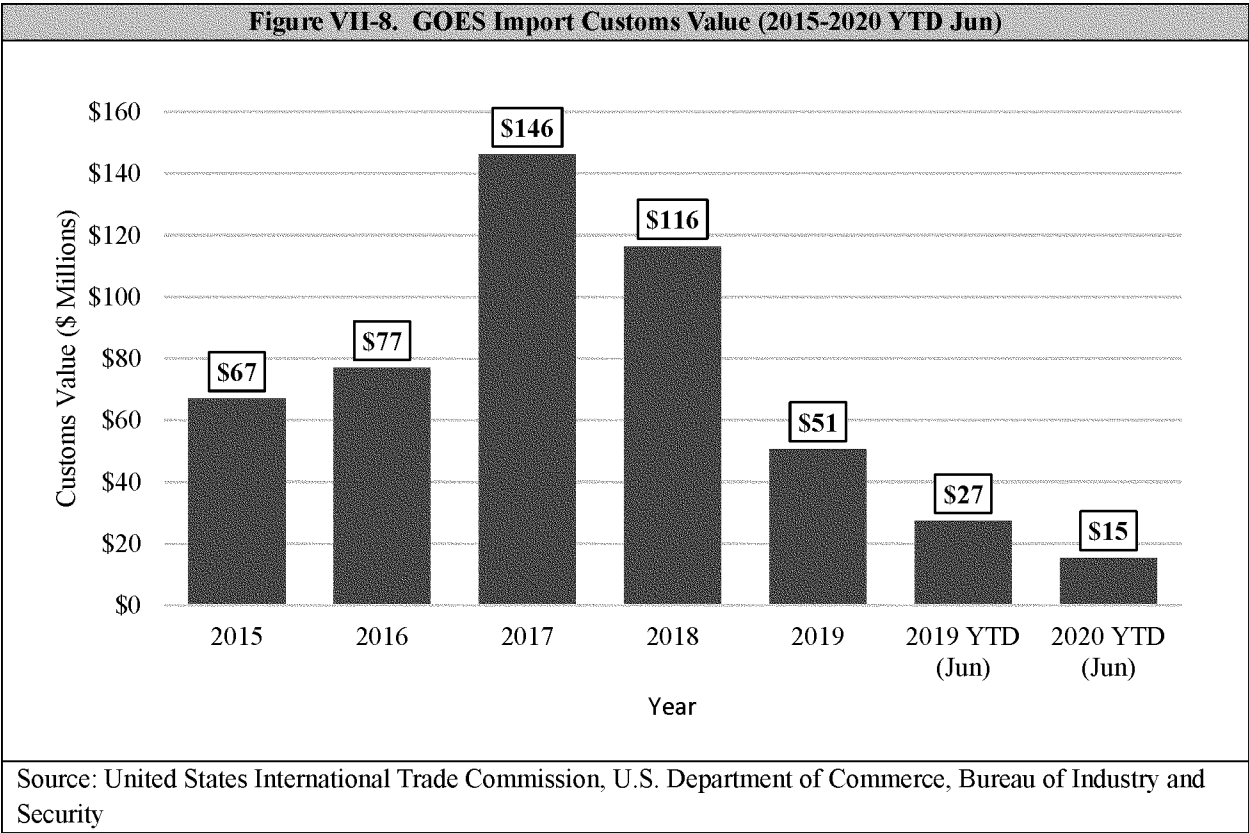
Impact on National Security of Imports of Steel, 2017.

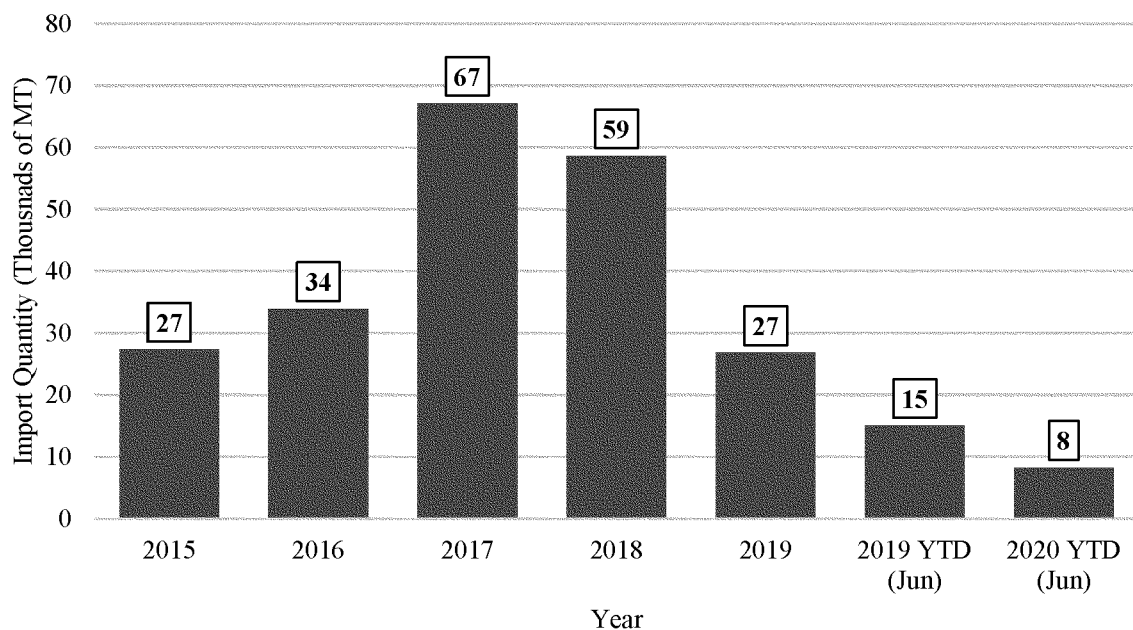
<sup>60</sup> [TEXT REDACTED].

<sup>61</sup> Ibid.

<sup>62</sup> Ibid.

<sup>63</sup> AK Steel Public Comments.



**Figure VII-9. GOES Import Customs Quantity (2015-2020 YTD Jun)**

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

**Figure VII-10. GOES Import Quantities by Top 10 Countries (MT, 2015-2020 YTD Jun)**

Country	2015	2016	2017	2018	2019	2019 YTD (Jun)	2020 YTD (Jun)	Total* 2015-2019
Japan	9,705	10,397	25,543	17,251	6,581	4,506	1,711	71,188
South Korea	4,122	5,270	18,868	22,794	11,915	4,770	4,402	67,372
China	455	3,262	9,061	4,608	1,045	571	493	18,924
Russia	3,777	5,701	4,132	2,475	639	397	822	17,546
Czech Republic	2,760	3,704	4,299	916	374	374	13	12,065
United Kingdom	1,990	2,128	2,262	2,835	79	57	35	9,329
Brazil	1,539	2,575	1,120	1,416	2,170	1,113	424	9,245
Thailand	-	-	-	4,110	2,738	2,543	-	6,848
Poland	140	184	1,016	1,652	920	641	240	4,151
Canada	1,006	186	62	338	30	23	60	1,682

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

\*Excludes 2019 YTD (Jun) Data

**Figure VII-11. GOES Import Penetration by Weight**

Year	2015	2016	2017	2018	2019
[TEXT REDACTED]					
Imports For Consumption	27,311,498	33,893,810	67,082,534	58,572,133	26,764,624
Domestic Exports	96,669,121	57,014,300	42,772,205	41,523,736	34,786,151
[TEXT REDACTED]					
Import Penetration	21%	22%	37%	31%	18%
[TEXT REDACTED]					

**Figure VII-12. GOES Import Penetration by Value**

Year	2015	2016	2017	2018	2019
[TEXT REDACTED]					
Imports For Consumption	\$66,915,489	\$76,976,977	\$146,193,243	\$116,343,595	\$50,658,381
Domestic Exports	\$230,523,114	\$138,029,576	\$90,527,328	\$87,625,426	\$69,715,767
[TEXT REDACTED]					
Import Penetration	19%	20%	31%	24%	13%
(Table excludes domestic production for 2015/2016 by Allegheny Ludlum)					

Thus, based on production and trade data for GOES (presented in Table VII-11), imports accounted for less than 20 percent of domestic consumption (on a tonnage basis) in 2019. This is down from a high of 37 percent in 2017, prior to imposition of the steel tariffs. On a value basis, penetration is even lower, at 13 percent. These simple calculations do not present an accurate picture of the dependence of the domestic transformer industry on imported GOES, however, as will be discussed in the section analyzing suppliers to U.S. transformer manufacturers provided in the BIS industry survey.

## 2. Analysis of BIS Survey Supplier Data: GOES

The Department's industry survey provided additional data and insight on domestic consumption of GOES. Thirty-nine survey respondents reported that they directly sourced GOES and provided details on their suppliers and purchases. The aggregated amount of GOES that they procured on an annual basis was relatively stable between 2015 and 2019, [TEXT REDACTED]. This figure is roughly consistent with estimates for domestic GOES demand. Moreover, the total amount supplied by AK Steel as reported by survey respondents is consistent with that company's GOES production data. This data indicates that the Department's survey accurately captured most of the market.

The survey respondents reported obtaining GOES from a wide variety of global suppliers. Purchases were made from suppliers in Japan, China, Mexico, Germany, Russia, Canada, France, Brazil, Poland, and South Korea, as well as the United States. In addition to the steel mills that produce GOES sheets in coils, some respondents included in their responses information on purchases from suppliers that provide GOES in slightly more processed forms. These suppliers typically start their production with electrical steel sourced from a steel mill producing electrical steel and perform additional processing such as cutting, slitting, stamping, and/or coating. In this regard, the line between GOES and transformer laminations is seemingly quite indistinct, as other survey recipients recorded purchases from these same suppliers under the "laminations" category.

[TEXT REDACTED]

Four GOES suppliers accounted for 93 percent of purchases by the survey population in 2019. [TEXT REDACTED]. The remainder of the market shifted considerably among other players, with the most significant development the exit of ATI (Allegheny Ludlum) from the market in 2016. [TEXT REDACTED].

[TEXT REDACTED]

[TEXT REDACTED].  
[TEXT REDACTED].  
[TEXT REDACTED].  
[TEXT REDACTED].

## 3. Sufficient Quantity and Quality of Domestic GOES

A number of transformer companies have indicated, through their public comments, through the Section 232 steel tariff exclusion process, and through survey responses, that the sole domestic source of GOES (AK Steel) lacks the capacity to meet the domestic demand for the full range of GOES products. U.S. consumption of GOES is estimated at approximately 220,000 metric tons per year, [TEXT REDACTED].<sup>64</sup> However, AK Steel's stated capacity does not take into consideration the production of variable grades of GOES. For example, much of the company's production is of conventional grades of GOES (M class); its production capacity for higher grades is limited.

In its public comments, the Core Coalition noted that although AK Steel is widely recognized in the industry as a supplier of high-quality GOES. However, it is a high-cost supplier compared to foreign sources, which the Core Coalition attributes to the company's lack of capital investment and its continued use of obsolete production equipment and processes. AK Steel notes that the Department's

<sup>64</sup> Core Coalition Public Comments.

antidumping investigations have found that foreign GOES manufacturers sell at unfair prices (dumping) or are subsidized by their governments. The European Union has found AK Steel practices dumping.

In addition, AK Steel does not manufacture or offer an intermediate grade of GOES, called MOH, which is widely available from suppliers in South Korea, Japan, and China. While AK offers a higher grade GOES that can be used instead of MOH, it is more expensive and is not optimal for use in certain standard-issue transformers where GOES price weighs more heavily than energy efficiency in sourcing decisions.

Another concern expressed by domestic transformer manufacturers is the maximum width of AK's Steel's product. The company does not produce

steel wide enough (>932mm) to form the laminations and cores of larger transformers. According to the technical specifications on AK Steel's website, the maximum width of its domain-refined products (TRAN-COR) is 920mm.<sup>65</sup> While two pieces of steel can be patched together, this process leads to increased production costs and loss of efficiencies in the core.<sup>66</sup>

Many transformer companies submitting public comments during the investigation indicated that AK Steel's lack of capital investment over many years has affected the company's ability to supply the highest grades of steel grades that steel transformer

<sup>65</sup> [https://www.aksteel.eu/files/downloads/TRAN-COR\\_H\\_%20Grain\\_Oriented\\_Electrical\\_Steel.pdf](https://www.aksteel.eu/files/downloads/TRAN-COR_H_%20Grain_Oriented_Electrical_Steel.pdf).

<sup>66</sup> Public comments of Domestic Transformer Producers.

manufacturers prefer to use in the cores of distribution transformers subject to DOE energy standards. In addition, in general, utility companies are increasingly seeking to install transformers with high efficiency/lower losses (that tend to require higher grades of GOES) that reduce costs and are environmentally friendly. For example, European and Asian manufacturers offer a high permeability GOES called HI-B (originally developed by Nippon Steel of Japan but licensed the technology to other companies).<sup>67</sup>

A summarized list of concerns with AK Steel's capabilities and capacity expressed through the public comments process is provided in the table below.

<sup>67</sup> Public comments of Domestic Transformer Producers.

**Figure VII-15. Analysis of Negative Comments Aimed Toward AK Steel**

Public Commenter	Nature of Comment
Central Moloney Inc.	<ul style="list-style-type: none"> <li>• Passing the proposal will create a monopoly for AK Steel, allowing them to control price and determine who is successful in the transformer industry</li> <li>• AK Steel does not have capacity to keep up with the demand, Central Moloney has been put on allocation several times due to capacity issues</li> <li>• AK does not have the ability to make the same quality of steel (Permanent Domain Refined core steel) which meets current efficiency levels set by the Department of Energy</li> </ul>
Southwest Electric Company	<ul style="list-style-type: none"> <li>• There is only one domestic provider and they have not invested and adapted enough to stay competitive with global players</li> <li>• Additionally they would not be able to provide the volumes in specific quality/performance graded needed to support the U.S. market alone</li> </ul>
WEG Transformers USA	<ul style="list-style-type: none"> <li>• Foreign competition is not a significant issue related to GOES</li> <li>• AK Steel already has a 70% market share of the current industry and they are not able to support significant growth and changes to the electrical grid that renewable energy is driving</li> </ul>
Tempel Steel Co	<ul style="list-style-type: none"> <li>• AK Steel's outdated technology and antiquated equipment limits the quantity and quality of grades it offers and inflates the cost structure</li> <li>• A transformer has a life expectancy of 25 years and the average transformer at AK Steel is dated 38 years</li> </ul>
JFE Shoji Steel America Inc.	<ul style="list-style-type: none"> <li>• AK Steel individually does not have the capacity to supply the domestic demand for transformers and transformer parts</li> <li>• AK Steel is not capable today of manufacturing some of the best available and required materials in the world</li> <li>• AK Steel's process capability does not enable them to produce their best published grades in large quantities</li> <li>• All GOES and NOES is not interchangeable. To the extent that AK Steel cannot or will not quickly be able to meet those specifications and obtain certification, those customers will be the most negatively impacted</li> </ul>
U.S. Chamber of Commerce	<ul style="list-style-type: none"> <li>• U.S. production of GOES, including cores and laminations, is insufficient to supply the needs of the entire U.S. transformer manufacturing base</li> <li>• Some specific high-grade silicon electrical steels used in some transformer manufacturers' current designs to meet mandatory U.S. Department of Energy conservation standards for transformers are either not available or are not available in sufficient quantities from domestic producers and therefore must be imported</li> </ul>
ABB Enterprise Software, Inc.	<ul style="list-style-type: none"> <li>• Tariffs on imported transformer components will undermine the industry's ability to supply the U.S. market. Domestic producers are not able to manufacture all of the laminations and cores used in their transformers or secure those components from U.S. sources</li> </ul>
Cogent Power Inc.	<ul style="list-style-type: none"> <li>• AK Steel is also not capable today of manufacturing some of the best available and required materials in the world</li> <li>• Not only will there be restrictions on total capacity output from AK Steel to the US market, there will be restrictions on the best available grades</li> </ul>



Hyosung Heavy Industries Corporation	<ul style="list-style-type: none"> <li>• Currently, there is limited availability of domestically-produced GOES from the single U.S. supplier, AK Steel</li> <li>• Forcing entire U.S. transformer industry to rely on a single U.S. GOES supplier with limited capacity raises serious concerns. Indeed, U.S. transformer manufacturers continue to submit product exclusion requests for GOES under the existing Section 232 measures on steel imports, citing a persistent lack of domestic availability</li> </ul>
Eaton Corporation	<ul style="list-style-type: none"> <li>• The domestic manufacturer of GOES still does not meet the specifications needed to manufacture our specific transformers in the United States</li> </ul>
National Foreign Trade Council	<ul style="list-style-type: none"> <li>• Foreign-produced electrical steel is imported precisely because U.S. electrical steel manufacturing capacity is insufficient to meet domestic demand. The one GOES producer in the United States cannot meet all of the domestic demand and will not be able to do so for the foreseeable future</li> </ul>
Domestic Transformer Manufacturers	<ul style="list-style-type: none"> <li>• These are high-value materials that cannot be replicated by the domestic steel industry (Delta Star, Inc.; SPX Transformer Solutions, Inc.; Pennsylvania Transformer Technology; and Niagara Transformer Corp)</li> </ul>
The Core Coalition	<ul style="list-style-type: none"> <li>• AK Steel, the only current producer of GOES in North America, prices GOES well above all other global competitors—the current 25 percent tariffs still do not make AK price competitive</li> <li>• This gap in prices has persisted for years before tariff protection for all steel products under Section 232</li> <li>• The main reason for high AK prices is an aberrational cost structure, higher than global competition. This disparity stems from AK's failure to modernize its production methods to keep pace with global competition</li> <li>• The US does not have the production capacity to support total production requirements for inputs for production of Power transformers</li> </ul>
Source: Public Comments Submitted to <i>Federal Register</i>	

[TEXT REDACTED].<sup>68</sup>

A number of transformer manufacturers indicated that the sole domestic source of GOES does not offer the full range of efficient GOES, with the result that the manufacturers must seek foreign suppliers. For example, transformer manufacturers indicated that they are unable to obtain permanent, heat resistant domain-refined grain oriented steel (PDR GOES) from the sole domestic manufacturer.<sup>69</sup> DOE energy efficiency standards for distribution transformers that came into effect in 2016 have reduced demand for

lower-permeability, conventional grades of GOES, and increased the demand for high grades, such as PDR-GOES. PDR-GOES is capable of being annealed after core production while retaining its domain-refined properties, which is important for use in wound cores often used in distribution transformers.<sup>70</sup> Nippon Steel of Japan is recognized as the primary source of this product.

[TEXT REDACTED]. However, while there is some degree of interchangeability among different grades of GOES in transformer core construction, doing so could result in higher core losses/decreased efficiencies and/or require a larger size transformer. As a result, using non-permanent DR-GOES in lieu of PDR-GOES could affect the competitive position of the transformer manufacturer when bidding for contracts.<sup>71</sup>

This apparent deficiency in U.S. production capabilities for GOES with

superior magnetic qualities helps explain continued imports of GOES (especially from Japan) despite the additional cost due imposition of tariffs. In fact, the Department has granted some requests for exclusion from the 25 percent tariffs on imported steel due to lack of domestic capability of the particular product grade. Additionally, some imports of GOES from South Korea and Brazil continue to be economical because the Section 232 remedy resulted in a quota, rather than tariffs for steel from those countries.

While just a rough estimate, the average unit value by country (based on value imports divided by unit imports) is broadly illustrative of the varying grades of GOES from different suppliers. Other than the United Kingdom, which is not a major source of GOES imports, GOES imported from Japan has an average unit value significantly higher than from other sources. This suggests that Japan is the source of the highest grades GOES imported into the United States.

<sup>68</sup> Joe Paladino Technical Advisor, DOE Office of Electricity, in written comments to BIS submitted on 9/21/202.

<sup>69</sup> For example, in its public comments, Central Moloney, a domestic manufacturer of distribution transformers, expressed concern over the quality of AK Steel's GOES. They said that the company's manufacturing equipment and processes are antiquated, and it lacks the capability to produce electrical steel that it prefers to use to meet DOE efficiency standards for distribution transformers—namely Permanent Domain-Refined GOES (PDR). In addition, tariff exclusion requests from Sumitomo, ABB, Eaton/Cooper, and SPX cited lack of domestic capabilities.

<sup>70</sup> <https://Agmetalmiller.com/tag/grain-oriented-electrical-steel/>.

<sup>71</sup> See, e.g., SPX Exclusion Request.

Figure VII-16. GOES Customs Value Imports AUV by Top 10 Countries (\$/Kg, 2015-2020 YTD Jun)								
Country	2015	2016	2017	2018	2019	2019 YTD (Jun)	2020 YTD (Jun)	Average* 2015- 2019
United Kingdom	\$2.64	\$2.64	\$2.88	\$2.28	\$2.68	\$2.83	\$2.41	\$2.59
Japan	\$2.66	\$2.61	\$2.58	\$2.42	\$2.12	\$2.05	\$2.10	\$2.41
Canada	\$2.48	\$2.64	\$2.62	\$2.26	\$2.22	\$0.34	\$1.50	\$2.29
Russia	\$2.52	\$2.31	\$2.75	\$2.04	\$2.19	\$2.04	\$1.60	\$2.24
South Korea	\$2.16	\$2.21	\$1.80	\$1.90	\$1.97	\$1.64	\$1.89	\$1.99
Poland	\$2.25	\$1.99	\$2.00	\$1.90	\$1.73	\$1.90	\$1.67	\$1.92
China	\$2.23	\$1.93	\$1.73	\$1.67	\$2.15	\$2.25	\$1.58	\$1.88
Czech Republic	\$2.17	\$1.82	\$1.66	\$1.71	\$1.62	\$0.67	\$1.77	\$1.79
Brazil	\$1.92	\$1.79	\$1.51	\$1.73	\$1.83	\$1.94	\$1.61	\$1.73
Thailand	-	-	-	\$0.93	\$0.91	\$0.72	-	\$0.92
Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security								
*Weighted Average by Quantity. Excludes 2019 YTD (Jun) Data								

## BILLING CODE 3510-33-C

*C. Laminations and Cores*

Transformer lamination and core producers make up the primary customer base for GOES suppliers. There are very few companies in the United States that manufacture only transformer laminations and cores; some major transformer companies produce laminations and cores for in-house use in their transformers. Manufacture of these critical transformer components requires expensive, specialized equipment which can only produce laminations within a specific size range. This limits the ability of independent companies to offer laminations in the varied sizes required across transformer product categories. Over the past few years, there has been a marked decline in domestic manufacturing of laminations and cores (by both transformer companies and independent producers), and a movement of production offshore (especially to Canada and Mexico). A corollary to the movement of lamination and core manufacture out of the United States is the loss of a potential domestic market for AK Steel's GOES.

Because electrical steel accounts for such a large percentage of the cost of transformer laminations and cores (averaging about 60 percent for the surveyed companies), the 25 percent import tariff raised material costs and decreased transformer manufacturers' ability to compete. The CEO of one of the remaining domestic producers of these items, Orchid Monroe LLC

(Wisconsin), stated that imported laminations and cores often cost less than the price at which its company can procure domestic electrical steel, without any processing or manufacturing costs included.<sup>72</sup>

Global transformer companies with multiple facilities have adapted to changes in raw material prices by shifting their lamination and/or core production or sourcing offshore in order to continue to utilize foreign-origin GOES without the price premium for domestically produced GOES. Smaller companies that specialize in these products either moved their operations offshore or ceased production.

The trend toward moving lamination production offshore occurred prior to the Section 232 steel tariffs, but the situation worsened after their imposition. The expansion of core-making capacity in Canada and Mexico began in the mid-2010s, at which time the United States had initiated antidumping investigations on GOES from many foreign sources. In the antidumping investigations conducted by the Department, many foreign suppliers of GOES were found to be selling at less than fair value, or in the case of China, with the benefit of government subsidies. However, the International Trade Commission did not find material injury to U.S. industry was not found, no duties were imposed.<sup>73</sup>

<sup>72</sup> Public Comments from Gordon Bibby, Orchid Monroe LLC.

<sup>73</sup> See *Grain-Oriented Electrical Steel from Germany, Japan, and Poland*, Inv. Nos. 731-TA-

Despite this, partly to avoid potential duties, transformer and transformer component manufacturers began to shift production offshore where they are able to use foreign origin GOES without the risk of increasing costs due to the imposition of duties.

Another factor in the movement of core and lamination toward offshore outsourcing was the new DOE energy efficiency standards for distribution transformers that were implemented in 2016. To meet these standards, transformer companies had to redesign their products, including the choice of electrical steel and core construction. [TEXT REDACTED].<sup>74</sup> [TEXT REDACTED].<sup>75</sup>

As a result, there are very few remaining domestic producers of laminations and cores. The Department's survey included responses from 10 small businesses in the United States that reported production of laminations, stacked core, and/or wound cores using GOES. The table below presents the state of transformer lamination and core manufacturing in the United States by these non-captive producers.

[TEXT REDACTED]

[TEXT REDACTED]. Moreover, analysis of these companies' financial reports reveals additional weaknesses.

1233, 1234, and 1236, USITC Pub. 4491 (Sep. 2014), at 2.

<sup>74</sup> [TEXT REDACTED].

<sup>75</sup> [TEXT REDACTED].

Respondents were assigned a comprehensive financial risk score by the Department, which incorporated yearly scores and trends in financial health. Based on this scorecard, respondents were categorized as low/neutral risk, moderate/elevated risk, or high/severe risk.<sup>76</sup>

[TEXT REDACTED]

All of the companies noted in their survey responses that they face serious negative impacts from foreign competition. Three of the 10 have shut down their domestic operations in recent years [TEXT REDACTED]. A fifth company has reduced its capacity in an attempt to return to profitability. The five companies remaining have had to increasingly rely on niche markets, including aerospace and defense, to counter the loss of demand from other customers (which have either shifted sourcing or are themselves impacted by foreign competition).

Among the domestic laminations and core manufacturers that have been negatively affected is [TEXT REDACTED].

[TEXT REDACTED].

[TEXT REDACTED].

As mentioned above, in addition to these specialized manufacturers, several transformer companies produce laminations and/or cores in the United States for their own internal consumption. [TEXT REDACTED]. These captive producers, too, have changed production and sources for laminations and cores, either completely or partially outsourcing. [TEXT REDACTED].

[TEXT REDACTED]. The new company (80 percent owned by Hitachi and 20 percent by ABB) is called Hitachi ABB Power Grids.<sup>77</sup> Although Hitachi's long-term plans for the facility are unknown, the sale may impact domestic production of laminations and cores.

### 1. Lamination Suppliers

The lack of domestic production capability is validated by the lamination

and core supplier data provided by survey recipients. Twenty-two survey participants reported sourcing *stacked laminations for use in transformer cores*. They sourced laminations from suppliers in a variety of countries, including the United States, South Korea, Mexico, Canada, Turkey, Italy, and India.

In 2019, laminations with a total value of \$40.2 million were sourced by surveyed companies.<sup>78</sup> Of this \$40.2 million, less than 12 percent came from domestic suppliers, while 88 percent were from foreign sources. [TEXT REDACTED].

[TEXT REDACTED]

[TEXT REDACTED].<sup>79</sup> [TEXT REDACTED]. In addition to these two companies, survey respondents reported several other suppliers from Mexico along with minor suppliers located in South Korea, Italy, Turkey, India, and China.

It is clear from respondents' replies to the supplier question that there is an ambiguity between what is considered GOES and what is considered a lamination; data from the survey show that 60 percent of the value of laminations is accounted for by the cost of GOES. Among the suppliers listed, as noted earlier, there is overlap between the two categories. [TEXT REDACTED].

### 2. Stacked Core Suppliers

Outside of captive production by several transformer manufacturers, 16 transformer companies participating in the Department's survey procured a total of \$114.7 million worth of *stacked cores* in 2019. Their suppliers were located in Canada, Mexico, Italy, and China, as well as the United States. Of the \$114.7 million total, [TEXT REDACTED]. The other leading core suppliers were [TEXT REDACTED]. As with the lamination sector, this would

mean that foreign fabricated cores could account for over 80 percent of the future market.

[TEXT REDACTED]

As noted above, Cogent Power was recently purchased by JFE Shoji. This Japanese steel trading company also acquired an unspecified interest in another leading source of stacked cores, [TEXT REDACTED].

[TEXT REDACTED], several Chinese companies were minor suppliers of stacked cores.

### 3. Wound Core Suppliers

Twenty-nine respondents to the Department's survey indicated that they procured *wound cores* for use in manufacturing transformers during the 2015–2019 period. The total value of the wound cores that these companies purchased increased markedly in the last three years of the time period, from \$132 million in 2017 to \$410 million in 2019. The increase may be because wound cores are often used in distribution transformers that are subject to the DOE energy efficiency standards. PDR–GOES, which is not produced in the United States, is desirable for use in wound cores because it is capable of withstanding the annealing process.

By far the leading source of wound cores for the survey sample was [TEXT REDACTED].

[TEXT REDACTED] mentioned that make up the other 25 percent of consumption are domestic companies that have shut down their U.S. facilities since 2019.

### 4. U.S. Imports of Laminations and Cores

U.S. import statistics affirm the Department's survey data with regard to the dominant role that foreign sources play in the United States domestic transformer market. The dramatic increase in imports of these products, particularly from Canada has resulted in the displacement of U.S. production of transformer components.

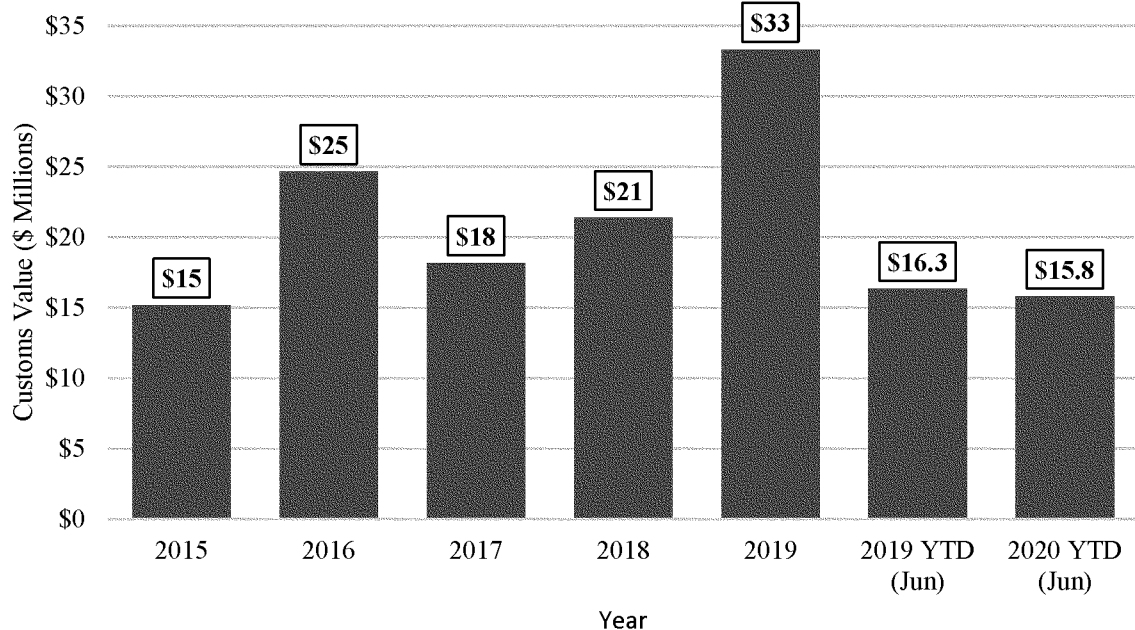
BILLING CODE 3510-33-P

<sup>76</sup> For how BIS assessed financial health, see note [45], *infra*.

<sup>77</sup> [http://www.hitachi.com/New/cnews/month/2020/07/f\\_200701.pdf](http://www.hitachi.com/New/cnews/month/2020/07/f_200701.pdf).

<sup>78</sup> This figure exceeds the value of imports of laminations (HTS 8504.90.9634) according U.S. Census trade statistics, which was \$33 million in 2019; purchases in an annual period and export shipments in an annual period do not necessarily match.

<sup>79</sup> <https://magneticmag.com/jfe-gains-foothold-in-na-with-acquisition-of-cogent-power-from-tata-steel/>.

**Figure VII-21. Lamination Import Customs Value (2015-2020 YTD Jun)**

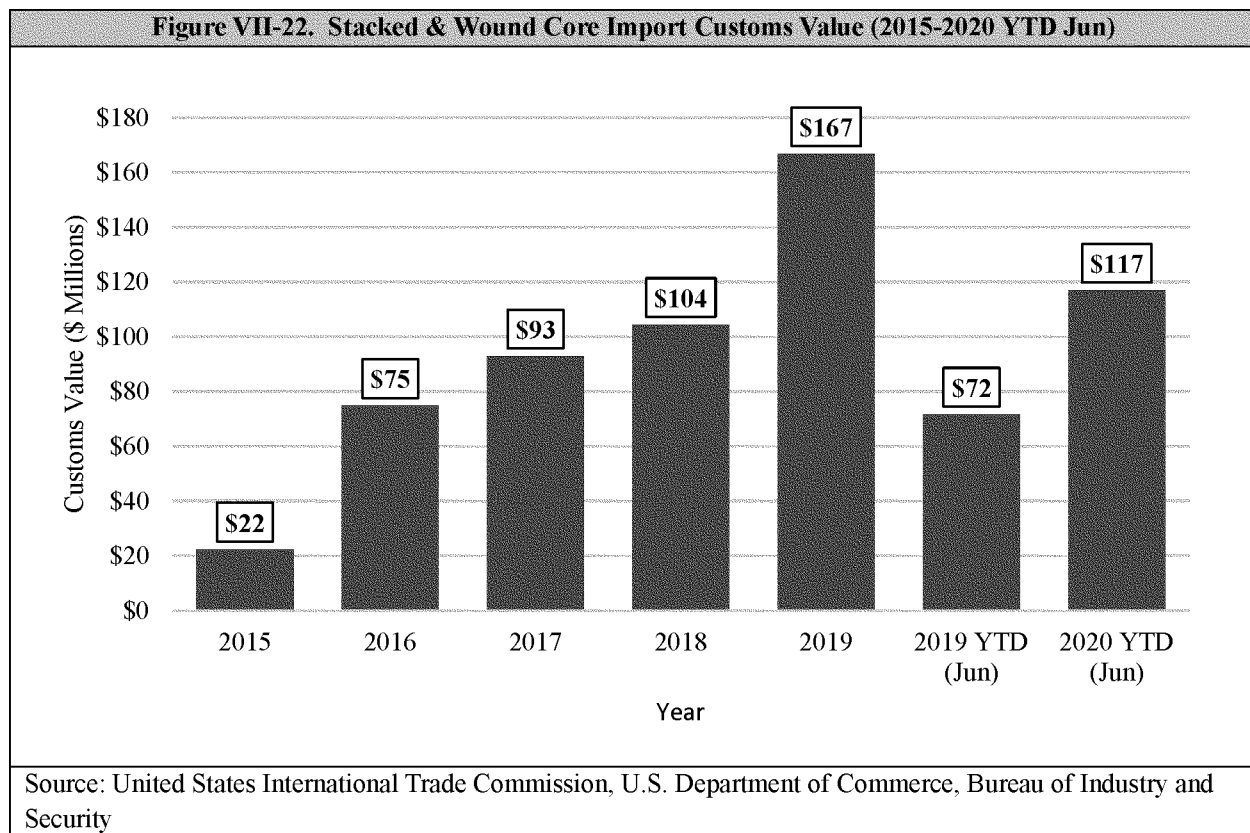
Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

**Figure VII-21. Lamination Import Customs Value by Top 10 Countries  
(\$ Millions, 2015-2020 YTD Jun)**

Country	2015	2016	2017	2018	2019	2019 YTD (Jun)	2020 YTD (Jun)	SUM*
Canada	\$0.16	\$8.04	\$8.92	\$15.36	\$22.61	\$11.32	\$10.29	\$65.39
Mexico	\$13.87	\$15.21	\$8.10	\$5.61	\$9.55	\$4.69	\$5.02	\$57.36
Italy	\$0.31	\$0.56	\$0.08	-	\$0.84	\$0.20	\$0.32	\$2.11
South Korea	\$0.73	\$0.70	\$0.29	\$0.17	\$0.13	\$0.03	\$0.02	\$2.05
Germany	\$0.00	\$0.02	\$0.29	\$0.05	\$0.11	\$0.06	\$0.05	\$0.53
China	\$0.03	\$0.03	\$0.11	\$0.14	\$0.04	\$0.01	\$0.04	\$0.39
Japan	-	\$0.01	\$0.16	-	-	-	-	\$0.17
Czech Republic	-	-	\$0.08	-	-	-	-	\$0.08
Taiwan	\$0.01	\$0.02	\$0.05	-	-	-	-	\$0.07
Philippines	-	-	\$0.01	-	-	-	\$0.04	\$0.04

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

\*Excludes 2019 YTD (Jun) Data



**Figure VII-23. Stacked & Wound Core Import Customs Value by Top 10 Countries (\$ Millions, 2015-2020 YTD Jun)**

Country	2015	2016	2017	2018	2019	2019 YTD (Jun)	2020 YTD (Jun)	SUM*
Canada	\$1.20	\$54.41	\$69.71	\$70.84	\$86.65	\$42.49	\$58.30	\$341.1
Mexico	\$17.79	\$17.34	\$17.00	\$28.48	\$74.60	\$26.67	\$55.76	\$211.0
China	\$1.65	\$1.55	\$1.85	\$0.78	\$0.46	\$0.27	\$0.32	\$6.61
Bulgaria	\$0.00	\$0.01	\$0.11	\$1.45	\$1.85	\$0.89	\$0.76	\$4.18
Japan	\$0.43	\$0.44	\$0.36	\$0.53	\$1.05	\$0.46	\$0.54	\$3.36
South Korea	\$0.00	\$0.01	\$0.89	\$0.71	\$0.00	\$0.00	\$0.68	\$2.29
India	\$0.16	\$0.08	\$0.52	\$0.42	\$0.63	\$0.21	\$0.05	\$1.86
Turkey	\$0.23	\$0.19	\$0.45	\$0.37	\$0.40	\$0.18	\$0.19	\$1.83
Italy	\$0.02	\$0.01	\$0.50	\$0.17	\$0.27	\$0.00	\$0.04	\$1.01
Thailand	\$0.11	\$0.26	\$0.17	\$0.14	\$0.07	\$0.05	\$0.02	\$0.76

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

\*Excludes 2019 YTD (Jun) Data

U.S. imports of transformer laminations rose from \$18 million in 2017 to \$33 million in 2019, with most of the increase due to imports from Canada. For stacked and wound transformer cores, imports rose from \$22 million in 2015 to \$167 million in 2019—a 650 percent increase—with Canada and Mexico accounting for more

than 95 percent of the total imported. Data for the first six months of 2020 indicate that the trend toward increased imports is continuing. As domestic demand for laminations and cores has not increased, this surge in imports represents displaced domestic production.

The United States-Mexico-Canada Agreement (USMCA) establishes a country of origin (COO) rule for transformers and transformer components, including laminations and cores. These rules of origin, which will come into force in five years (2025), will consider transformer laminations and cores as derived from the country in

which the electrical steel from which they are made was produced, based on the high percentage of these products' value that is accounted for by the electrical steel. As Canada and Mexico have no electrical steel production, those cores will not be considered products of either Mexico or Canada when full implementation of USMCA is achieved.<sup>80</sup> However, even when this new requirement for preferential treatment comes into effect, it will likely not discourage the production of these items in Canada or Mexico (using foreign GOES) for export to the United States, because that the general, most-favored-nation U.S. tariff rate on imports of these items is zero.

#### 5. Consumption of GOES Contained in Transformer Cores

Due to the movement offshore of lamination and core production, U.S. imports of these products must also be considered as part of U.S. GOES consumption that is not captured in the trade statistics for GOES. In 2019, the United States imported an estimated 68,000 metric tons of GOES in the form of transformer laminations and cores.<sup>81</sup>

[TEXT REDACTED]. Based on these figures, the import penetration for GOES was approximately 44 percent in 2019. (Note: this number could include double counting from U.S. exports of

GOES that is then imported into the United States in the form of cores, but this is likely minimal because Canada was not a major destination for U.S. GOES exports or a major source of Canadian imports).

A public comment by the Core Coalition estimates that total U.S. core imports, in kilograms, will be much higher in 2020 than in 2019 (due primarily to an anticipated increase in imports of wound cores; trade data from the first half of 2020 validates this). Based on the Coalition's estimate of 2020 core imports of 96,000 metric tons, and assuming steady U.S. GOES production and export and import levels, import penetration is estimated to reach over 50 percent this year.

#### 6. Dominance of Suppliers for Laminations and Cores

As discussed, Canada and Mexico are by far the leading suppliers of components for U.S. transformer manufacturers. [TEXT REDACTED].

[TEXT REDACTED]. Until 2019, Cogent was owned by Tata of India, which also owned Orb Steel, which may explain why Orb was a major supplier to Cogent. Now that Cogent is owned by JFE Shoji, it is likely that JFE Steel will emerge as one of its major suppliers.

[TEXT REDACTED].

#### 7. Consumption of GOES Imported in Finished Transformers

Despite the grim results that the inclusion of the GOES-derivative products discussed above presents, the complete picture with regard to the true dependency of the U.S. electricity grid on foreign sources for GOES,

laminations, and cores remains incomplete until the impact of finished transformers is included. Given that transformers have a high percentage value of GOES, domestic GOES production (and transformer production) is adversely impacted by imports of complete transformers. The vast majority of imported transformers contain cores composed of foreign-origin GOES. In 2019, the United States imported a total \$2.56 billion worth of transformers (of all power handling capacities), representing about 35 percent of the market (per Global Insights/D&B). For LPT (which by nature of their size contain the most GOES by weight), imports accounted for over 80 percent of the domestic market.

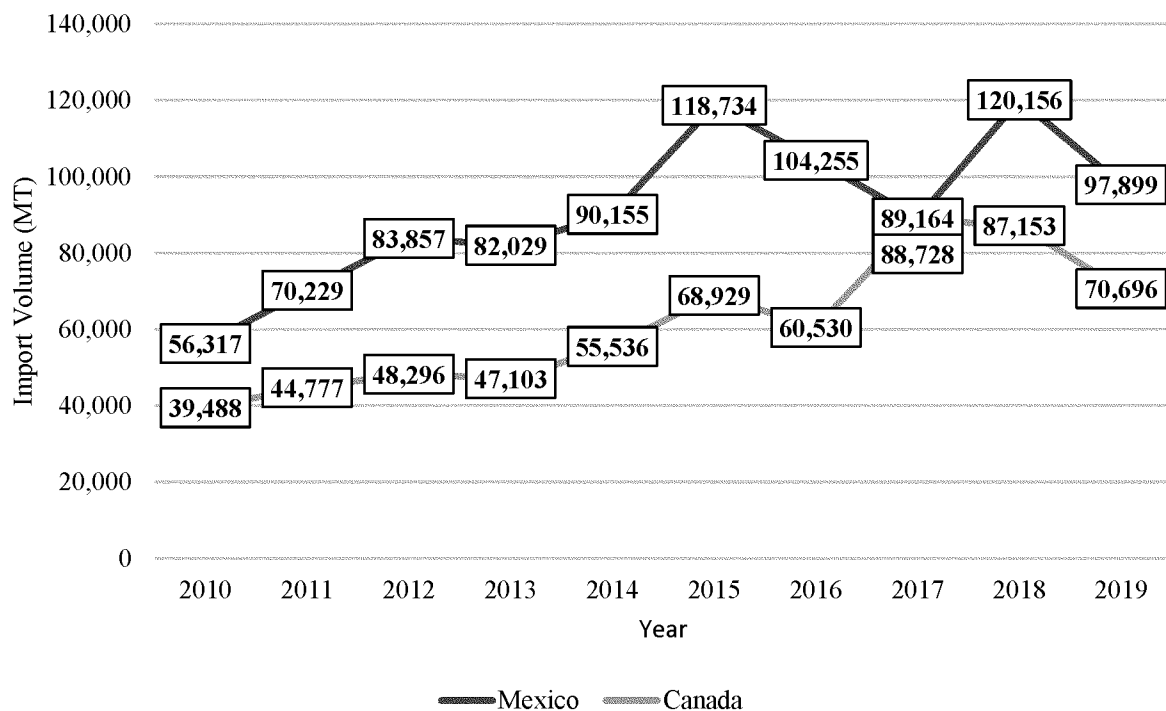
#### 8. Source of GOES for Mexico and Canada

Corresponding to the migration of core and lamination production to Canada and Mexico from the United States was an increase in imports by these countries of GOES. As neither Canada nor Mexico have domestic GOES production capability, both needed to increase their imports of GOES in order to increase core and lamination production. The table below shows total imports of GOES by Canada and Mexico over the past ten years. Both are substantial consumers of GOES. The table shows that imports of GOES has been rising substantially over the ten year period, particularly between 2014 and 2016. For both countries, imports of GOES declined significantly in 2019 from 2018 levels, but are still higher than earlier in the decade.

<sup>80</sup> <https://ustr.gov/sites/default/files/files/agreements/FTA/USMCA/Text/04-Rules-of-Origin.pdf>.

<sup>81</sup> Trade data for cores are not collected by weight, but rather by units. Estimate of the weight of lamination and core imports is based on the estimates provided by the Core Coalition in its public comments.

**Figure VII-24. Canada and Mexico GOES Imports by Weight, 2010-2019**  
Includes HTS Codes 7225.11 and 7226.11



Source: Global Trade Atlas, retrieved on October 1, 2020

The leading sources of GOES imports in Canada in 2019 were Japan and South Korea, but China and Russia were also sources. Note that the United Kingdom was also a major supplier to Canada throughout the period. There was one producer of GOES in the United Kingdom, Orb Steel (owned by Tata of India), which, as previously discussed, shut down production in 2019. One of

Canada's leading transformer lamination and core manufacturers, Cogent Power, was, at the time, also owned by Tata and this might explain why the United Kingdom was such a major supplier. As discussed above, JFE Shoji recently acquired Cogent Power. In the case of Mexico, Japan was the leading supplier in 2019, with China and Russia ranked second and third. Imports of GOES from

the United States declined to virtually zero in Mexico in 2019. In the case of Canada, 2019 imports of GOES from the United States accounted for less than three percent of the total (2,609 metric tons of 97,889 total metric tons), compared to about a third of imports as recently as 2015 (23,210 metric tons out of 68,929 total metric tons).



<b>Figure VII-25. Mexican GOES Import Quantities by Top 10 Countries (MT, 2010-2019)</b>											
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	SUM
<b>Japan</b>	35,538	39,489	54,630	61,440	56,810	67,102	50,827	43,653	45,368	54,151	<b>509,008</b>
<b>China</b>	245	335	1,343	1,634	4,700	10,670	19,640	8,142	25,660	23,625	<b>95,992</b>
<b>Russia</b>	2,536	4,806	6,905	7,225	7,550	11,885	11,688	9,848	15,035	8,227	<b>85,706</b>
<b>Korea South</b>	2,807	6,540	8,000	2,544	5,150	6,858	4,107	4,714	4,101	3,822	<b>48,643</b>
<b>Poland</b>	84	1,663	701	278	3,119	6,567	5,099	10,438	13,781	6,325	<b>48,056</b>
<b>United States</b>	6,248	9,483	5,738	5,380	3,695	4,957	4,317	1,081	1,529	289	<b>42,717</b>
<b>Czech Republic</b>	1,028	1,345	1,531	398	1,540	1,685	1,789	3,979	2,111	---	<b>15,406</b>
<b>Germany</b>	1,110	897	310	199	813	1,818	877	904	2,047	---	<b>8,975</b>
<b>France</b>	780	1,232	923	348	382	---	618	1,027	54	---	<b>5,363</b>
<b>Brazil</b>	61	---	81	20	1,331	298	295	207	1,190	106	<b>3,590</b>
Source: Global Trade Atlas, U.S. Department of Commerce, Bureau of Industry and Security											

Moreover, transformer components produced in Mexico and Canada were largely destined for the U.S. market. Virtually all of Mexico's exports of transformer components were to the United States (>99 percent), as were over 90 percent of Canada's exports of

these items.<sup>82</sup> Mexico, also a significant manufacturing center for transformers, had domestic GOES requirements. However, here again, the United States is the primary destination for Mexico's transformer production so the GOES contained in them is also part of U.S.

GOES consumption. Based on the data and statistics on Mexican and Canadian imports of GOES, some transformers in the United States likely contain GOES originating from China and Russia.

<b>Figure VII-26. 2019 Exports of Transformer Parts Under HTS Code 8504.90 from Mexico and Canada to the U.S.</b>			
Country	Percent of Exports to the U.S./ to the World	Exports to the U.S. (\$ millions)	Exports to the World (\$ millions)
Mexico	99.3%	\$281.4	\$283.5
Canada	91.4%	\$168.0	\$183.9
Source: Global Trade Atlas, retrieved on September 12, 2020			

## 9. Amorphous Metal

While not technically subject to this investigation, amorphous metal (also known as metallic glass or metglas) competes with GOES as a material for transformer cores in certain power handling categories. Demand for amorphous metal cores increased as a result of the 2016 distribution transformer efficiency standards. As is the case with GOES, there is only one domestic source for amorphous metal ribbon—Metglas, Inc., based in Conway, South Carolina, which is a subsidiary of Hitachi Metals of Japan. In 1999, AlliedSignal bought Honeywell and

took on the Honeywell name. In 2003, Hitachi Metals of Japan bought Metglas from Honeywell.

Just as AK Steel (then Armco Steel) invented GOES, Metglas pioneered amorphous metal in the 1970s (when the company was known as AlliedSignal). The first commercial transformer using the product in its core was installed in the United States in 1982; and commercial production of transformer core alloy began in 1989.<sup>83</sup>

While more expensive than GOES on a per kilogram basis, and more labor intensive to form into cores, the material has the potential to reduce costs in the long run for utilities over the life of the

transformer due to lower core losses. The production technology has been widely adopted in developing countries, including China and India. As producing transformers cores using metglas is more labor intensive, it is more economical in countries with low labor costs. There are about 600,000 amorphous metal transformers installed in the United States, compared to over 1 million in China and 1.3 million in India.<sup>84</sup>

Metglas's patent on the production technology has expired; Metglas' competitive strength is its proprietary production process. The company has accused former employees of divulging

<sup>82</sup> Global Trade Atlas.

<sup>83</sup> <https://metglas.com>.

<sup>84</sup> Ibid.

confidential information to Chinese competitors and in 2017 filed a case under Section 337 of the Tariff Act of 1930 (investigations conducted by the International Trade Commission involving patent infringement or intellectual property theft in imported goods) against five Chinese companies. The case was suspended without prejudice. Metglas has lost 50 percent of its employees due its inability to compete with imports from China that have flooded the world market. Metglas alleges that the same avoidance of tariffs that occurred with GOES is happening on amorphous metal; in other words, that imported metal goes to Canada and Mexico, where it is made into cores that are shipped to the United States.

Despite this trend in imported amorphous metal cores (the trade statistics for which are combined with GOES cores), in June 2020, Metglas announced the commercial launch of its own amorphous metal transformer core business. The company now has in-house capability to produce distribution transformer cores using its amorphous alloy.

The use of amorphous metals in future innovations of the electric grid is an area of research interest to the Department of Energy/National Labs. The National Labs have partnered with Metglas to supply the metal ribbon to support this research; loss of domestic capability to imports would leave the U.S. Government dependent on foreign suppliers for this promising research.

### **VIII. U.S. Production Capabilities, Industry Health and Competitiveness, and the Impact of Imports on National Security for Transformers**

#### **A. Introduction/Summary**

As discussed in Chapter V, LPTs are a critical component of the BPS. Distribution transformers and smaller power transformers are used extensively

and play an essential role in the electrical grid of the United States in providing power to commercial and residential customers. In addition to their essential role in the electrical grid, distribution transformers, smaller power transformers, and, in particular, dry-type transformers that can be used indoors play a vital role in other critical infrastructure sectors such as manufacturing, hospitals, and in weapons systems. However, they are not considered to be part of the BPS, the security of which is subject to the Presidential Bulk Power Executive Order.

The Department's survey included 36 companies with domestic manufacturing of transformers of various types and power handling capacities, from 1 kVA to over 100,000 kVA. Table VIII-1 below lists these survey participants, as well as the type(s) of transformers that they manufacture. The survey responses indicate that companies tend to produce either liquid-dielectric transformer or dry-type transformers, although some major producers manufacture both types.

[TEXT REDACTED]

Aggregated data on U.S. production of transformers in various power handling capacities by survey participants are presented in Figure VIII-1. Note that most companies produce transformers in multiple categories. In all, the transformer companies participating in the Department's survey employed 15,238 production workers in the United States and had total transformer sales of \$4.42 billion in 2019.

Over the five-year period covered by the survey, domestic production in each transformer product category was been relatively steady. Survey data indicated that the smaller the transformer in terms

of power handling capacity, the greater the volume of production, with over one million liquid dielectric transformers with under 650 kVA capacity produced in 2019, compared to just 137 of the largest power transformers (>100,000 kVA).

[TEXT REDACTED]

Figure VIII-3 (below) illustrates the import penetration of a range of transformers of various power handling capacities, using the calculation (apparent consumption = domestic production + imports – exports). These import penetration figures are based on unit production of transformers as reported by respondents to the Department's survey, as well as export and import statistics from the U.S. Census Bureau. Note that actual domestic production is likely higher than listed because the Department's survey did not capture all producers (while the major players in each sector participated in the survey, it is possible that smaller manufacturers did not). This implies that the import penetration levels in the table are overstated, further verifying the conclusion that, with the exception of the largest transformers, import penetration in liquid dielectric transformer categories remains relatively low and domestic production is robust.

In comparison, dry-type transformers have higher levels of imports. However, particularly for the small dry transformer category (under <16 kVA), the Department's survey may represent an incomplete sample of the industry. Millions of these small transformers are produced (and imported) on an annual basis. Due to the lack of sufficient data on U.S. production of dry transformers, a reasonable estimate of import penetration is not possible.

Figure VIII-3. Transformer Production, Imports, and Exports by Handling Capacity				
Category (HTS code)	U.S. Production (units)	U.S. Imports	U.S. Exports	Import Penetration
Liquid <650 kVA (8504.21)	1,035,055	210,999	33,871	17%
Liquid 650-10,000 kVA (8504.22)	23,298	8,240	3,029	29%
Liquid 10,000-100,000 kVA (8504.23.0040)	1,640	594	99	28%
Liquid >100,000 kVA (8504.23.0080)	137	617	5	82%
Source: BIS Survey (Production); USITC Dataweb (Exports and Imports)				

The remainder of this section presents industry data and evaluates the status of the domestic industry, as well as the impact of imports, by grouping the transformer industry in general categories: Distribution transformers and small power transformers (liquid dielectric transformers with a power handling capacity up to 10,000 kVA); small and medium power transformers (with power handling capacity of 10,000–100,000 kVA); LPT (100,000 kVA and up); dry-type and other transformers (1 kVA–500 kVA); and voltage regulators.

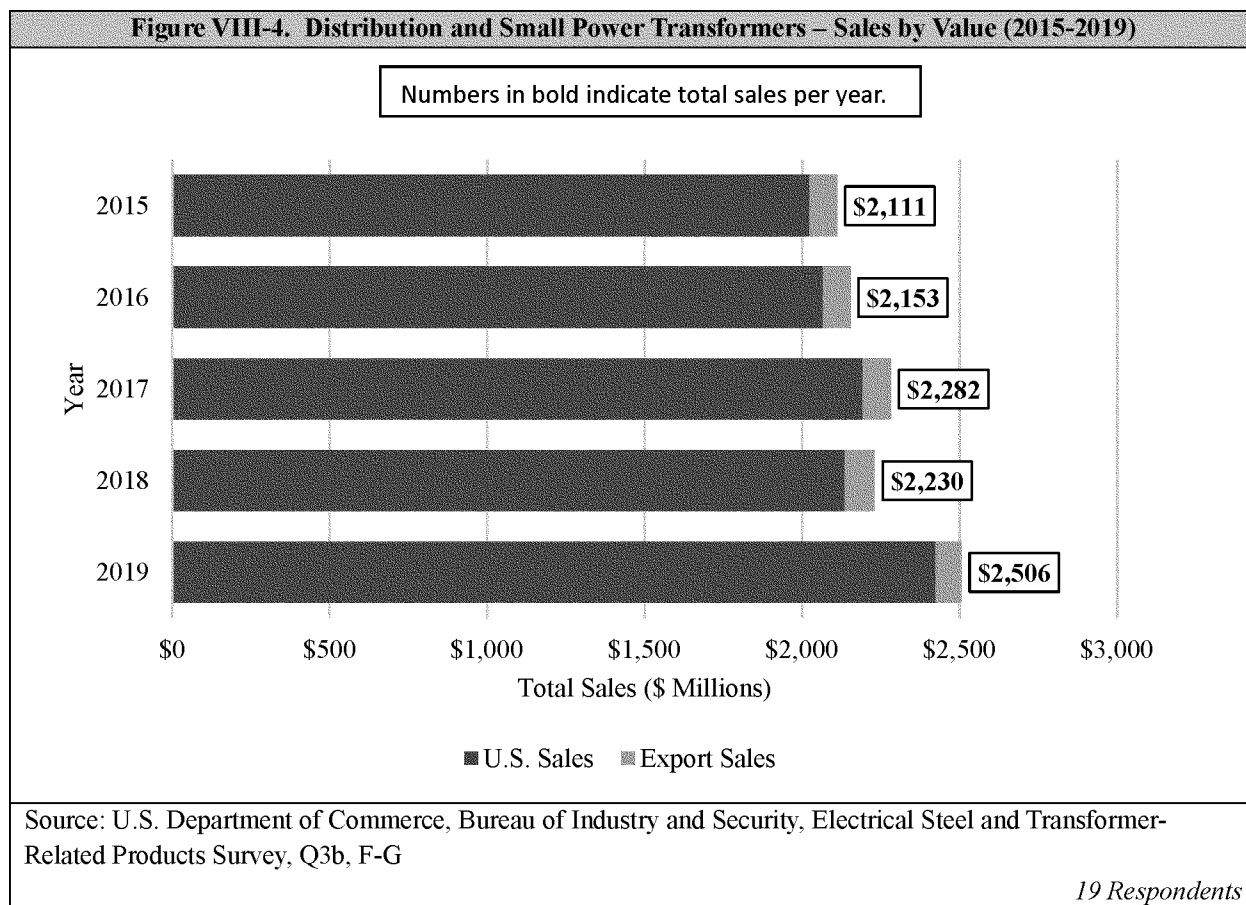
#### *B. Distribution and Small Power Transformers (Up to 10,000 kVA)*

There were 19 survey respondents reporting domestic production of small power transformers (up to 10,000 kVA) during the 2015–2019 period. Companies in this sector employed more than 10,000 production workers and sold more than a million transformer units, with a total value of \$2.5 billion, in 2019.<sup>85</sup>

[TEXT REDACTED].

The data received via the Department's survey is largely

consistent with DOE's 2009 market study, which identified that, from a manufacturing point of view, the six largest companies operating in the liquid-immersed distribution transformer market at that time were (in alphabetical order): [TEXT REDACTED]. Together, these six companies represented more than 80 percent of the sales revenue of liquid-immersed distribution transformers in the United States (up to 2,500 kVA) in 2009. [TEXT REDACTED].



<sup>85</sup> Note that there is overlap with employment in other transformer categories as some survey recipients participate in multiple sectors.

[TEXT REDACTED].

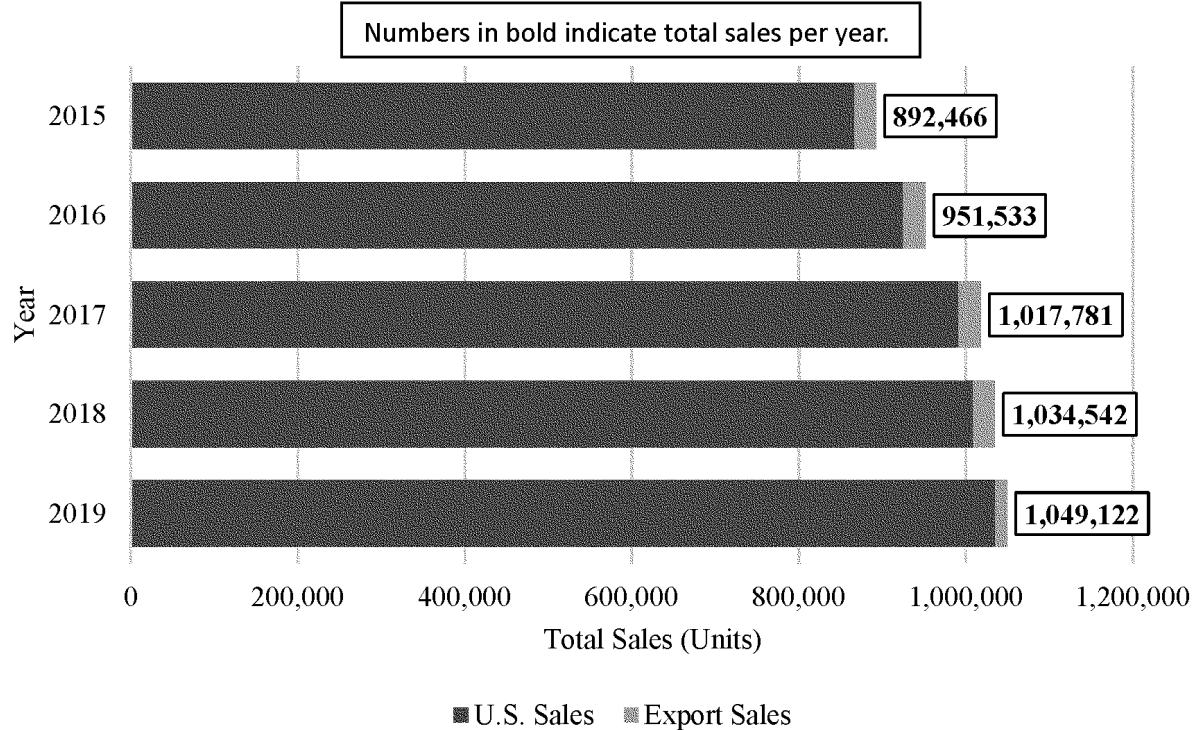
[TEXT REDACTED]

[TEXT REDACTED]

[TEXT REDACTED]

[TEXT REDACTED].

[TEXT REDACTED]

**Figure VIII-9. Distribution and Small Power Transformers – Sales by Volume (2015-2019)**

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q3b, F-G

19 Respondents

Both dollar sales and unit sales of transformers in this category have risen consistently over the past five years. The average price of transformers in this category was \$55,000. A slight majority of these transformers use cores comprised of GOES (as opposed to other core materials, such as metglas), and on average GOES accounted for about 20 percent of the cost of each transformer.

[TEXT REDACTED]

Figure VIII-X assesses the financial status of the major players in this industry segment. The four market leaders all ranked as “moderate/elevated risk” based on the Department’s financial risk metric.

Overall, the companies manufacturing distribution transformers and small power transformers did not devote a high level of funding to research and development (R&D), as compared to R&D spending in other industry sectors.

In total, the 19 companies spent about \$650 million on R&D each year between 2015–2019, with one company—[TEXT REDACTED]. In part, the low level of R&D spending is because transformers are a mature technology. Other factors include the relatively poor financial status of domestic manufacturers.

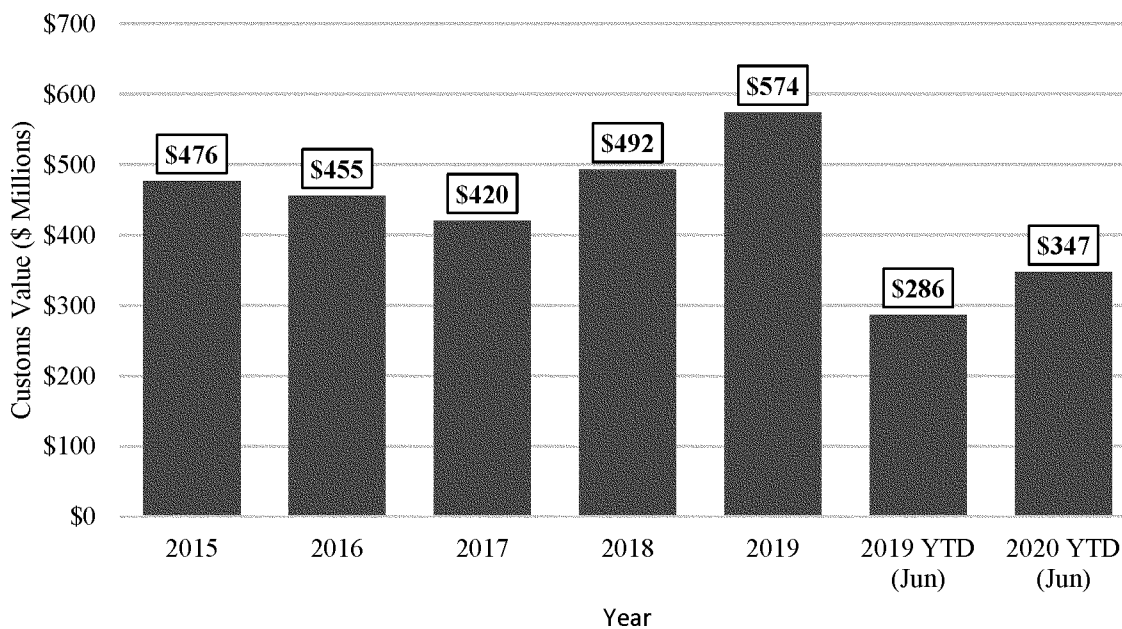
Capital investment by the companies in this industry subsector showed a similar pattern: Capital expenditures ranged between \$560 and \$660 million per year, with [TEXT REDACTED]. The relatively low levels of capital investment is likely due to the factors listed above, including the maturity of the technology and the financial status of domestic manufacturers.

#### 1. Apparent Consumption and Import Penetration

U.S. imports of distribution and small power transformers have remained consistent over the past ten years, averaging about 200,000 units and \$500

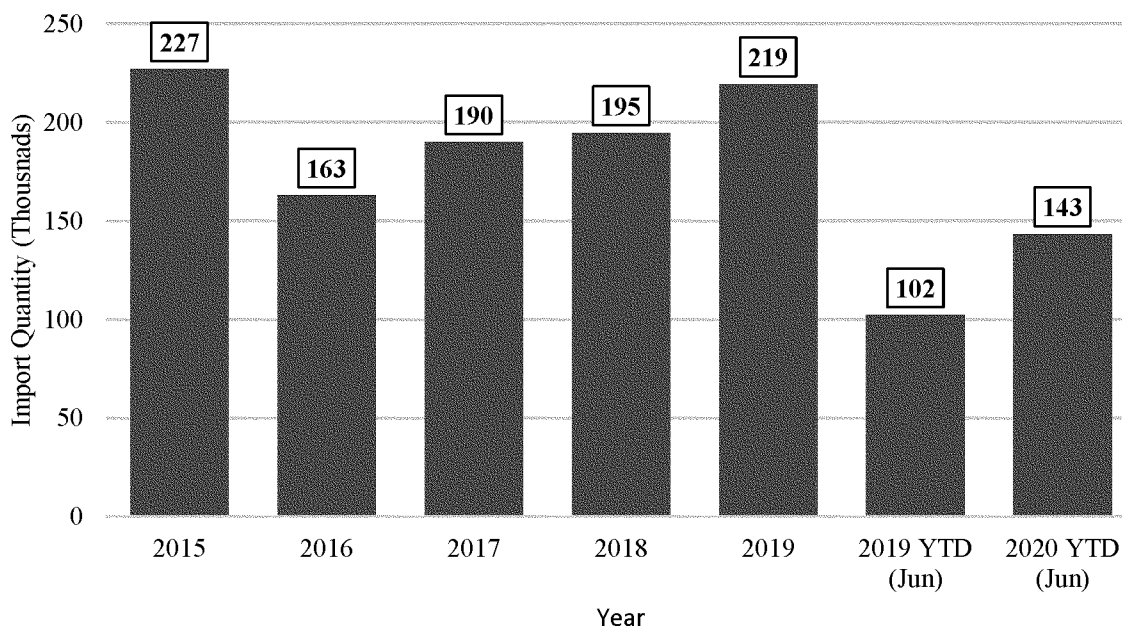
million per year. Imports in 2019 were slightly above the long-term average, and imports for the first part of 2020 are significantly higher than during the same period in 2019. Mexico is by far the largest source of these imports, accounting for over 80 percent of the units in 2019. Many major global transformer companies have manufacturing facilities in Mexico [TEXT REDACTED], taking advantage of lower labor costs and duty-free access to the U.S. market. The significant suppliers of transformers of this power handling capacity located outside of Mexico are in Canada and China. However, imports from China have declined in recent years from 2013–2014 levels (likely due to the tariffs on many imports from China imposed in recent years), with an increase in the first part of 2020. Imports from Canada remained steady throughout the period.

**Figure VIII-11. Distribution Transformers & Small Power Transformers (<650 KVA to 10,000 KVA)  
Import Customs Value (2015-2020 YTD Jun)**



Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

**Figure VIII-12. Distribution Transformers & Small Power Transformers (<650 KVA to 10,000 KVA)  
Import Customs Quantity (2015-2020 YTD Jun)**



Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

<b>Figure VIII-13. Distribution Transformers &amp; Small Power Transformers (&lt;650 KVA to 10,000 KVA) Import Quantities by Top 10 Countries (Units, 2015-2020 YTD Jun)</b>								
<b>Country</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2019 YTD (Jun)</b>	<b>2020 YTD (Jun)</b>	<b>SUM*</b>
<b>Mexico</b>	150,696	136,823	145,907	151,687	178,375	85,592	105,622	<b>869,110</b>
<b>China</b>	29,833	3,706	11,465	16,270	9,075	2,069	4,531	<b>74,880</b>
<b>Canada</b>	11,675	10,441	11,776	12,321	13,937	6,672	6,219	<b>66,369</b>
<b>Taiwan</b>	1,121	713	710	2,722	6,430	138	21,873	<b>33,569</b>
<b>United Kingdom</b>	14,049	1,180	358	267	186	25	103	<b>16,143</b>
<b>Poland</b>	-	-	4,896	2,520	3,059	3,053	8	<b>10,483</b>
<b>Hong Kong</b>	6,297	795	40	32	-	-	-	<b>7,164</b>
<b>India</b>	903	5	4,481	1,007	6	5	7	<b>6,409</b>
<b>Germany</b>	1,295	1,117	915	1,140	779	552	605	<b>5,851</b>
<b>Sri Lanka</b>	5,567	-	-	-	-	-	-	<b>5,567</b>
Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security								
*Excludes 2019 YTD (Jun) Data								

Based on sales information provided through survey responses and Census import and export statistics, import penetration was about 18 percent for this industry segment (liquid dielectric transformers up to 10,000 kVA) in 2019. Based on production data for transformers in these power handling capacities from the survey, import penetration was 20.6 percent.

## 2. Reliance on Foreign Sources for Transformer Components

Despite the relatively low level of the market for finished transformers accounted for by imports, domestic transformer producers rely heavily upon foreign sources for critical components. Using imported laminations and cores

contributes to their competitiveness by reducing costs. Many of them never had or no longer have in-house capability to manufacture transformer cores. Even those that do have this capability have either begun to source some of these items from abroad in order to stay competitive or have eliminated in-house production all together. For the major companies in this industry segment:

- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].

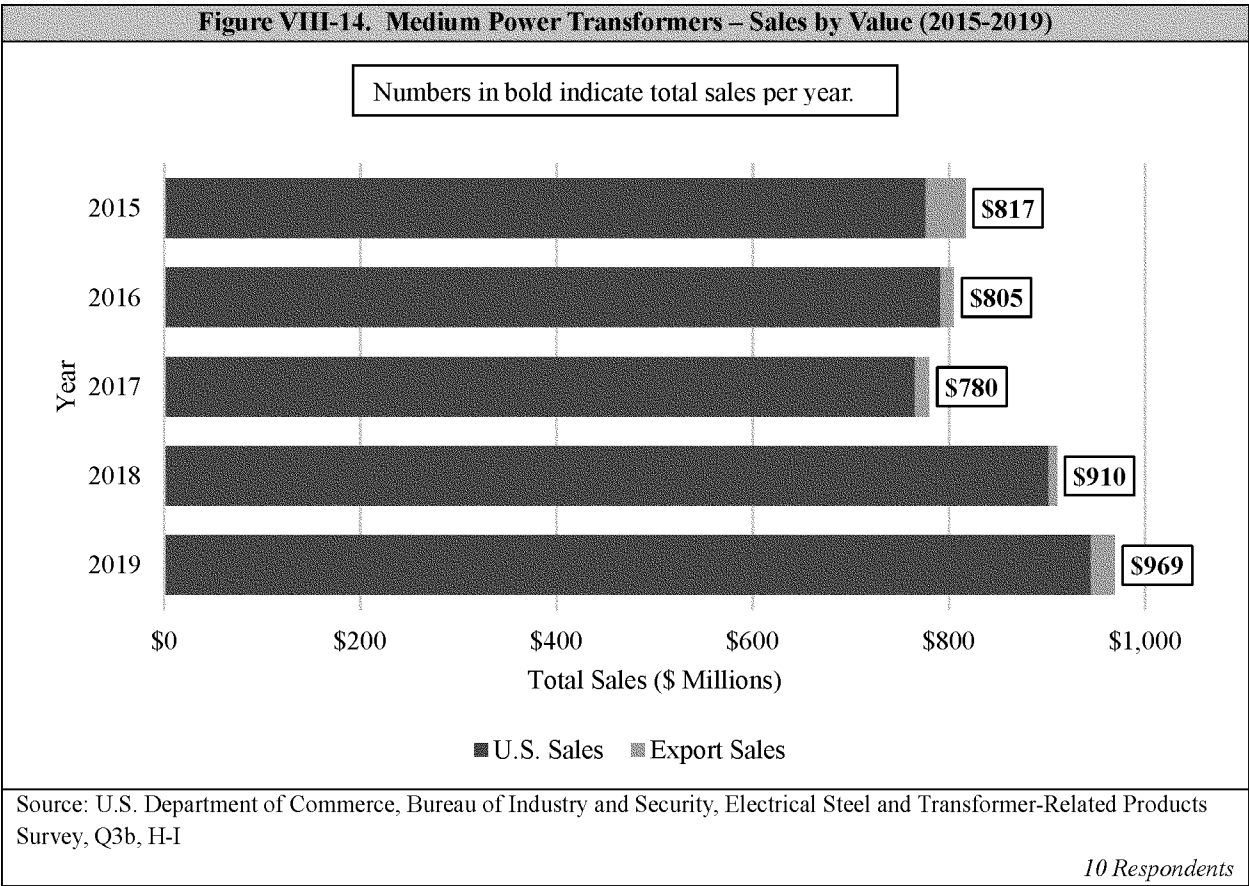
### C. Medium Power Transformers (10,000 kVA–100,000 kVA)

Ten survey respondents indicated that they domestically produced

transformers with power handling capacities between 10,000kVA and 100,000 kVA. The sales price of transformers in this broad category averaged about \$500,000. About 90 percent of these transformers used GOES in their cores, and the cost of GOES accounted for about 13 percent of transformer production costs.

Total domestic employment in this industry segment was about 7,200 production workers. [TEXT REDACTED].

Survey participants had sales of transformers in this size range of about 1,700 units valued at \$969 million in 2019. [TEXT REDACTED].



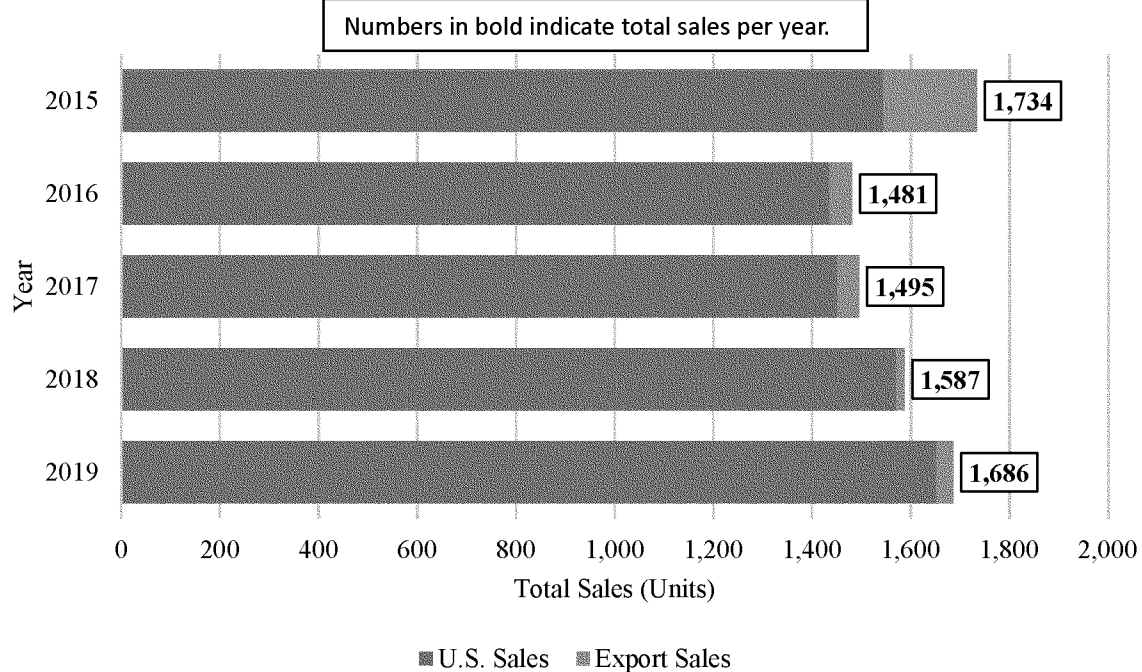
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[TEXT REDACTED]

[TEXT REDACTED]



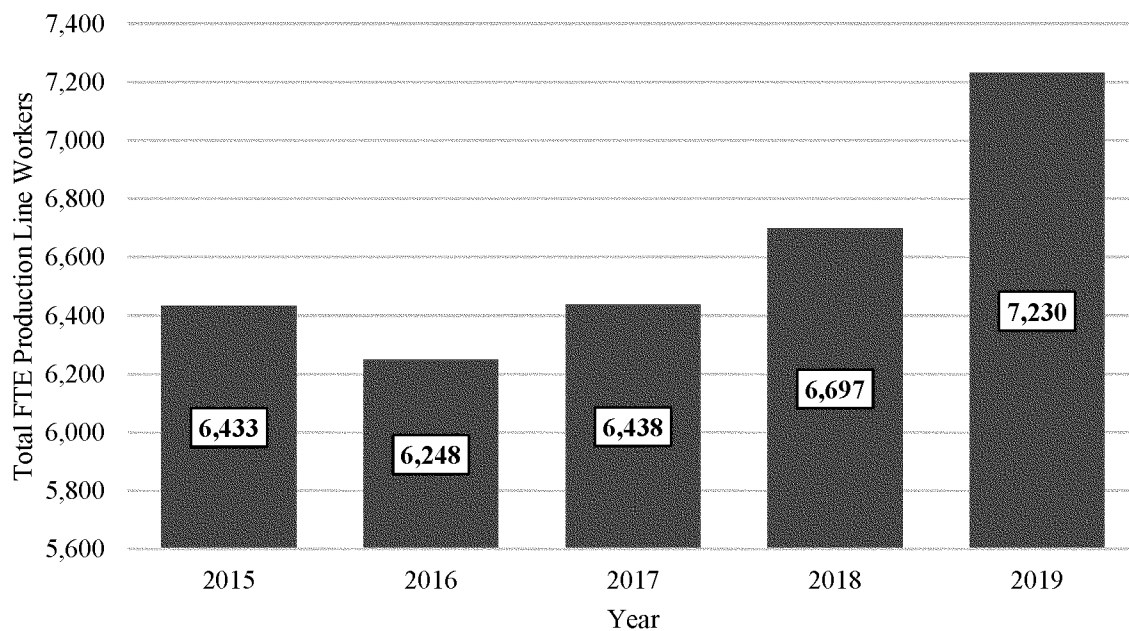
**Figure VIII-17. Medium Power Transformers – Sales by Volume (2015-2019)**

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q3b, H-I

10 Respondents

**Figure VIII-19. Medium Power Transformers Production Line Employment (2015-2019)**

[TEXT REDACTED]



Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q7, A

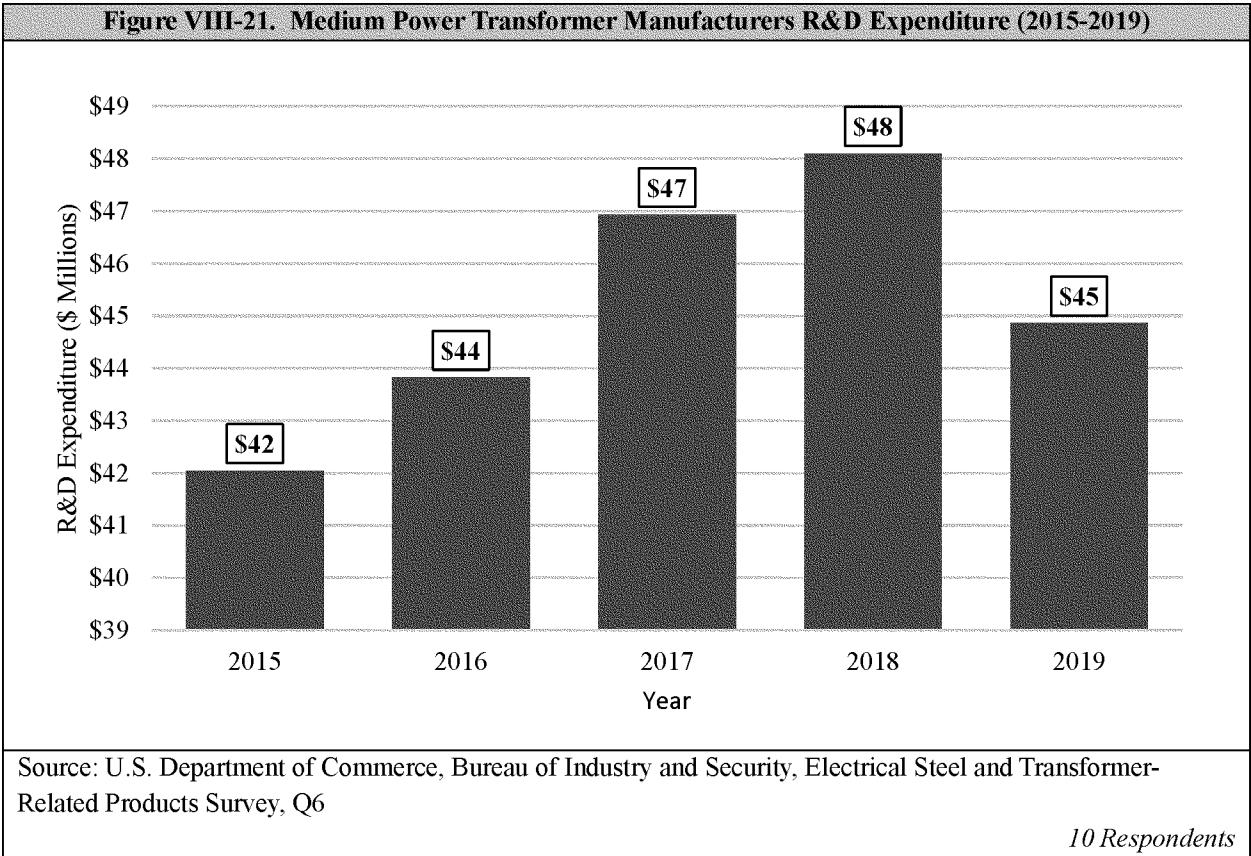
9 Respondents

[TEXT REDACTED]

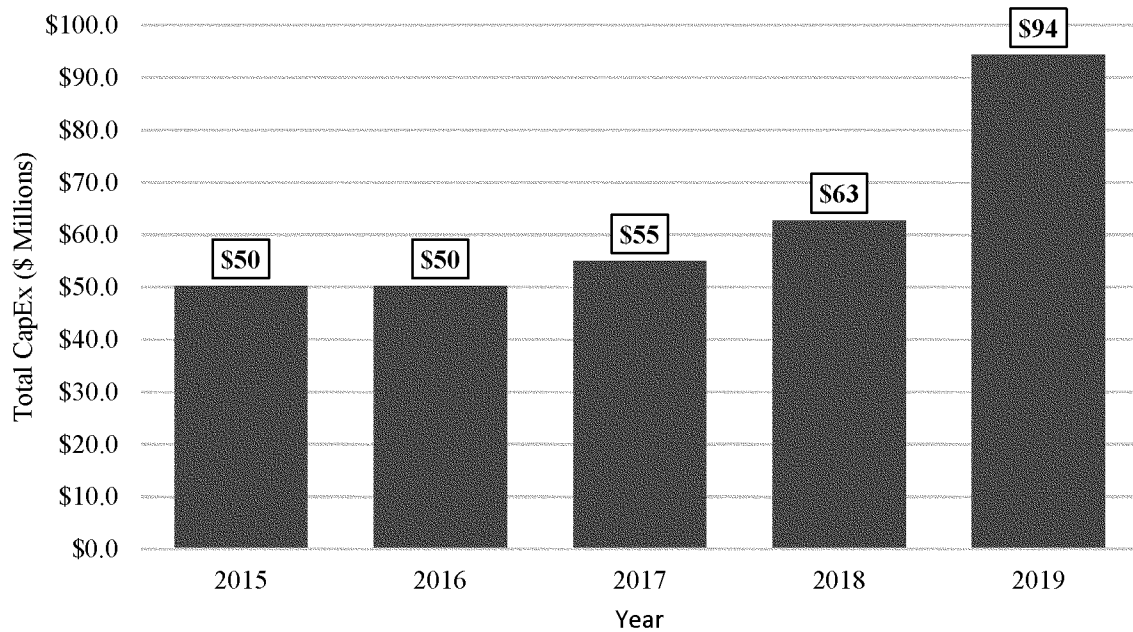
A measure of the financial performance of the top firms in the medium power transformer category is

presented in Figure VIII–20. In general, the market leaders are financially healthy based on the Department’s metrics, with the exception of Hyundai. [TEXT REDACTED].

In total, the ten companies with production of transformers in this segment spent \$45 million on R&D in 2019. Of this total, four companies— [TEXT REDACTED].



Aggregated capital expenditures for the ten companies are presented below. [TEXT REDACTED].

**Figure VIII-22. Medium Power Transformer Manufacturers Capital Expenditure (2015-2019)**

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q6

*19 Respondents*

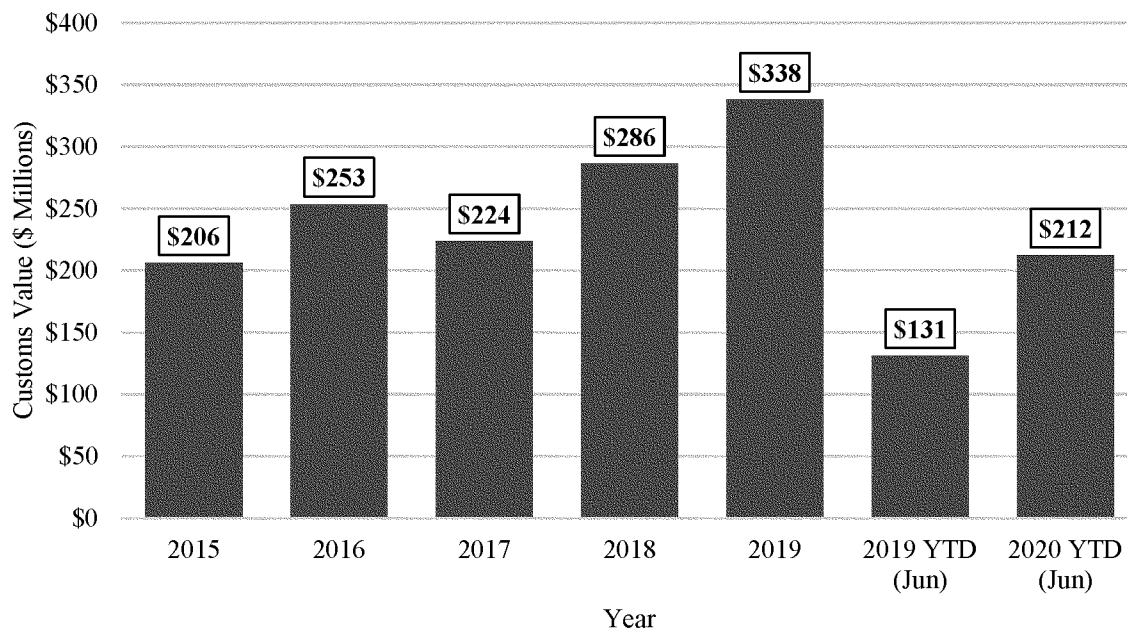
**1. Apparent Consumption and Import Penetration**

Imports of transformers in the medium power handling capacity range

have increased over the past three years and are on track to exceed \$400 million in 2020, on the basis of data from the first six months of the year. On a unit basis, imports show a similar trend,

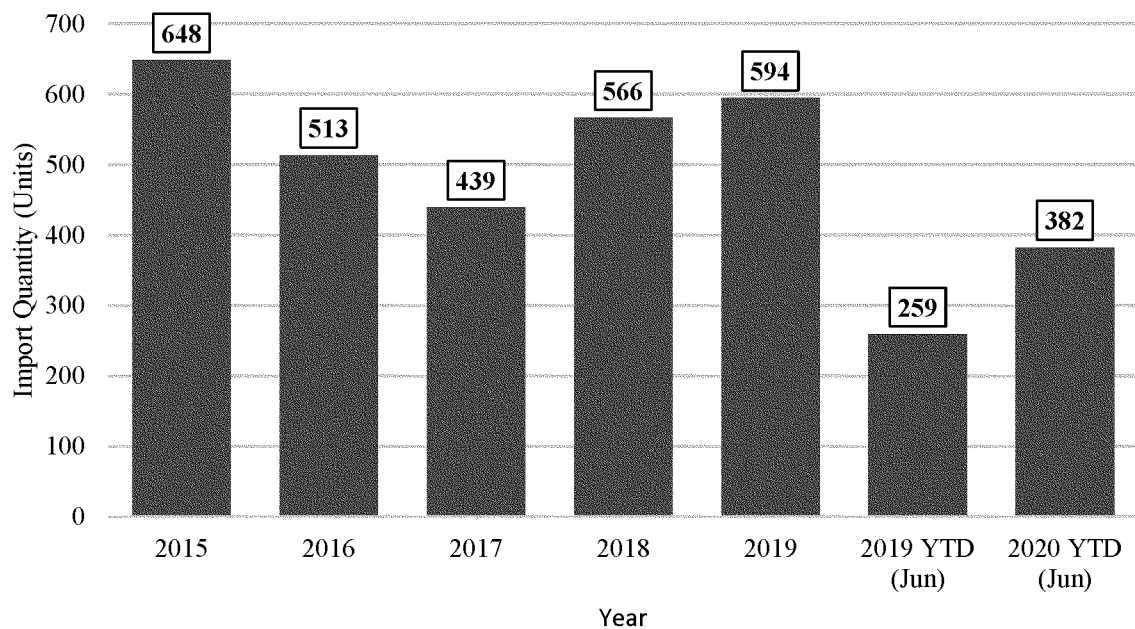
exceeding 600 units per year. Mexico and South Korea are by far the largest sources of imported transformers in this subsector.

**Figure VIII-23. Medium Power Transformers (10,000 KVA to 100,000 KVA)  
Import Customs Value (2015-2020 YTD Jun)**



Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

**Figure VIII-24. Medium Power Transformers (10,000 KVA to 100,000 KVA)  
Import Customs Quantity (2015-2020 YTD Jun)**



Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

**Figure VIII-25. Medium Power Transformers (10,000 KVA to 100,000 KVA)  
Import Quantities by Top 10 Countries (Units, 2015-2020 YTD Jun)**

Country	2015	2016	2017	2018	2019	2019 YTD (Jun)	2020 YTD (Jun)	SUM*
Mexico	430	234	255	254	280	135	150	1,603
South Korea	43	90	66	109	124	61	73	505
Taiwan	72	45	15	37	36	12	26	231
Germany	6	38	42	66	38	13	15	205
Austria	9	19	25	32	39	9	36	160
Portugal	41	6	14	14	30	9	10	115
Colombia	5	18	4	40	13	10	23	103
Brazil	0	11	4	1	0	-	23	39
Japan	12	4	2	0	8	0	12	38
Italy	14	4	1	4	3	0	1	27

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

\*Excludes 2019 YTD (Jun) Data

Based on production as reported on the Department's survey and Census Bureau-based import statistics, import penetration in this industry segment was 28 percent on both a unit and value basis.

As with other transformer categories, companies that produce transformers between 10,000 and 100,000 kVA rely heavily on imports for key components. The company snapshots show leading

suppliers for the essential items—GOES, laminations, and/or cores.

#### *D. Dry-Type Transformers*

Of all of the transformer categories covered by this investigation, dry transformers had the greatest direct

usage in defense applications. This is because this type of transformer is designed for safe usage indoors (including on ships and aircraft), as it poses fewer environmental and fire risks than do oil-immersed transformers. However, defense applications represent only a small percentage of sales of these types of transformers, which are also used extensively in the electrical grid, as well as in a multitude of industrial and commercial applications.

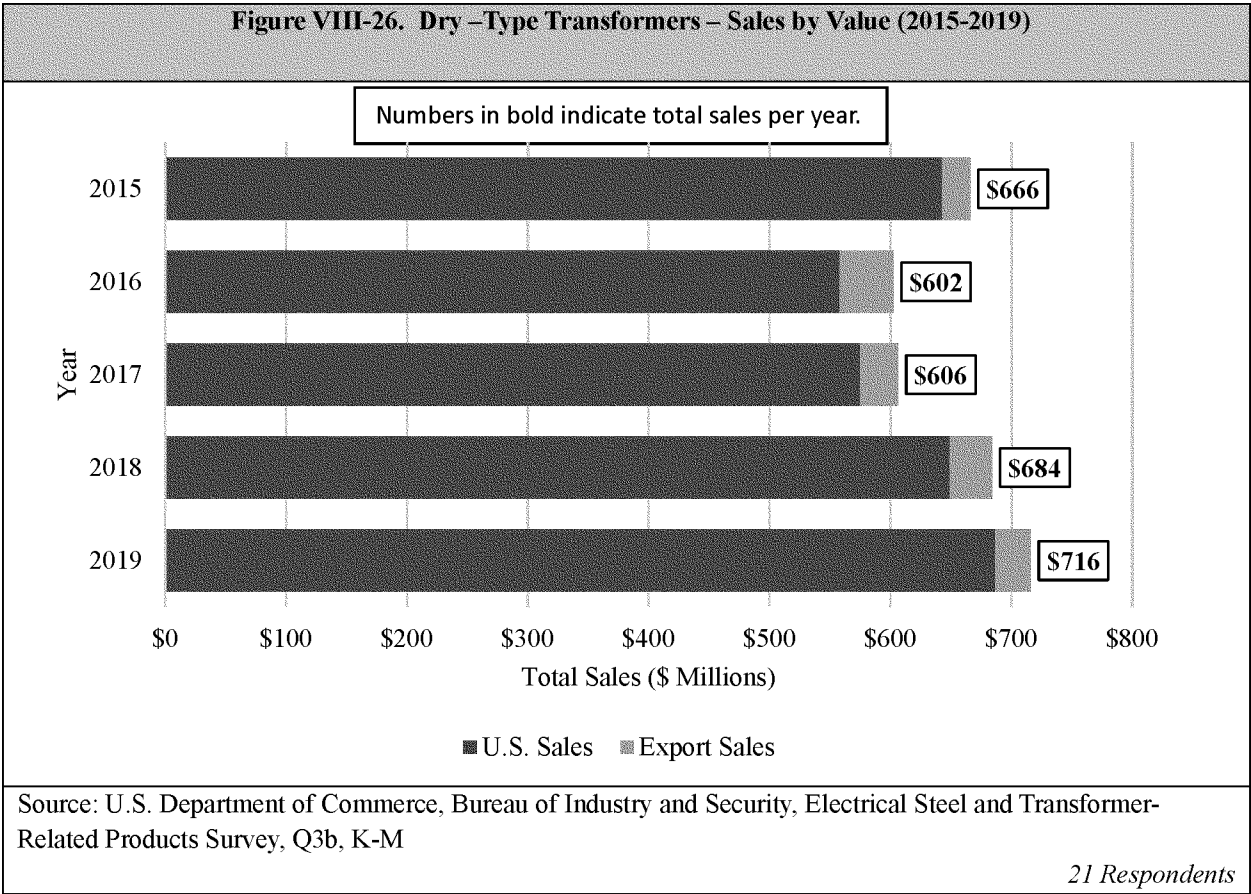
The Department’s survey data capture input from the predominant players in the dry-type transformer category, but are less complete than for other industry sub-segments. Particularly for the

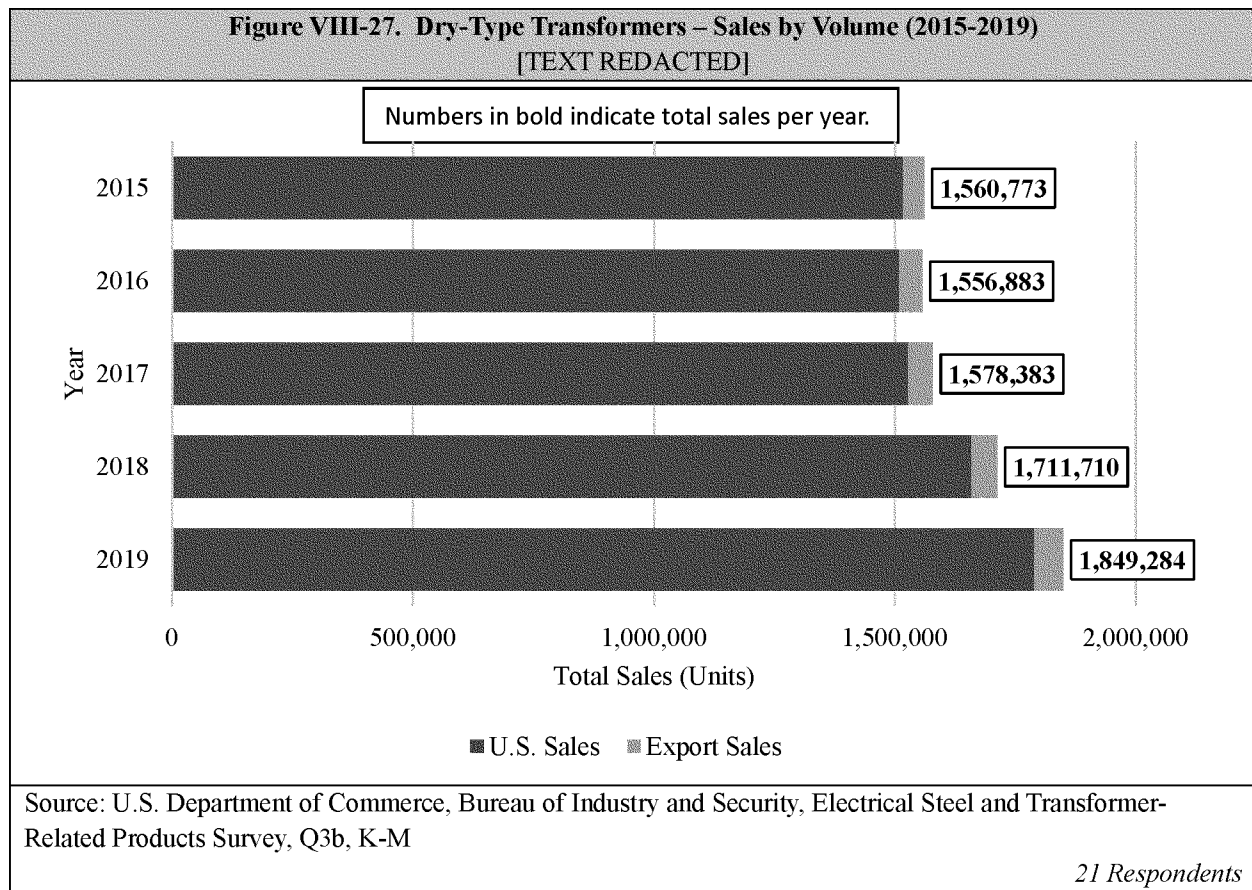
smallest dry-type transformers (under <16kVA), production (and imports) is in the millions of units, and the survey did not fully capture this. Despite this, the survey provided useful information on industry trends and competitiveness issues.

Twenty-one survey participants with just over 9,000 production workers sold 1.8 million dry transformers of various power handling capacities between 2015 and 2019. However, production in the United States was about half of this unit total because most of the major players have both domestic and overseas production facilities and distribute the product from both in the

United States. Total sales by these respondents were about \$700 million, with the average transformer price about \$13,000. In aggregate, about half of these dry-type transformers require GOES in their cores, according to the survey respondents; when it was used, it accounted for about 25 percent of the cost of the transformer.

Six respondents represent about 97 percent of dry-type transformer sales (of all capacities) by value from 2015–2019. [TEXT REDACTED]. Note that these sales values include transformers manufactured outside the United States, as reported by several of the survey recipients.



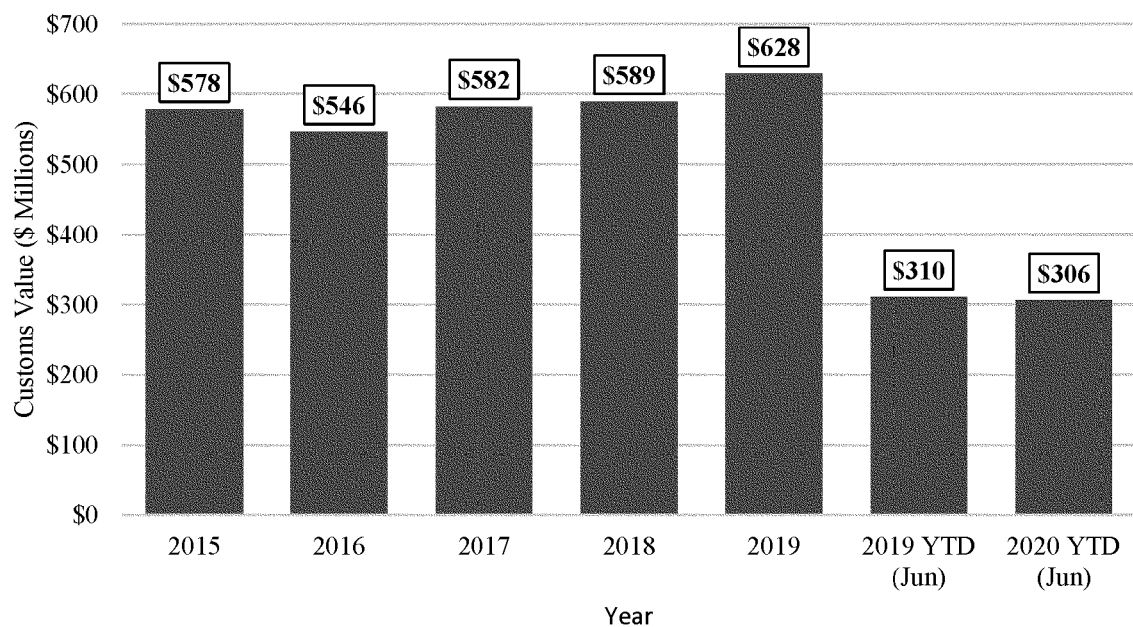


As indicated above, imports play a major role in the dry transformer sector. Countries with low cost labor—

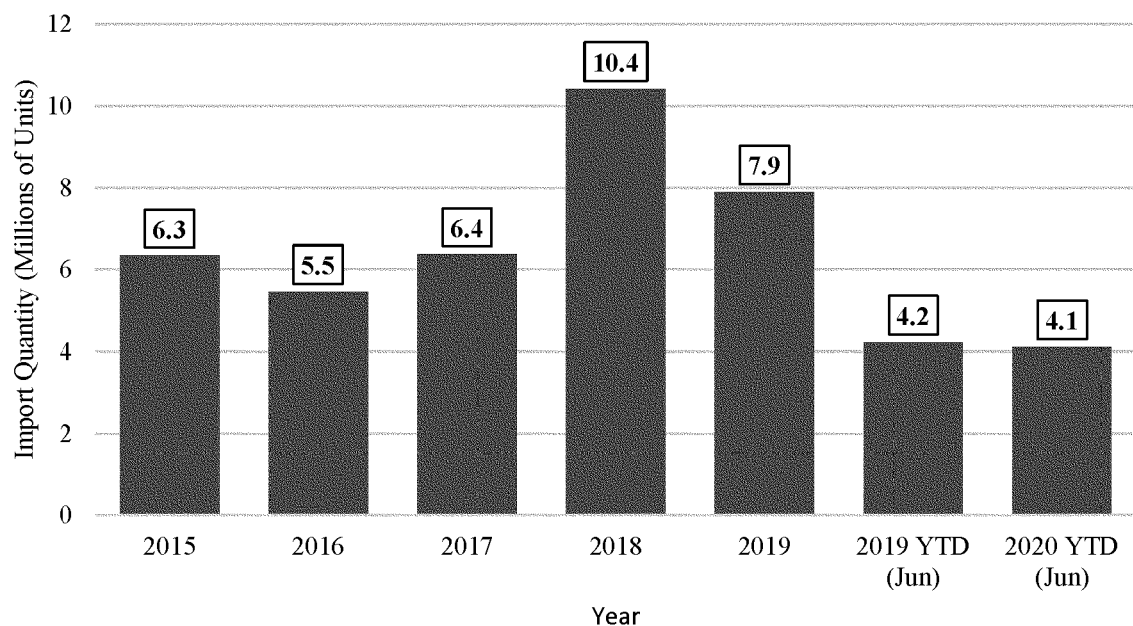
including China, Indonesia, and Mexico—are major sources of imported dry-type transformers. On a unit basis,

more than half of dry-type transformer imports originate in China.

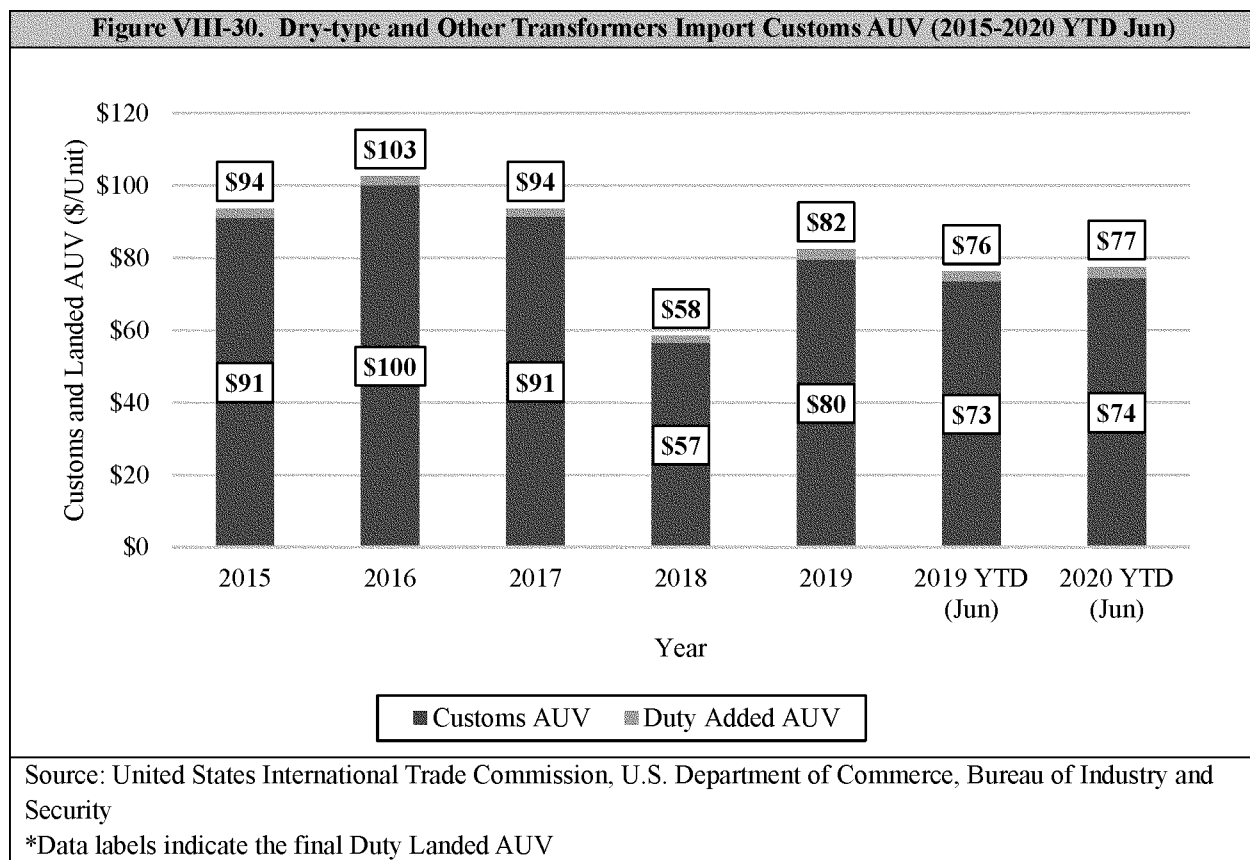


**Figure VIII-28. Dry-Type and Other Transformers Import Customs Value (2015-2020 YTD Jun)**

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

**Figure VIII-29. Dry-Type and Other Transformers Import Customs Quantity (2015-2020 YTD Jun)**

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security



**Figure VIII-31. Dry and Other Transformers Import Quantities by Top 10 Countries (Thousands of Units, 2015-2020 YTD Jun)**

Country	2015	2016	2017	2018	2019	2019 YTD (Jun)	2020 YTD (Jun)	SUM*
China	2,482	2,341	3,006	6,689	4,993	2,785	2,858	22,369
Indonesia	1,736	1,648	1,840	1,253	1,148	658	300	7,926
Mexico	667	528	605	1,082	754	315	323	3,959
India	291	253	207	230	260	157	87	1,328
France	248	18	36	336	223	72	130	991
Honduras	147	92	68	115	128	66	33	584
Germany	276	130	16	42	10	6	3	477
Taiwan	80	83	96	38	32	15	138	468
Canada	94	53	87	117	67	40	35	453
Malaysia	70	167	53	52	13	7	6	361

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security  
\*Excludes 2019 YTD (Jun) Data

During the time period, dry-type transformers in the 1–16 kVA range were both produced domestically and imported by the millions. Leading domestic producers, including [TEXT REDACTED], together accounted for over 80 percent of the production volume by survey participants in 2019.

[TEXT REDACTED]. The average sales price was just \$20. [TEXT REDACTED]. The primary application for these transformers is in industrial settings for power distribution.

[TEXT REDACTED].

While it was not possible to determine import penetration levels due

to lack of data on U.S. production, based on official trade statistics, imports of dry-type transformers in the 1–16 kVA range have a significant market presence. In this sector, Mexico and China are the leading suppliers, with China accounting for much of the volume (over million units) and Mexico

much of the value of total imports (due to varying sizes and prices of transformers). As mentioned, a number

of the U.S. companies in participating this sector have overseas production

facilities and contribute to the import volume.

<b>Figure VIII-32. Dry and Other Transformers (&lt;1 KVA to 16 KVA) Import Value by Top 10 Countries (\$ Millions, 2015-2020 YTD Jun)</b>								
<b>Country</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2019 YTD (Jun)</b>	<b>2020 YTD (Jun)</b>	<b>SUM*</b>
<b>Mexico</b>	\$36.7	\$40.3	\$33.5	\$40.1	\$48.4	\$24.7	\$21.1	<b>\$220.1</b>
<b>China</b>	\$31.0	\$33.5	\$31.1	\$24.1	\$20.8	\$8.3	\$13.1	<b>\$153.7</b>
<b>Canada</b>	\$7.9	\$8.4	\$8.6	\$9.0	\$10.5	\$5.6	\$4.3	<b>\$48.8</b>
<b>Germany</b>	\$6.5	\$6.6	\$4.8	\$7.0	\$6.3	\$2.9	\$2.9	<b>\$34.0</b>
<b>Japan</b>	\$6.8	\$5.6	\$6.1	\$3.0	\$3.3	\$1.1	\$3.5	<b>\$28.4</b>
<b>Philippines</b>	\$4.7	\$3.6	\$3.6	\$4.4	\$4.9	\$2.1	\$2.6	<b>\$23.7</b>
<b>Taiwan</b>	\$4.2	\$3.7	\$2.8	\$3.4	\$3.7	\$1.7	\$1.9	<b>\$19.7</b>
<b>United Kingdom</b>	\$2.8	\$1.9	\$2.8	\$3.0	\$2.3	\$1.3	\$1.4	<b>\$14.1</b>
<b>Sri Lanka</b>	\$2.3	\$2.1	\$2.4	\$2.4	\$2.5	\$0.9	\$1.3	<b>\$13.1</b>
<b>France</b>	\$1.6	\$3.2	\$2.2	\$1.6	\$2.3	\$0.8	\$0.8	<b>\$11.7</b>
<b>ROW</b>	\$11.0	\$9.2	\$12.8	\$13.1	\$13.4	\$5.7	\$6.9	<b>\$66.5</b>
<b>Total</b>	<b>\$115.6</b>	<b>\$118.2</b>	<b>\$110.8</b>	<b>\$110.9</b>	<b>\$118.4</b>	<b>\$55.2</b>	<b>\$59.9</b>	<b>\$633.8</b>
<b>AVG AUV (\$/Unit)</b>	\$25.42	\$28.16	\$22.67	\$13.62	\$17.58	\$16.68	\$16.57	\$20.10
Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security (HTS 8504.32)								
*Excludes 2019 YTD (Jun)								

In the 16–500 kVA dry-type transformer category, the leading domestic producers were [TEXT REDACTED]. These transformers were produced domestically in the tens of thousands of units, are valued in the \$2,500 to \$25,000 range, and are used in electric power distribution for commercial and industrial customers. GOES is used in almost all transformers in this range, and accounts for up to 50 percent of production costs.

Manufacturers in this industry sector manufacture distribution transformers

that are subject to the DOE Energy Efficiency Standards that took effect in 2016. The new standards increased manufacturers' demand for higher grades of GOES in order to remain competitive in the bidding process. Business decisions to remain competitive after the introduction of the DOE standards also increased demand for the quantity of GOES, as well as laminations, and cores, from global suppliers. For example, [TEXT REDACTED]. [TEXT REDACTED].

Statistics on imports of dry-type transformers between 16 and 500 kVA are presented in Table VIII–33 below. Once again, China and Mexico are the major sources for imports, with India and France also supplying substantial numbers. Based on survey data, it appears that transformers in this broad category that are manufactured in the United States have a higher unit value than imports.

**Figure VIII-33. Dry and Other Transformers (<16 KVA to 500 KVA)  
Import Quantities by Top 10 Countries (Thousands of Units, 2015-2020 YTD Jun)**

Country	2015	2016	2017	2018	2019	2019 YTD (Jun)	2020 YTD (Jun)	SUM*
China	788	655	782	826	356	224	76	3,483
Mexico	279	206	241	720	237	122	116	1,800
India	258	231	184	213	232	142	76	1,194
France	247	17	35	332	223	72	130	984
Hong Kong	52	12	128	84	0.3	0.3	0.1	276
Canada	14	18	54	54	29	21	19	188
Germany	57	45	10	5	3	1	1	122
Taiwan	25	29	25	8	15	7	9	112
Hungary	26	0.003	5	1	1	1	0.1	32
Spain	0.1	0.4	1	1	25	0	3	31
ROW	14	31	10	16	30	17	14	116
<b>Total</b>	<b>1,762</b>	<b>1,245</b>	<b>1,475</b>	<b>2,260</b>	<b>1,150</b>	<b>607</b>	<b>445</b>	<b>8,337</b>
<b>Average AUV</b>	<b>\$177</b>	<b>\$258</b>	<b>\$245</b>	<b>\$158</b>	<b>\$320</b>	<b>\$360</b>	<b>\$404</b>	<b>\$275</b>

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security  
(HTS 8504.33)

\*Excludes 2019 YTD (Jun) Data

In the largest dry-type transformer category (>500kVA), the domestic industry leaders are [TEXT REDACTED].

The average value of Federal Pacific's transformers in this size range was \$23,000. They are used for electrical power delivery to industrial,

commercial, and residential customers. High-quality GOES is required in order to meet DOE energy efficiency standards for this product, and accounts for 50 percent of the cost of the transformers. [TEXT REDACTED].

As with the other dry-type transformer categories, imports are

significant and the major sources are China, Mexico, and India. Imports in 2015 were significantly greater than in other years, due to high import levels that year reported from China and India. In 2019 and the first six months of 2020, Mexico was by far the leading supplier.

**Figure VIII-34. Dry and Other Transformers (>500 KVA)  
Import Quantities by Top 10 Countries (Units, 2015-2020 YTD Jun)**

Country	2015	2016	2017	2018	2019	2019 YTD (Jun)	2020 YTD (Jun)	SUM*
China	15,466	3,828	456	730	1,137	432	1,051	22,668
Mexico	1,691	1,986	1,812	1,671	3,967	2,334	1,673	12,800
India	3,388	392	36	274	1,235	793	513	5,838
Canada	958	718	800	683	793	384	390	4,342
Hong Kong	2,040	1	3	13	1	1	-	2,058
Germany	571	506	193	172	291	168	161	1,894
Malaysia	214	100	336	360	35	18	103	1,148
South Korea	142	49	32	466	98	65	95	882
Poland	13	51	259	334	202	89	-	859
Spain	101	29	144	237	211	160	136	858
ROW	827	1,046	614	767	441	116	439	4,134
<b>Total</b>	<b>25,411</b>	<b>8,706</b>	<b>4,685</b>	<b>5,707</b>	<b>8,411</b>	<b>4,560</b>	<b>4,561</b>	<b>57,481</b>
<b>Average AUV</b>	<b>\$5,936</b>	<b>\$12,216</b>	<b>\$23,349</b>	<b>\$21,137</b>	<b>\$16,884</b>	<b>\$17,276</b>	<b>\$19,911</b>	<b>\$16,673</b>

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security  
(HTS 8504.34)

\*Excludes 2019 YTD (Jun) Data

#### E. Large Power Transformers

LPTs are the transformers most critical to the BPS and the critical energy infrastructure of the United States. They are used to “step-up” power at the power generation site for long-distance transmission, and then to “step-down” the power to the levels that are needed for industrial, commercial, military and household consumers. Because they serve the greatest number of customers, the failure or destruction of just a single LPT can have a large impact on U.S. economic, public health, and security interests. Moreover, long procurement lead times and limited availability of spare LPTs and the parts thereof have serious implications for the resiliency of critical infrastructure.

[TEXT REDACTED].<sup>86</sup> Power transformers fell into the highest category for both criticality and supply chain vulnerability. In terms of criticality, transformers are complex, vulnerable to failure, have a significant impact on the BPS in the case of failure,

and have a lengthy replacement time. The Market Study also found transformers pose a high risk in the supply chain, as suppliers are dominated by foreign-owned companies, with a minimum of four years required to establish domestic manufacturing capability.

The U.S. market for LPTs is less than 1,000 units per year; their average lifespan is 30 to 40 years and relatively few are needed because they serve large populations. Despite the relatively small quantities produced and purchased annually, there is a sizable market for LPTs because each has a value in the millions of dollars. Moreover, because of their enormous size (up to 400 tons), these LPTs account for a significant percentage of consumption of GOES by weight.

##### 1. Domestic Production Capacity

The Department’s survey gathered detailed industry data on all domestic manufacturers of LPTs (here defined as those with greater than 100 MVA power handling capacity, HTS 8504.23.0080). While most of these manufacturers of LPTs also make liquid transformers of

lesser power handling capacities, manufacturers of smaller power transformers cannot easily produce larger units, as they typically do not have the necessary equipment, such as large overhead cranes and annealing equipment, to produce LPTs.

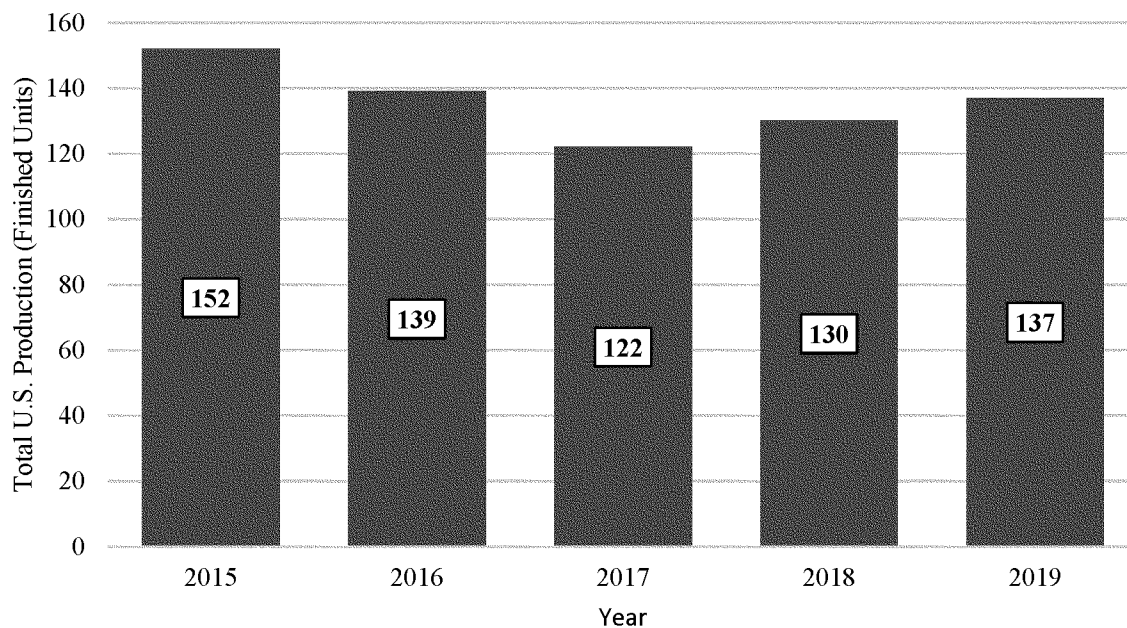
In 2019, seven companies manufactured LPTs of 100 MVA or more in the United States: [TEXT REDACTED]. In 2020, Mitsubishi sold its Memphis transformer facility, and no longer manufactures LPTs (or any transformers) in the United States. Hyosung (HICO) of Korea purchased the facility and intends to manufacture transformers there, including LPTs, but as of the date of this report had not begun production.

[TEXT REDACTED]<sup>87</sup>

Domestic production of LPTs has been fairly steady over the past five years, albeit at a low level of about 130 units per year (see Figure VIII-35). [TEXT REDACTED].

<sup>86</sup> [TEXT REDACTED].

<sup>87</sup> [TEXT REDACTED].

**Figure VIII-36. U.S. Liquid-Dielectric Transformer Over 100,000 KVA Production (2015-2019)**

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q3a, J

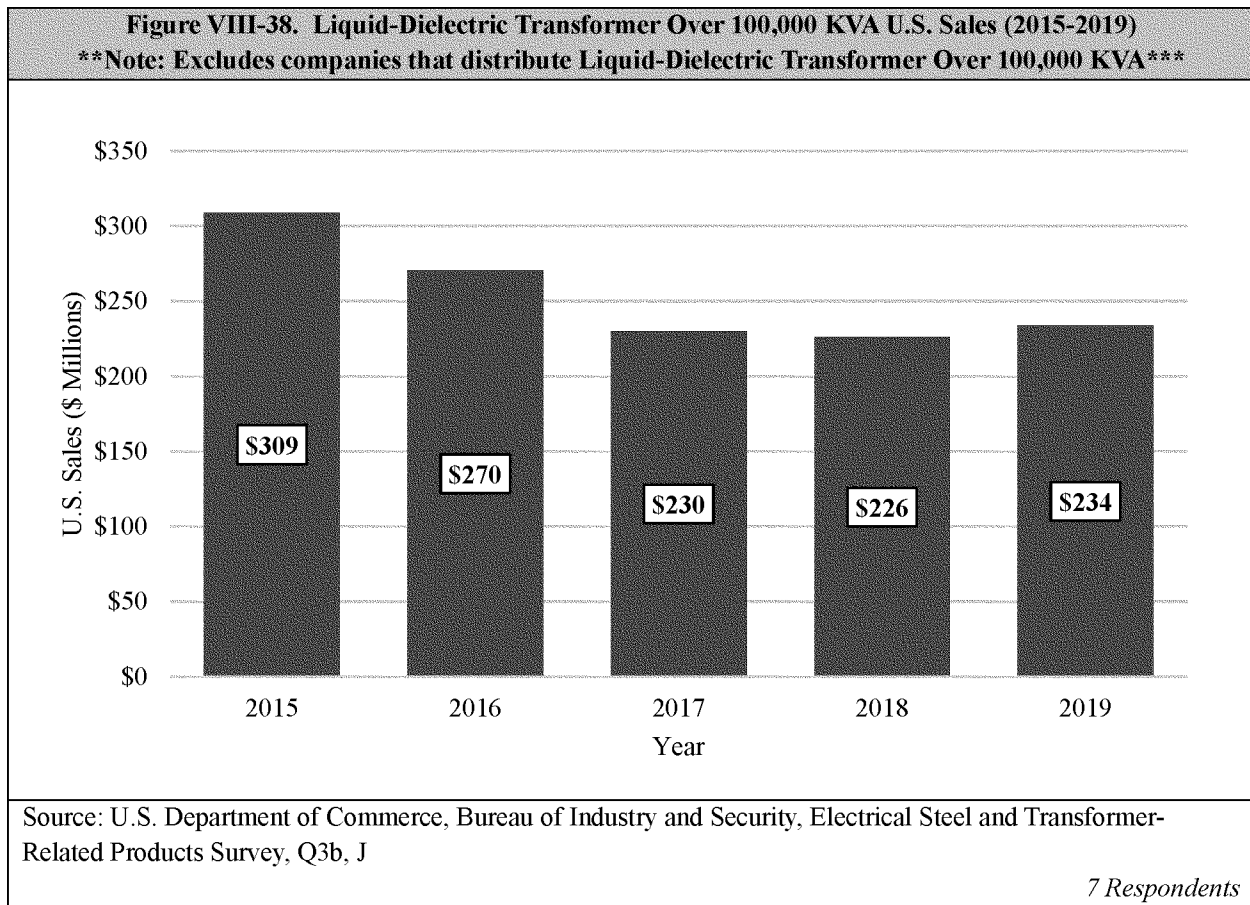
*7 Respondents*

In 2019, [TEXT REDACTED]. Whereas most domestic producers of LPTs also manufacture transformers of lesser power handling capacities in the same facility, [TEXT REDACTED].

In terms of LPT sales, the trend is similar to production, with total sales averaging around \$250 million per year (Figure VIII-36). [TEXT REDACTED]. Export sales of U.S.-produced large

transformers are negligible, with none reported in 2019 by the domestic manufacturers.

[TEXT REDACTED]



Overall domestic production capacity of LPTs remains inadequate to meet domestic demand, particularly with regard to the extra high voltage (EHV) transformers (those with >345 kV voltage rating) that are vital for long distance electricity transmission. While accounting for only a small percentage of units, EHV transformers are the most critical to the security and reliability of the electrical grid, because they handle over 60 percent of all electricity in the country.<sup>88</sup> The loss of Mitsubishi Electric Power (MEPPI) as a domestic manufacturer is significant in this regard, as their facility produced EVH transformers.

Only three companies—[TEXT REDACTED].

[TEXT REDACTED]

The domestic industry is in a constant state of flux—due to plant closures, company exits and entrances, and acquisitions—that affects production capacity. As noted above, Mitsubishi ceased production at its facility in Memphis, with a loss of 200 jobs. HICO (Korea) purchased this facility and plans

to invest \$103 million in the plant and hire 131 workers by 2021, but at present the facility is not operational. Another company that had briefly produced LPTs in the United States, Portugal-based EFACEC, sold its plant in Rincon, Georgia to Virginia Transformer in 2014.

In addition, ABB shuttered its St. Louis LPT manufacturing facility in late 2018, with a loss of 250 jobs; it also laid off 177 workers at its South Boston, VA plant that primarily produces smaller transformers and has limited capacity to produce LPTs. Some of the production formerly done in the United States will be performed at ABB's Varennes, Quebec plant, which is reportedly Canada's largest LPT manufacturing facility. ABB is also reportedly adding to its transformer production capabilities in India and China.<sup>89</sup>

Moreover, ABB's Power Grids business—including transformers—was sold to Hitachi of Japan in 2018 for \$11 billion (with the deal due to close in

mid-2020).<sup>90</sup> Hitachi has not indicated its plans for ABB's U.S. operations, which are substantial (including distribution transformer production). If Hitachi decides not to continue operations once it finalizes the purchase of ABB's U.S. operations, the impact will be significant; ABB claims that it was the manufacturer for 70 percent of the power transformers installed in the U.S. electric grid (including those made by Westinghouse's Transmission and Distribution Division, which ABB acquired in 1989).

## 2. Apparent Consumption and Import Penetration

As noted above, domestic demand for the mature LPTs market is relatively stable from year to year and is largely based on the replacement and modernization of aging equipment. Given the limited production and capacity of domestic manufacturers, the majority of demand is met through imports.

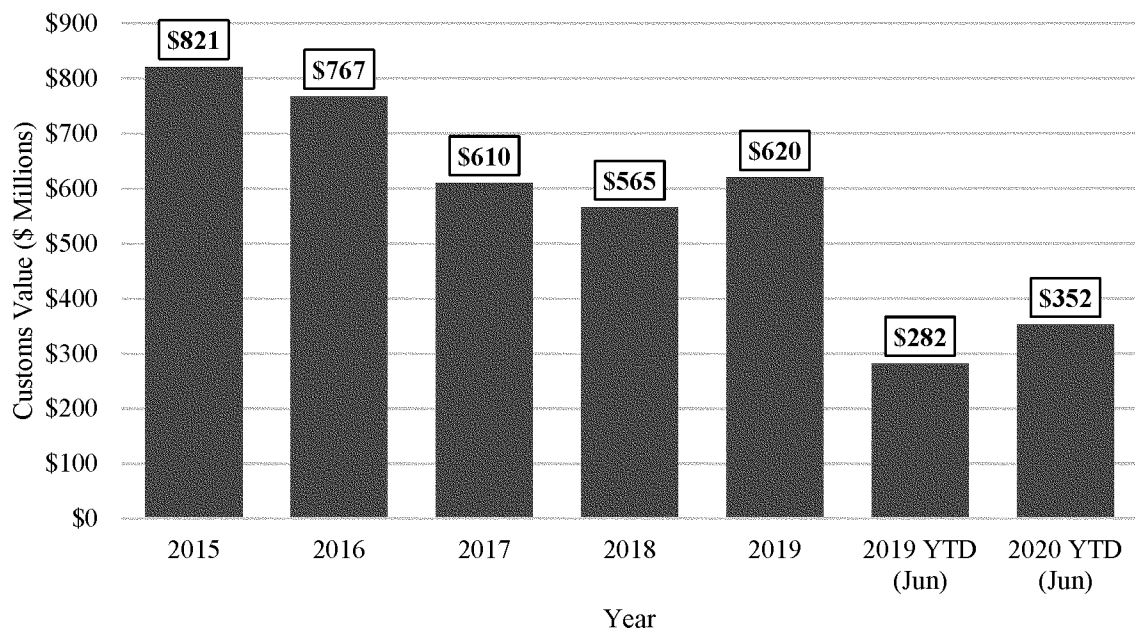
<sup>88</sup> Public Comments submitted by the Government of Canada, July 2, 2020.

<sup>89</sup> STLtoday. Nov. 6, 2017. [https://www.stltoday.com/business/local/abb-to-discontinue-production-in-st-louis-120-jobs-lost/article\\_c18fe08f-ab76-5e02-87d7-e4ea49c1d358.html](https://www.stltoday.com/business/local/abb-to-discontinue-production-in-st-louis-120-jobs-lost/article_c18fe08f-ab76-5e02-87d7-e4ea49c1d358.html).

<sup>90</sup> Powermag.com, Dec. 17, 2018. <https://www.powermag.com/hitachi-acquires-abb-power-grids-business-in-11-billion-deal/>.

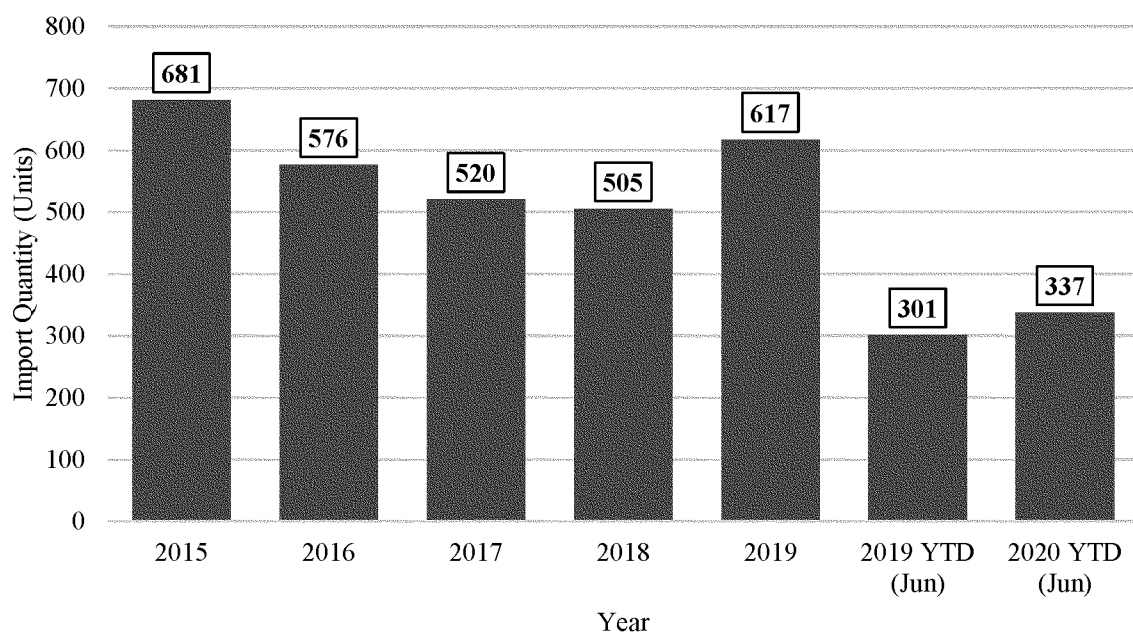


**Figure VIII-40. Large Power Transformers (>100,000 KVA)  
Import Customs Value (2015-2020 YTD Jun)**



Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

**Figure VIII-41. Large Power Transformers (>100,000 KVA)  
Import Customs Quantity (2015-2020 YTD Jun)**



Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

**Figure VIII-42. Large Power Transformers (>100,000 KVA)  
Import Quantities by Top 10 Countries (Units, 2015-2020 YTD Jun)**

Country	2015	2016	2017	2018	2019	2019 YTD (Jun)	2020 YTD (Jun)	SUM*
Mexico	297	151	124	150	202	92	139	1,063
South Korea	100	128	123	73	67	27	25	516
Austria	39	60	89	60	103	57	32	383
Netherlands	49	88	51	61	41	20	23	313
Canada	44	41	44	46	63	38	25	263
China	47	27	22	23	25	18	31	175
Taiwan	10	19	18	24	40	20	6	117
Spain	24	12	8	31	1	1	2	78
Brazil	6	7	16	8	14	7	12	63
Poland	6	8	10	13	16	11	3	56

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

\*Excludes 2019 YTD (Jun) Data

#### BILLING CODE 3510-33-C

Consistent with stable demand, the level of imports of LPTs was been relatively steady between 2015-2019 at between 500 and 700 units annually. Total value of U.S. imports of these items in 2019 was \$617 million. The leading sources for LPTs ( $\leq 100$  MVA)

into the United States in 2019 (by unit) were Mexico, where several global transformer manufacturers have manufacturing facilities (202 units); Austria, where [TEXT REDACTED]. These four countries accounted for 70 percent of U.S. imports by unit in 2019. On a value basis, the leading supplier

was Austria with \$188 million out of total U.S. imports of \$620 million, which implies that the LPTs from Austria are on average more expensive than those from Mexico.

One notable trend is that imports from Korea fell from a high of 128 units in 2016 to 67 in 2019, replaced by

production at Hyundai's U.S. facilities, which was not subject to tariffs. In addition, while not among the top five sources in 2019, China also supplied some LPTs for the U.S. electric grid. Although imports from China have declined from high of 47 units in 2015, 31 units were imported from China in the first six months of 2020, a number only behind Mexico and Austria. This is significant, as the President's emergency declaration and Bulk Power Executive Order is particularly concerned with possible vulnerabilities in the critical energy infrastructure due to sourcing from potential adversaries such as Russia and China.

Based on the level of imports compared to domestic production, it is clear that the U.S. BPS is heavily dependent on imported LPTs, which are among the most critical elements in the BPS. The U.S. dependency on foreign sources for LPTs has persisted for at least a decade; there has been little net change in total U.S. production capacity during this timeframe, with new investments offset by plant closures.

U.S. apparent consumption of LPTs was 750 units in 2019 (domestic production of 137 + imports of 617 – exports of 4 units). Thus, the import penetration level is over 82 percent. On a value basis, import penetration is slightly lower—about 73 percent based on apparent consumption of \$851 million (domestic sales of \$234 million, plus imports of \$620 million, less exports of \$2.6 million). The dependence of the U.S. electric grid on imported LPTs negatively affects the domestic GOES industry because imported transformers most often utilize foreign-origin GOES.

In contrast to the inadequate domestic production capacity for LPTs in the United States, China has abundant production capabilities. With Chinese demand for LPTs comparable to that of the United States, China has at least 30 LPT manufacturers. China's top three manufacturers can each produce double the total U.S. production capacity.<sup>91</sup>

As noted above, the grim state of domestic manufacturing capability for LPTs has persisted for more than a decade. In 2011, the ITC completed its antidumping investigation into imports of LPT from Korea. The investigation presented a detailed analysis of the state of the domestic industry at that time.<sup>92</sup> In 2010, there were six domestic manufacturers of LPTs, who were operating at an average capacity utilization rate of just 39.9 percent.

Imports accounted for 85 percent of apparent consumption (based on the total power handling capacity of units sold) or 81 percent of apparent consumption (value basis). The ITC found that the domestic industry was materially injured by the imports of LPTs from Korea that were being sold at less than fair value, which led to the imposition of tariffs.

In 2012, with an update in 2014, DOE also issued reports highlighting the deficiencies in domestic LPT industry. DOE's reports drew upon on ITC's industry data, but analyzed the information from the perspective of the implications for the nation's critical energy infrastructure rather than unfair trade practice issues. In its reports, DOE expressed concern over the lack of domestic production capabilities for large power transformers. DOE's 2014 update noted that some foreign investment in U.S. manufacturing facilities (e.g., by EFACEC, Hyundai, and Mitsubishi), as well as expansions by U.S. firms (SPX), contributed to a slight increase in domestic production capacity in the mid 2010's but that production still fell far short of domestic demand). Of the three foreign companies noted in DOE's report, only Hyundai still manufactures domestically and overall domestic production capacity has not increased.

In September 2018, five years after the imposition of antidumping duties on imports from Korea, the ITC reassessed the status of the domestic industry.<sup>93</sup> Since its initial report in 2011, the ITC noted a number of changes, both positive and negative, in domestic capacity/production (e.g., facilities closed, bought by other companies, opened). The ITC also examined the health of the domestic LPT industry compared to five years earlier (in 2013) and found that on all measures, the industry had deteriorated. Although the ITC withheld specific data from the public report, the report stated that employment, wages, sales, shipments, market share, and financial performance had all declined.

### 3. Reliance on Imported Key Components

Lack of domestic production capability for LPTs is exacerbated by the fact that most domestic manufacturers rely on imports for key transformer components, including electrical steel, laminations, and cores. In fact, none of the remaining domestic LPT

manufacturers source laminations or cores from U.S. suppliers, which highlights the lack of domestic capability in this area. Imported laminations and cores rely on almost exclusively non-U.S. GOES, which is significant because GOES, along with the copper used in the windings, accounts for a significant percentage of the cost of an LPT (up to 25 percent). GOES also accounts for between 75 percent and 90 percent of the cost of laminations, and 50–60 percent of the cost of transformer cores, based on the Department's survey data. As a result, price volatility and global market conditions for GOES continue to have an impact on the manufacturing and procurement strategies of LPT producers.

Specific company sourcing decisions, based on company responses detailed in the Department's survey, are as follows:

- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].

### 4. Other Issues Affecting LPT Manufacturers

Most of the domestic manufacturers of LPTs reported difficulty in hiring qualified workers, with more than 90 days required to source and train new employees. The companies reported experiencing a shortage of skilled production workers (e.g., testers, welders, and winders), field technicians, and design engineers. In addition, the workforce is aging, and it is difficult to attract younger workers to this industry and to the geographical regions in which the companies are located.

Several of the companies also reported being negatively impacted by foreign competition, particularly from South Korea and Mexico. Despite the successful antidumping investigation that resulted in the imposition of import duties, domestic transformer manufacturers stated that they continue to be disadvantaged due to the protection/subsidization of South Korean manufacturers by their government. Specific to Mexico, domestic producers cited the low cost labor there as to their detriment. In addition, some domestic transformer companies that make laminations and cores in-house reported adverse effects vis-à-vis their foreign competitors as a result of the Section 232 tariffs on GOES.

### F. Voltage Regulators

Six companies responding to the Department's survey indicated domestic

<sup>91</sup> DOE LPT Report, 2014.

<sup>92</sup> [https://www.usitc.gov/publications/701\\_731/Pub4256.pdf](https://www.usitc.gov/publications/701_731/Pub4256.pdf).

<sup>93</sup> ITC, "Large Power Transformers from Korea," Investigation No. 731-TA-1189, September, 2018, pp. 30–31. See Appendix F for additional information.

production of voltage regulators; most of these companies also produce liquid dielectric transformers in the United States. [TEXT REDACTED]. It is a major player in many of the other transformer categories, but the production of these products takes place in at offshore locations. [TEXT REDACTED].

The top four companies, which accounted for over 95 percent of reported production, were [TEXT REDACTED]. Imports of voltage

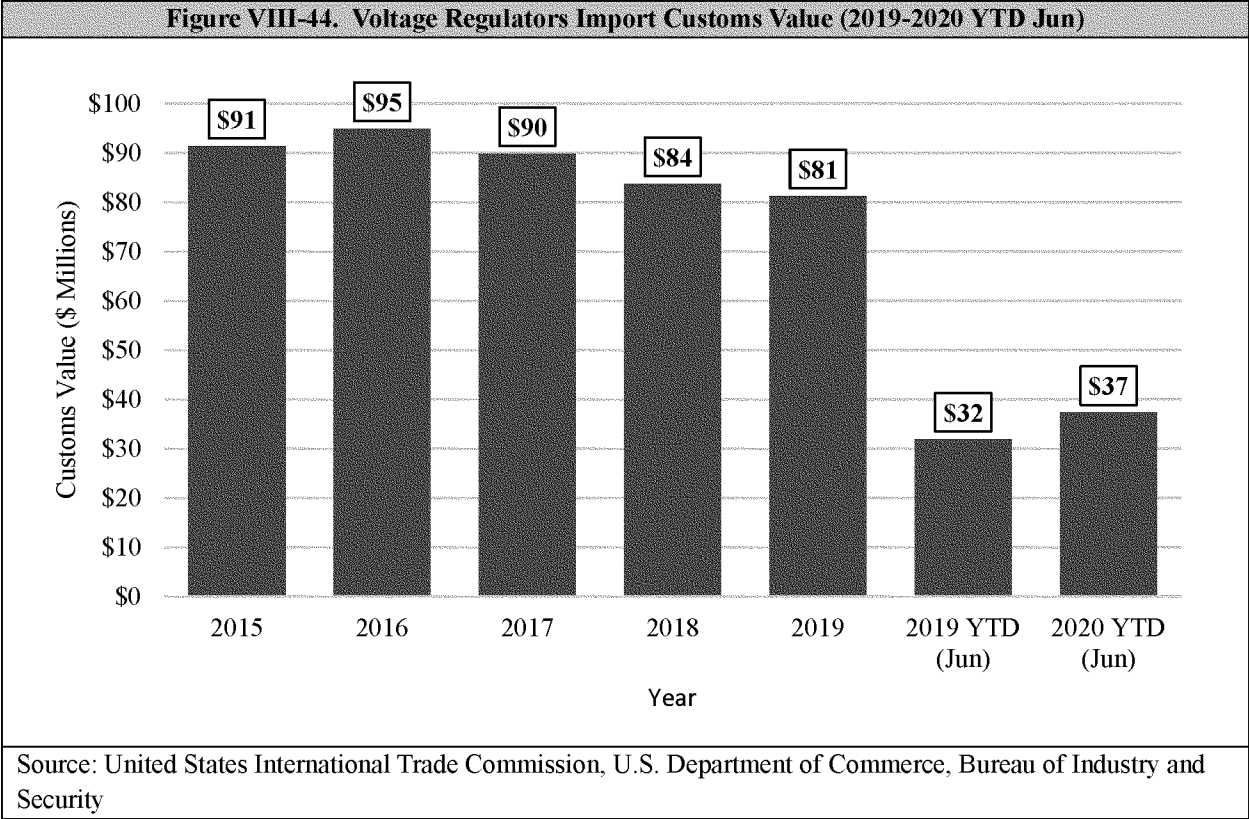
regulators have fallen slightly in recent years, to \$81 million in 2019. The leading sources of imports were Canada, Germany, the United Kingdom, and Mexico.

[TEXT REDACTED]

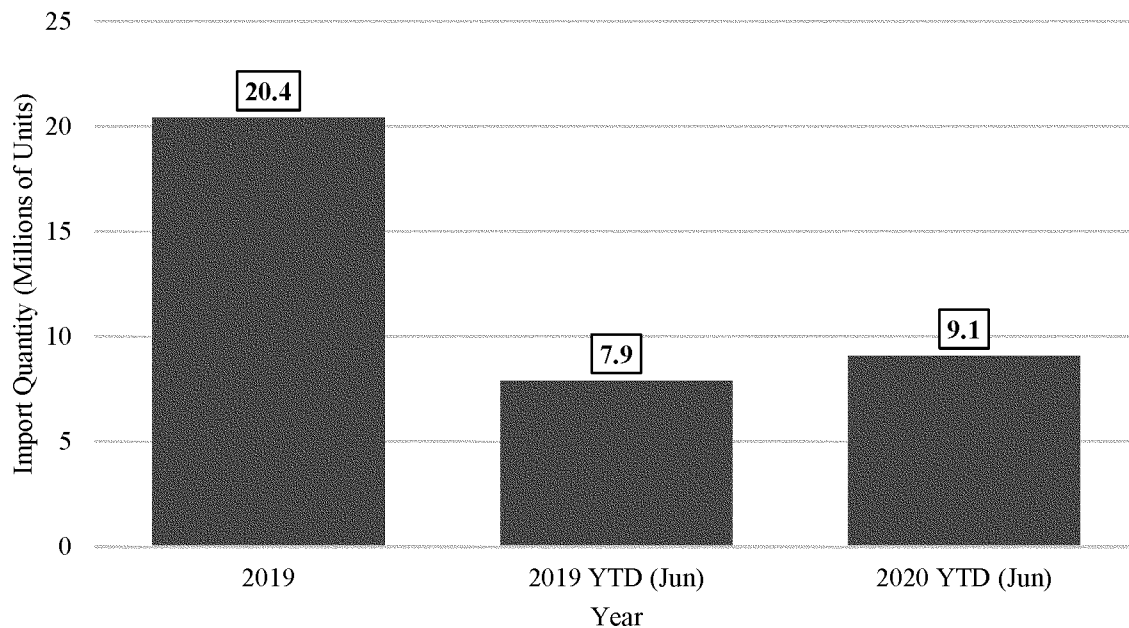
Import statistics do not appear to represent the voltage regulator segment of this investigation well. The large volume of imports (with low average

unit values) captured by the Harmonized Tariff Schedule category under which voltage regulators fall (HTS 9032.89.4000 <sup>94</sup>) includes many products unrelated to this investigation. Therefore, import penetration levels cannot be calculated. However, as mentioned, the manufacturers of voltage regulators are all major players in the other transformer categories that are addressed in this report.

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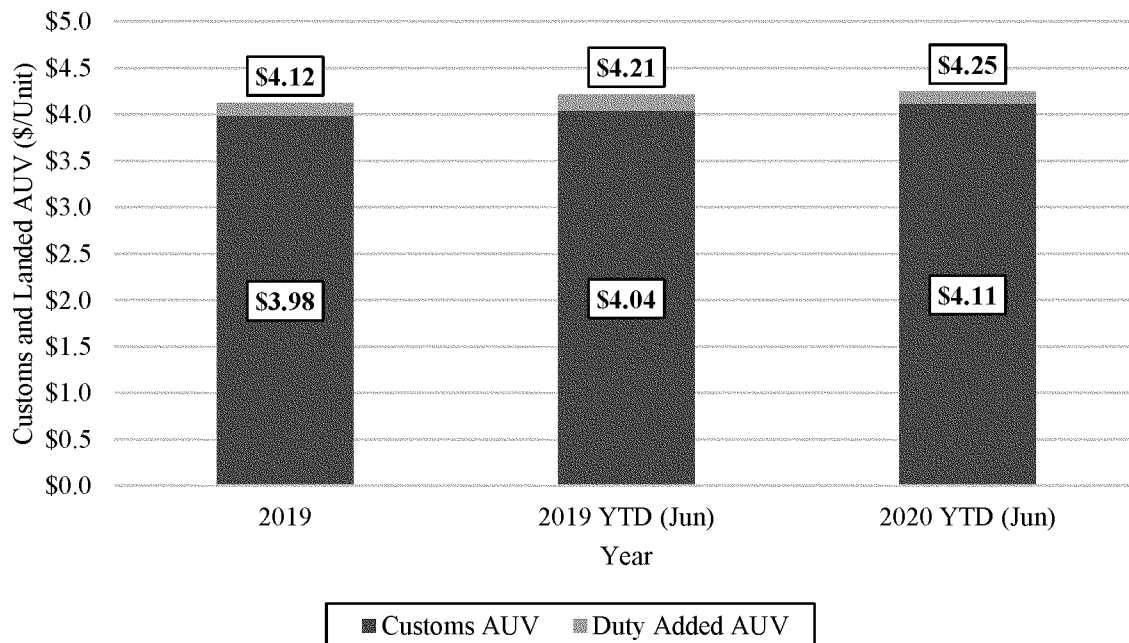


<sup>94</sup> Automatic voltage and voltage-current regulators, other than designed for use in a, 12, or 24 V system.

**Figure VIII-45. Voltage Regulators Import Customs Quantity (2019-2020 YTD Jun)\***

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

\*Quantity Data Pre-2019 Unavailable

**Figure VIII-46. Voltage Regulators Import Customs AUV (2019-2020 YTD Jun)**

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

\*Data labels indicate the final Duty Landed AUV

\*\*Quantity Data Pre-2019 Unavailable

<b>Figure VIII-47. Voltage Regulators</b>				
<b>Import Quantities by Top 10 Countries (Thousands of Units, 2019-2020 YTD Jun)</b>				
<b>Country</b>	<b>2019</b>	<b>2019 YTD (Jun)</b>	<b>2020 YTD (Jun)</b>	<b>SUM*</b>
<b>Canada</b>	9,025	3,435	6,039	<b>15,064</b>
<b>Germany</b>	4,671	1,482	154	<b>4,824</b>
<b>United Kingdom</b>	2,163	989	697	<b>2,859</b>
<b>Mexico</b>	1,165	463	641	<b>1,807</b>
<b>France</b>	650	186	384	<b>1,035</b>
<b>China</b>	746	353	238	<b>984</b>
<b>Philippines</b>	58	52	468	<b>526</b>
<b>Japan</b>	280	157	138	<b>419</b>
<b>Singapore</b>	411	224	0.028	<b>411</b>
<b>India</b>	260	161	32	<b>292</b>

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

\*Excludes 2019 YTD (Jun) Data

\*\*Quantity Data Pre-2019 Unavailable

<b>Figure VIII-48. Voltage Regulators</b>				
<b>Customs Value Imports AUV by Top 10 Countries (\$/Unit, 2019-2020 YTD Jun)</b>				
<b>Country</b>	<b>2019</b>	<b>2019 YTD (Jun)</b>	<b>2020 YTD (Jun)</b>	<b>AVG*</b>
<b>Singapore</b>	\$1.9	\$2.1	\$1,798.1	<b>\$900.0</b>
<b>Japan</b>	\$10.0	\$7.3	\$13.6	<b>\$11.8</b>
<b>Mexico</b>	\$10.0	\$6.4	\$12.8	<b>\$11.4</b>
<b>Philippines</b>	\$15.0	\$12.9	\$1.9	<b>\$8.5</b>
<b>Germany</b>	\$2.6	\$3.0	\$14.2	<b>\$8.4</b>
<b>China</b>	\$7.1	\$7.9	\$8.9	<b>\$8.0</b>
<b>United Kingdom</b>	\$6.2	\$5.1	\$5.6	<b>\$5.9</b>
<b>India</b>	\$2.8	\$3.3	\$6.0	<b>\$4.4</b>
<b>France</b>	\$4.5	\$6.5	\$3.5	<b>\$4.0</b>
<b>Canada</b>	\$2.3	\$2.4	\$2.2	<b>\$2.2</b>

Source: United States International Trade Commission, U.S. Department of Commerce, Bureau of Industry and Security

\*Weighted Average by Quantity, Excludes 2019 YTD (Jun) Data

\*\*Quantity Data Pre-2019 Unavailable

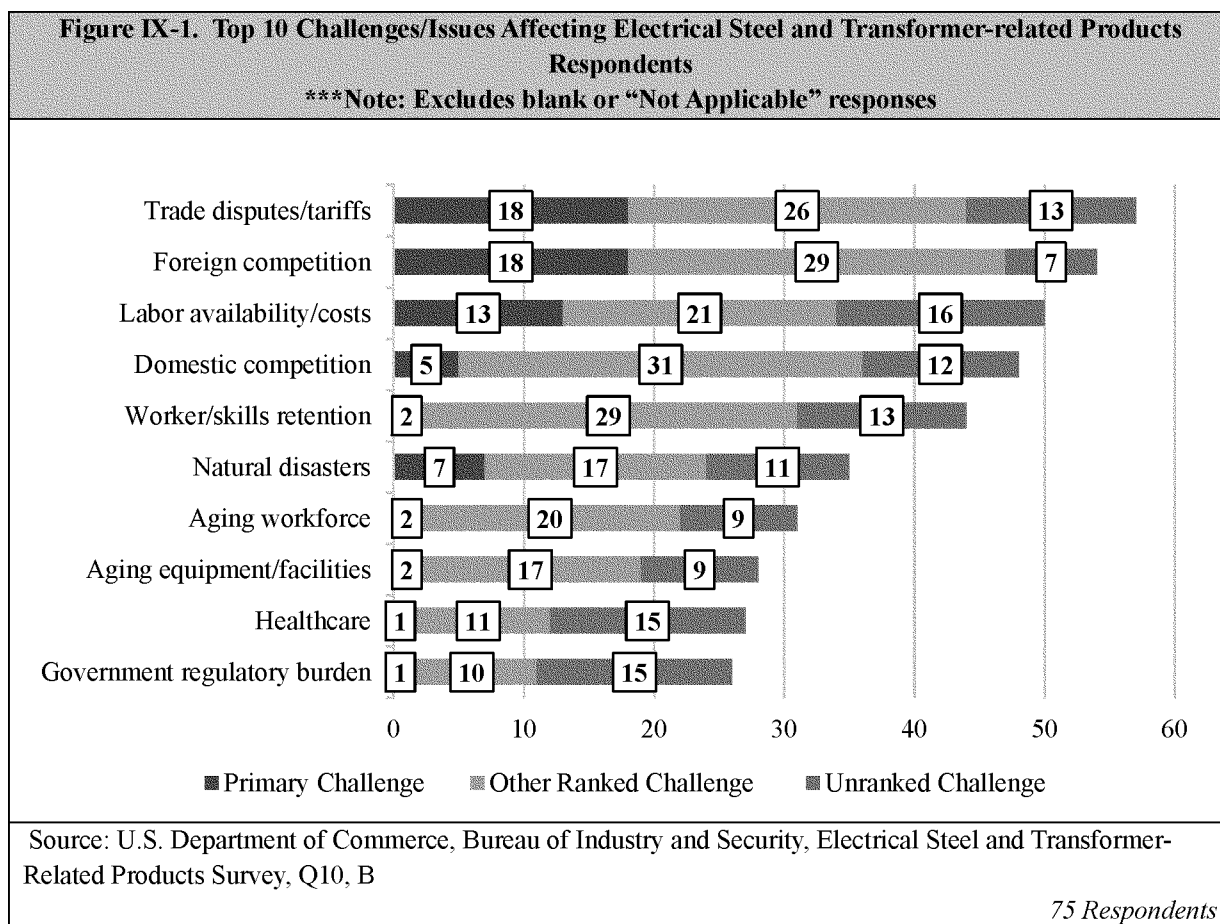
## IX. Competitiveness and Labor Issues

### A. Competitiveness

Recipients of the Department's survey were asked to identify and rank the top five challenges or issues affecting their global competitiveness position from a list of more than thirty options. In general, there was little difference in

responses among the respondents by specific transformer-related product sector. The most commonly identified primary challenge to their competitiveness reported was either trade disputes/tariffs or foreign competition. Seventy-six percent of respondents identified trade disputes/tariffs as a challenge, including 24

percent of respondents that noted it as the number one issue affecting their company's competitiveness. Similarly, 72 percent of respondents identified foreign competition as a challenge. Labor availability/cost was the third most commonly identified challenge and will be addressed in more detail in section B of this chapter.



### 1. Transformer Components

While mentioned by a majority of survey recipients across product categories, foreign competition is a particularly significant problem for the transformer cores and laminations sector. Of the survey respondents who produce laminations and cores for incorporation into transformers, 91 percent indicated that foreign competition is a major challenge. These responses are consistent with import data which show that imports of laminations increased 57 percent and imports of cores increased 61 percent between 2018 and 2019.<sup>95</sup>

Almost all of the domestic transformer lamination and core producers participating in the Department's survey took the opportunity to provide specific commentary on competitiveness issues. In particular, they were asked to describe how their competitiveness has been affected and to provide any recommendations specific to the U.S. Government's response, including steps to mitigate the challenges that they face (Survey question 10 D). All the

respondents in this sector presented similar information on the issues affecting their competitiveness but had different approaches and suggestions to address them. While many recommended imposing tariffs on downstream transformer components and finished transformers, others recommended removing the tariffs on imported GOES.

- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED].
- [TEXT REDACTED] to preserve what is left of the U.S. transformer industry.

While the domestic manufacturers of laminations and cores have been negatively affected by imports, some transformer companies that purchase these components for incorporation into transformers benefitted during the same time period. In particular, increased competition in the lamination and core sector was beneficial to their

competitiveness, as it led to reduced costs for these items.

### 2. Distribution, Small & Medium Power Transformers and Dry-Type Transformers

As compared to survey respondents from the transformer core and laminations sector, while increasing foreign competition was also a significant challenge for distribution, small and medium power, and dry-type transformer producers, a larger number of this group of survey respondents indicated labor-related issues as their number one concern. Labor challenges were listed by 17 out of the 19 distribution and small-power transformer manufacturers, and by nine out of ten medium-power transformer manufacturers. With regard to dry-type transformers, seventy percent of manufacturers indicated trade disputes/tariffs were challenges. Similarly, 60 percent and 55 percent of respondents in this group regarded foreign competition and labor availability/costs as challenges, respectively.

With regard to competitiveness issues, several of the transformer companies expressed strong opposition to the expansion of tariffs to downstream

<sup>95</sup> [TEXT REDACTED].



products because such an expansion would harm their competitiveness by increasing their costs and disrupting their supply chain.) Instead, they recommended the elimination of existing tariffs on GOES [TEXT REDACTED]. However, other transformer companies, facing the same competitive pressures due to rising material costs, recommended extending the tariffs to include complete transformers [TEXT REDACTED].

3. Large Power Transformers

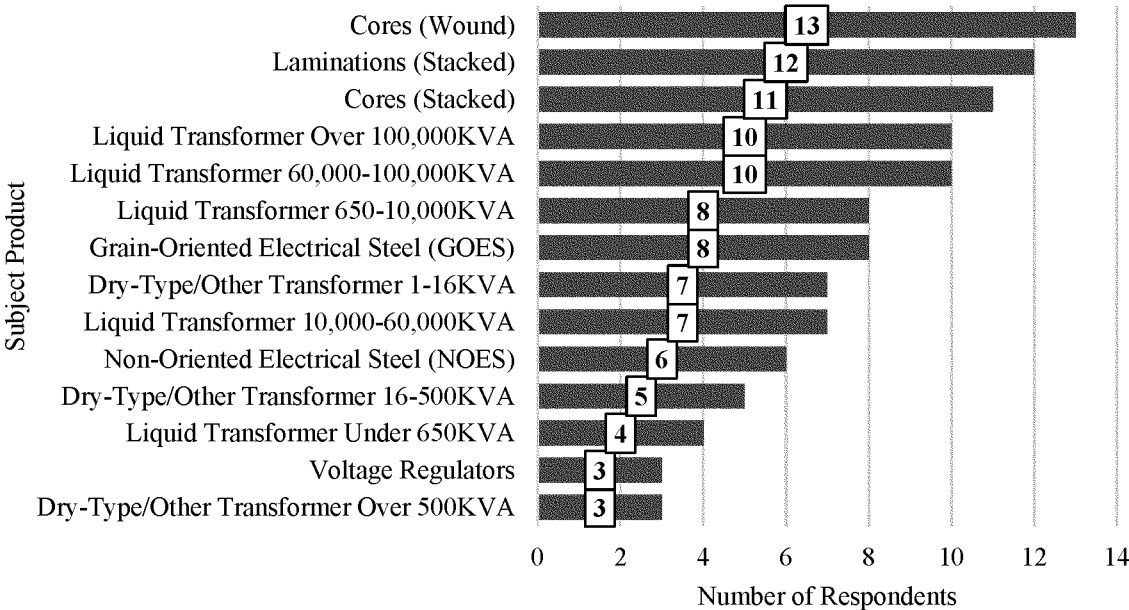
For the manufacturers of LPTs, foreign competition was again the leading problem. All seven survey

participants in this industry sector expressed this concern. The domestic producers were particularly concerned about competition from South Korea, where companies benefit from subsidies and protection by the South Korean Government. Increased competition from Mexico was also identified as a challenge. Other frequently mentioned issues affecting the competitiveness of large power transformer manufacturers were trade disputes/tariffs (specifically the increased production costs due to GOES tariffs), labor availability/costs, and aging equipment, facilities, or infrastructure.

4. Changes in Competition

In addition to identifying specific factors affecting them, survey respondents were asked to indicate whether or not there had been a significant change since 2018 with regard to foreign competition in any of the product categories subject to this investigation and whether the change was positive, negative, or neutral. Not surprisingly, respondents reported that significant increases in import competition are most prevalent in the wound cores, stacked laminations, and stacked cores product categories (*i.e.*, the product categories of which GOES is the primary input).

Figure IX-2. Electrical Steel and Transformer-related Products by Increased Import Competition Since 2018



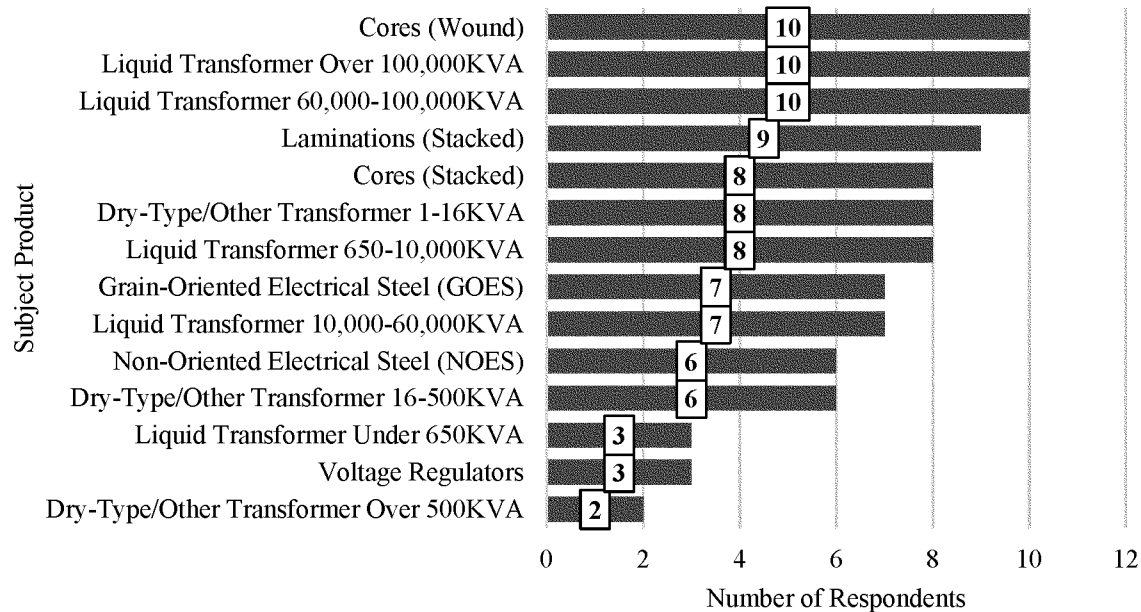
Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q10, A

39 Respondents

An overwhelming majority of the respondents that indicated an increase in import competition also indicated that the increase in competition had a

negative effect on their organizations. However, as mentioned above, some transformer manufacturers have benefitted from increased competition,

specifically in the component sector from which they source.

**Figure IX-3. Electrical Steel and Transformer-related Products Import Competition Change Since 2018 by Negative Organization Impact**

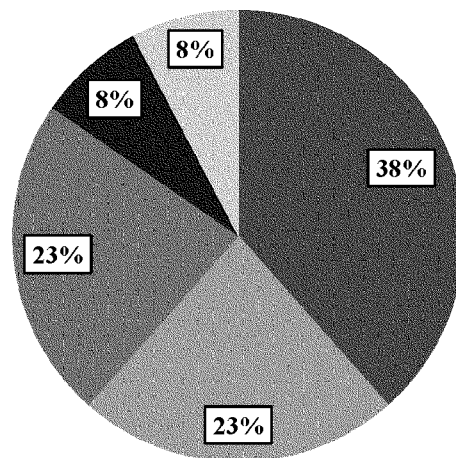
Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q10, A

36 Respondents

The countries most often listed as the source of increased foreign competition were Canada, China, Japan, and Mexico. For wound cores, Japan was mentioned

most frequently, followed by Canada and Mexico. In contrast, Japan was not mentioned as a source of competition for laminations; Canada was most often

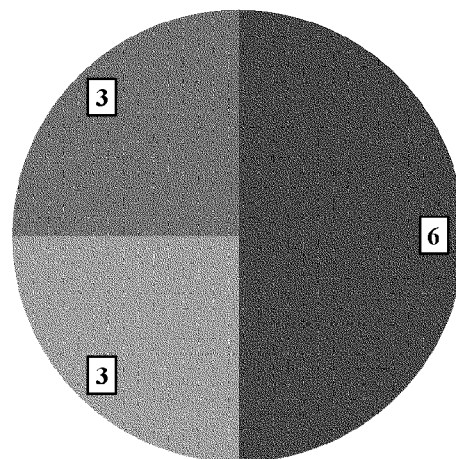
mentioned, followed by China and Mexico. For stacked cores, import competition was identified as coming from Canada, China, Mexico, and Japan.

**Figure IX-4. Cores (Wound) – Primary Source Country of Increased Import Competition Since 2018**

■ China ■ Canada ■ Mexico ■ India ■ Japan

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q10, A

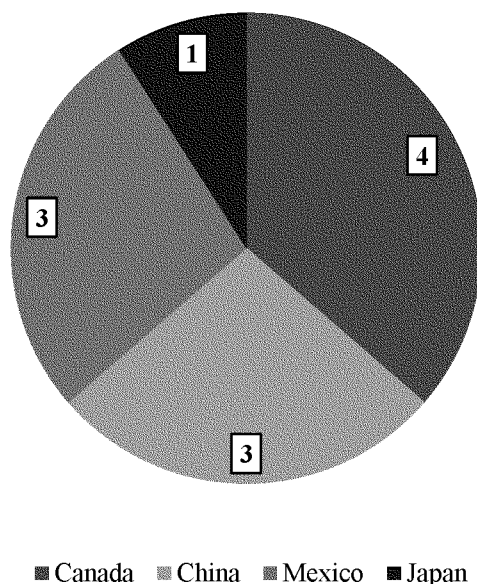
*13 Respondents*

**Figure IX-5. Laminations (Stacked) – Primary Source Country of Increased Import Competition Since 2018**

■ Canada ■ China ■ Mexico

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q10, A

*12 Respondents*

**Figure IX-6. Cores (Stacked) – Primary Source Country of Increased Import Competition Since 2018**

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q10, A

11 Respondents

#### B. Labor

In addition to questions about the labor-related issues affecting competitiveness, survey recipients were asked specific questions related to their workforce. On average, survey respondents that manufactured transformers or transformer components in the United States indicated that labor accounted for 36 percent of their costs, with a range between 1 percent and 83 percent.

Eighty-nine percent of survey respondents reported having had difficulties in finding qualified or

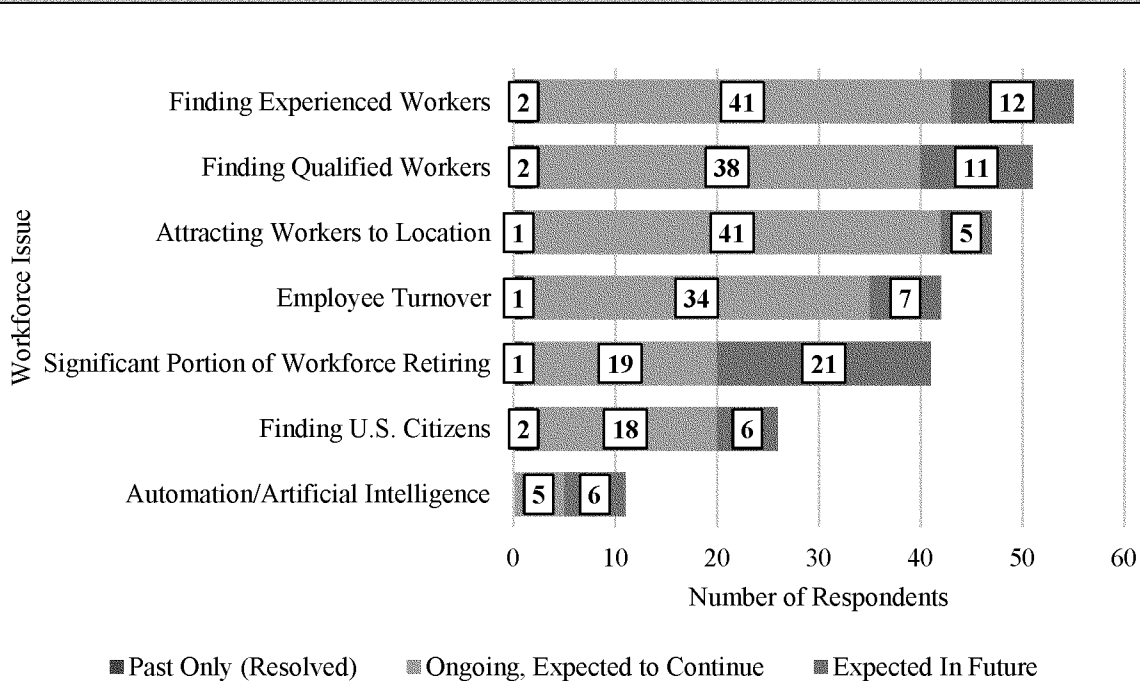
experienced workers, including 66 percent that identified the problem as an ongoing issue. This is significant, as transformer manufacturing requires specialized skills including welding, coil winding, and transformer testing. Survey respondents indicated that U.S. high schools do not offer programs that train young people for skills such as these. Transformer manufacturers also experienced difficulties in hiring employees with certain educational backgrounds or training, including manufacturing engineers, power electrical engineers, quality control, and electrical design engineers. Several

respondents mentioned that few universities offer training in these areas.

Survey respondents reported an aging workforce and trouble attracting and retaining younger workers. Seventy-eight percent of respondents that identified anticipated future workforce issues regarded the possibility of a significant portion of their workforce retiring as a challenge affecting their company. The location of the production facilities in remote and/or less desirable/economically challenged areas was cited by nearly 80 percent of survey respondents as a factor inhibiting attracting qualified labor.

**Figure IX-7. Workforce Issues Experienced by Electrical Steel and Transformer-related Products Respondents**

\*\*\*Note: Excludes blank or "Not Applicable" responses

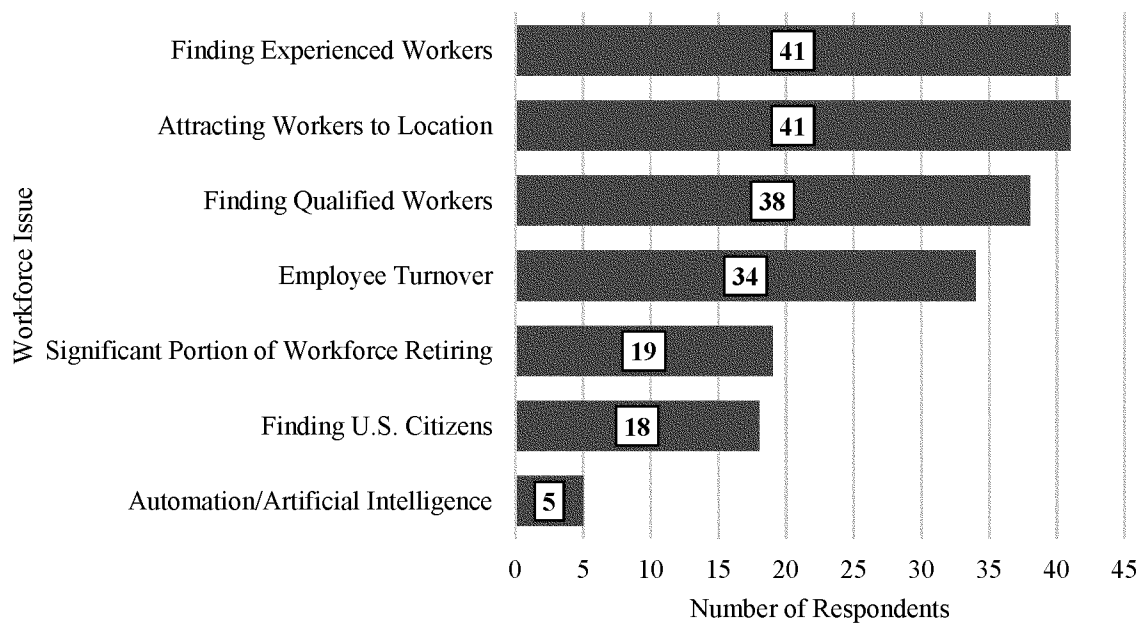


Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q7, B

62 Respondents

**Figure IX-28. Ongoing Workforce Issues Experienced by Electrical Steel and Transformer-related Products Respondents**

**\*\*\*Note: Excludes blank or "Not Applicable" responses**

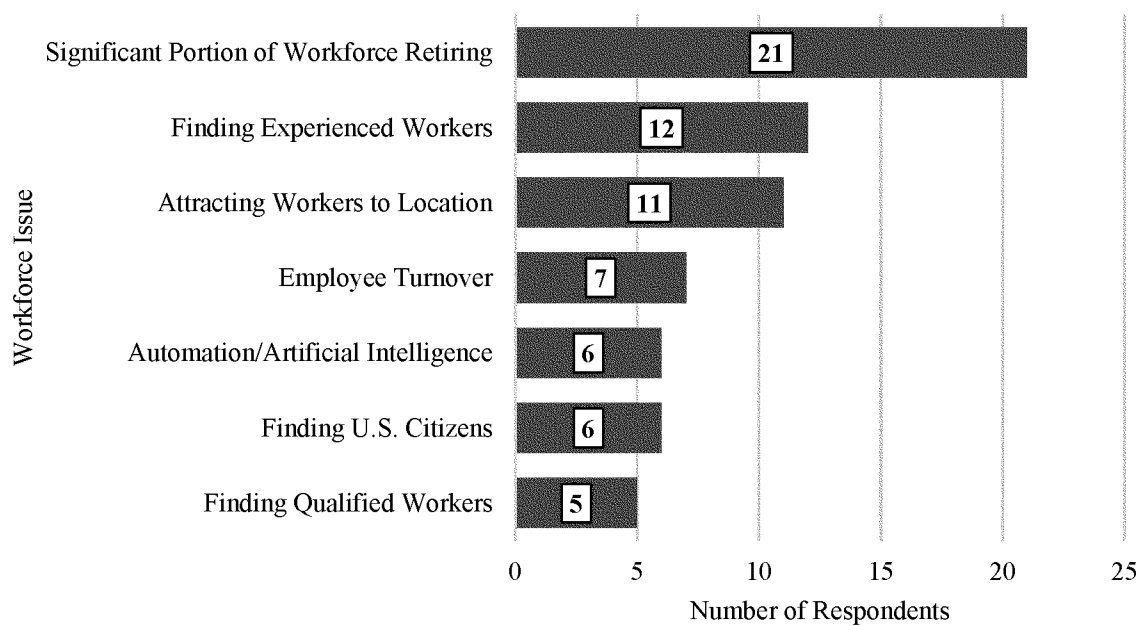


Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q7, B

52 Respondents

**Figure IX-9. Expected Future Workforce Issues Experienced by Electrical Steel and Transformer-related Products Respondents**

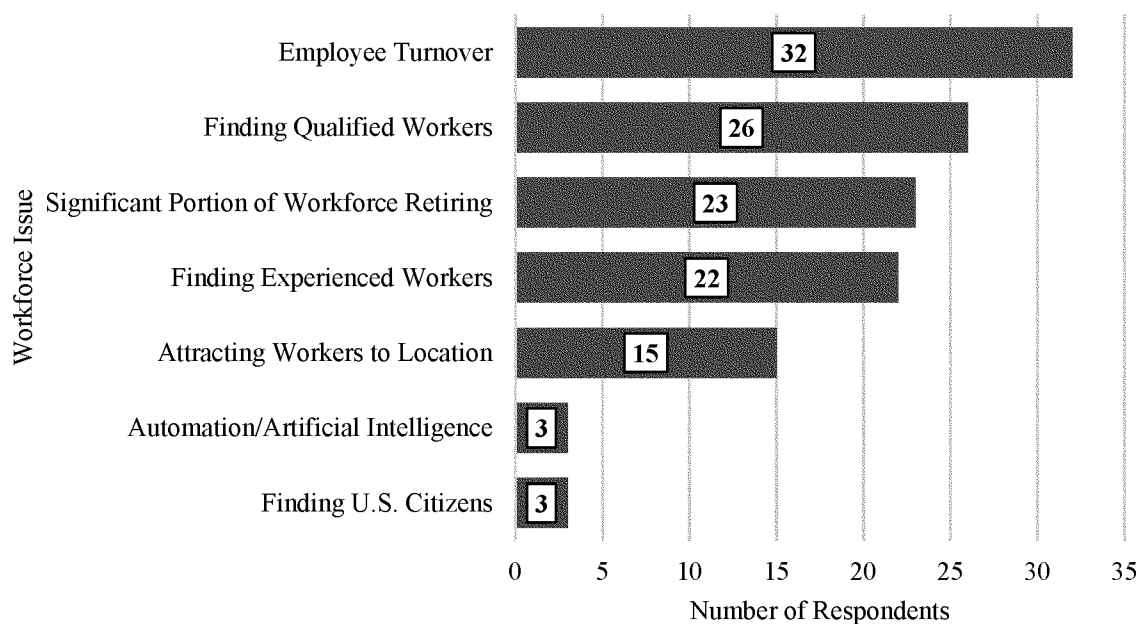
**\*\*\*Note: Excludes blank or "Not Applicable" responses**



Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q7, B

27 Respondents



**Figure IX-10. Workforce Issues Affecting Production Line Workers among Electrical Steel and Transformer-related Products Respondents****\*\*\*Note: Excludes blank or "Not Applicable" responses**

Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q7, B

47 Respondents

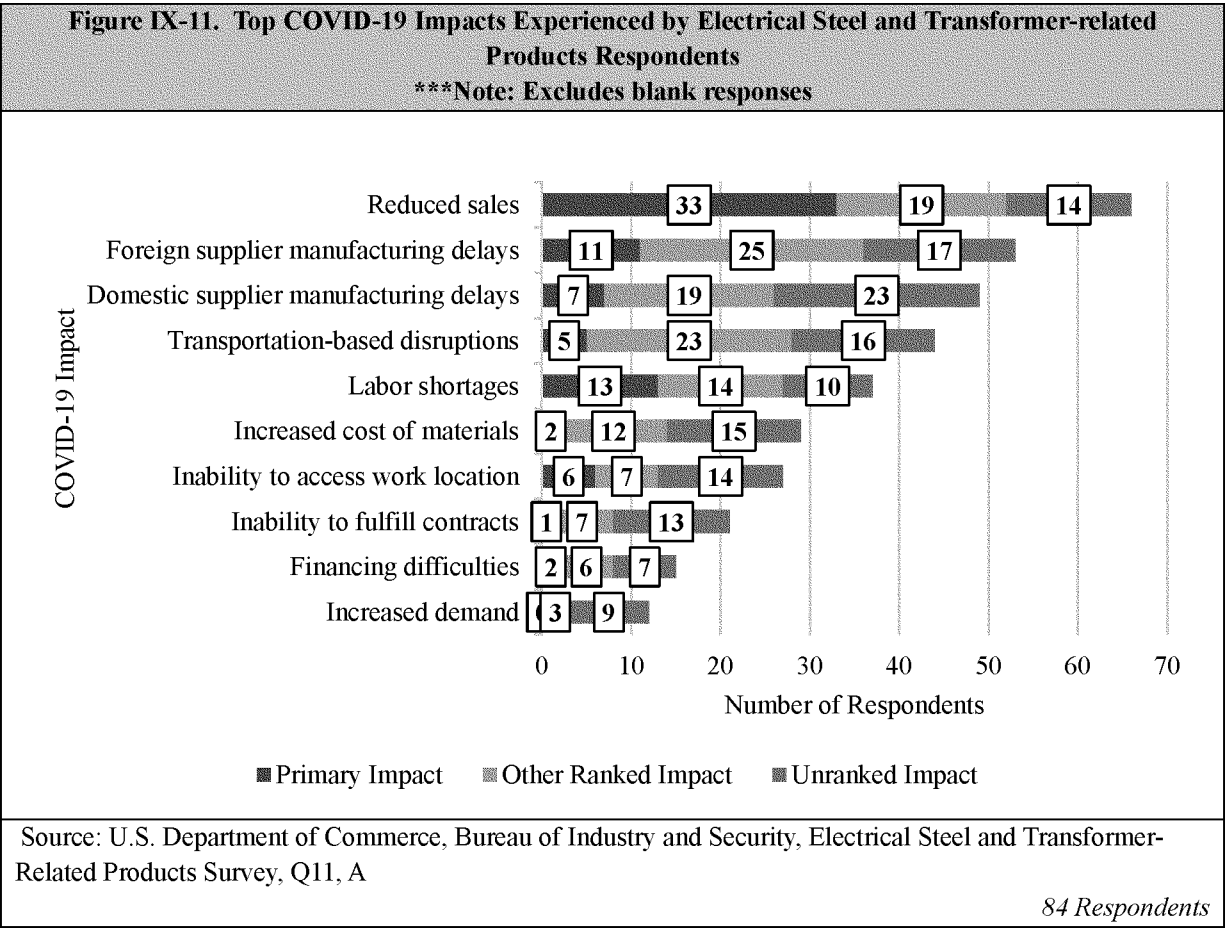
### C. COVID-19 Impact

This investigation and the industry survey associated with it were conducted during the time of the COVID-19 pandemic in the United States. The Department included questions on the survey related to COVID-19, as situations such as a global pandemic can disrupt supply chains and production. If they persist, these

disruptions may have implications on the ability of the industry to support critical national security and energy infrastructure needs.

Survey respondents were queried on specific ways the pandemic impacted their organization and their responses are listed in the tables below (note that respondents could list multiple impacts/responses). Only three respondents indicated that they

experienced no impact from COVID-19. Of the remaining respondents, 79 percent indicated that the pandemic reduced their organization's sales, including 38 percent that noted reduced sales as the primary coronavirus-related impact. Similarly, 63 percent and 58 percent of respondents, respectively, experienced foreign and domestic supplier manufacturing delays.



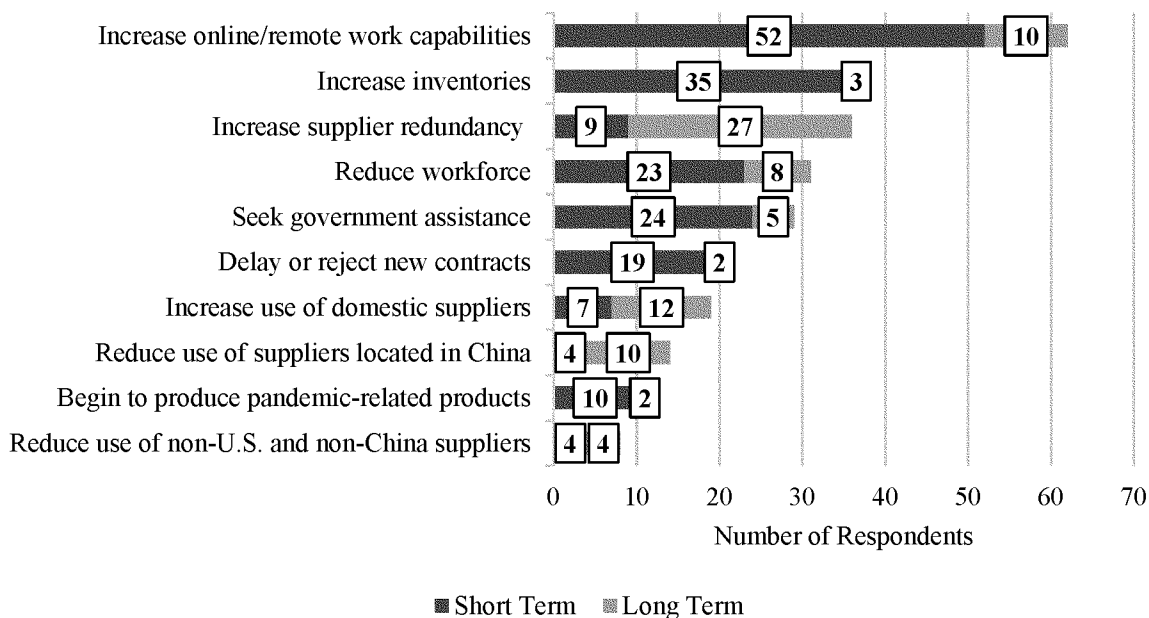
As reported, foreign supplier delays as a result of the Covid-19 pandemic were most prevalent among transformer manufacturers. Of the transformer manufactures that experienced foreign supplier delays, 50 percent manufacture dry-type/other transformers 1–16 KVA. An additional 43 percent and 40 percent of respondents that experienced foreign supplier delays manufacture liquid-dielectric transformers 650–10,000KVA and dry-type/other Transformers 16–500KVA, respectively. However, only

one wound core manufacturer reported that COVID-19 resulted in foreign supplier manufacturing delays; such delays were not reported by any lamination or stacked core manufacturers. These percentages generally correspond to the numbers of each type of manufacturer participating in the survey, they do not indicate that foreign supplier delays or other impacts were concentrated in any particular sector.

The most common response to the pandemic was to allow non-production line workers to work remotely, with 76 percent of respondents increasing online/remote work capabilities, including 63 percent of respondents that classified it as a short-term solution. Similarly, 45 percent and 44 percent of respondents increased their inventories and supplier redundancy, respectively. Five respondents indicated that their organizations took no action in response to the COVID-19 pandemic.

**Figure IX-12. Top Actions Taken in Response to COVID-19 by Electrical Steel and Transformer-related Products Respondents**

\*\*\*Note: Excludes blank responses



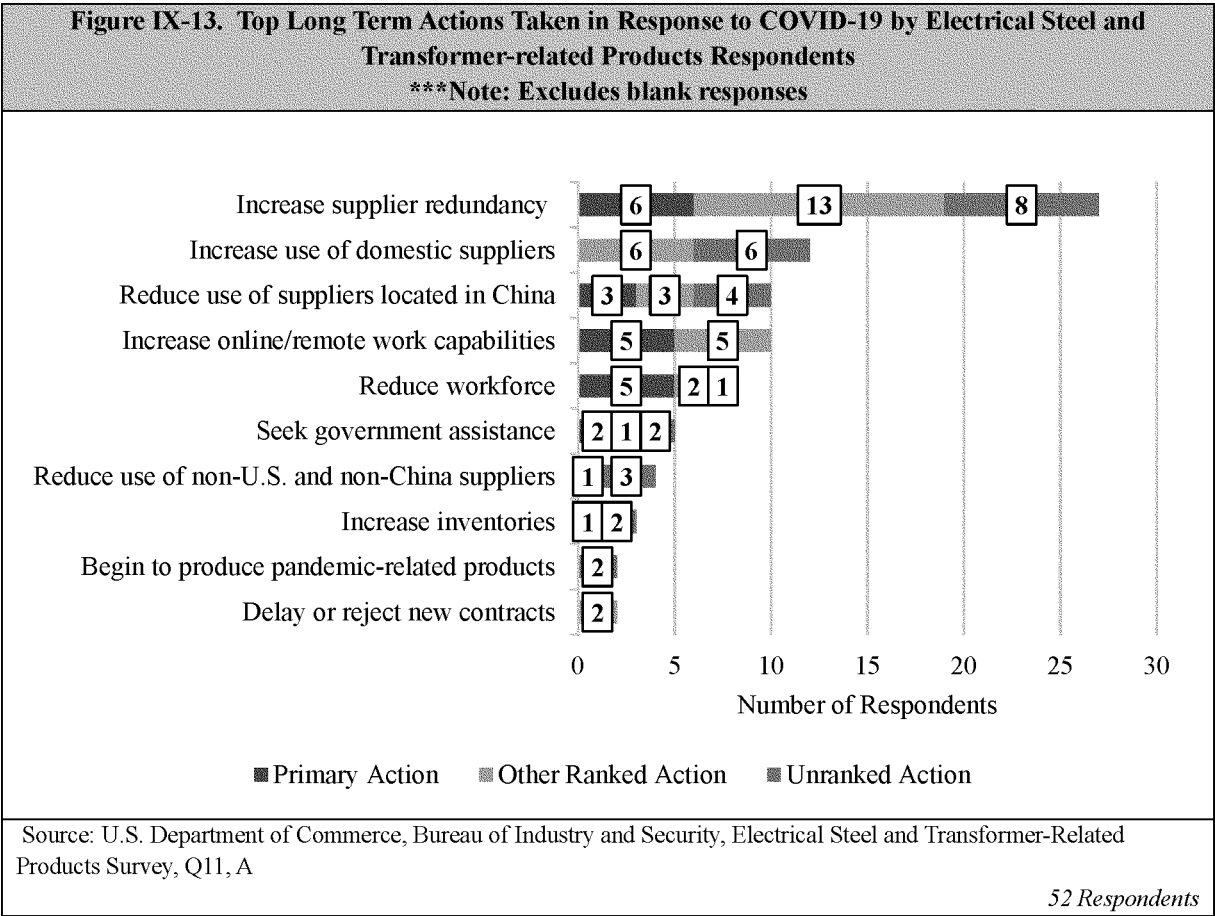
Source: U.S. Department of Commerce, Bureau of Industry and Security, Electrical Steel and Transformer-Related Products Survey, Q11, A

82 Respondents

Thirty-five respondents indicated that their organizations took no long-term actions in response to the pandemic. Of

the respondents that took long-term action, 52 percent indicated that they increased supplier redundancy.

Similarly, 23 percent of respondents increased their use of U.S. suppliers and reduced their use of suppliers in China.



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**X. Findings and Recommendations**

**A. Findings**

**1. Grain-Oriented Electric Steel**

As was determined by the 2017 Section 232 Investigation on the Impact of Imports of Steel on the National Security, GOES is critical to the national security. The United States must maintain a secure supply and robust production capacity for GOES, which was found to be harmed by imports brought on by unfair trade practices and artificially-induced global excess capacity. GOES is essential to the production and function of transformers of all power handling capacities that form the backbone of the U.S. electrical grid. Sufficient domestic production capacity for GOES is necessary in order to ensure the ability of the United States to address threats facing our critical energy infrastructure.

This investigation finds that imports of downstream GOES products, namely laminations for incorporation into transformers, and stacked and wound cores for incorporation into transformers, have negatively affected domestic GOES production, as these key

transformer components are the primary market for GOES. The value of U.S. imports of laminations has more than doubled from \$15 million in 2015 to \$33 million in 2019. Core imports were \$22 million in 2015 and soared to \$167 million in 2019. Together, Mexico and Canada account for more than 95 percent of these imports. As domestic demand for transformers has not increased, increased imports of laminations and cores represent displaced domestic production, and hence, domestic consumption of GOES.

There is only one remaining domestic producer of GOES (AK Steel), at which capacity utilization stands at [TEXT REDACTED] in 2019 due to loss of the domestic market to imported laminations and cores. At this capacity utilization level, the company cannot operate profitably and there is a risk it will cease GOES production altogether. Moreover, poor profitability over a number of years has impeded and will impede the ability of the sole U.S. manufacturer of GOES to invest in modern capital equipment necessary for it to produce sufficient quantities and qualities of GOES to meet domestic demand.

**2. Transformer Laminations and Stacked and Wound Cores**

The large increase in imports of transformer laminations and cores has not only hindered domestic GOES production, but also leaves the United States with a lack of sufficient capacity to produce these items that are essential to modern, efficient transformers. The United States transformer industry has become highly dependent on foreign sources for laminations and cores, and imports have displaced domestic production, leaving domestic capacity to manufacture them insufficient and in some cases is in danger of closing down. While the majority of imports of these items come from Canada and Mexico, neither country has indigenous production capability for the GOES which is the main material in them. Therefore, imports of transformer laminations and cores contain foreign-origin GOES, including some from potentially unreliable suppliers in China and Russia. Lack of domestic capacity and dependence on imports for these transformer components puts at risk the ability to maintain and repair the existing electric grid in the face of increasingly emboldened foreign adversaries.

### 3. Large Power Transformers

This investigation further finds that imports of LPT (those with power handling capacities of 100 MVA and above), pose a dual threat to the national security by constraining U.S. GOES production, as well as materially harming domestic LPT production. In this sector, imports account for over 80 percent of consumption, and the five remaining U.S.-based manufacturers are operating at less than 40 percent of capacity. Domestic production capability, even if operating at full capacity, falls far short of the ability to meet demand. Of particular concern is lack of domestic capacity with regard to extra high voltage transformers (those with >345 kV voltage rating) that are vital for long distance electricity transmission. This excessive level of foreign dependence on imported LPT, which are uniquely critical to the BPS, puts the resiliency of the critical energy infrastructure at risk. The global pandemic of 2020 has shown U.S. vulnerability to supply-chain shocks and has highlighted the need to ensure the availability of key equipment and major subcomponents thereof from American companies.

The Secretary therefore finds that laminations for incorporation into transformers, stacked and wound cores for incorporation into transformers, and LPT are being imported into the United States in such quantities and under such circumstances as to threaten to impair U.S. national security.

Because electricity, and therefore transformers, are vital to the nation's national defense and economy, the United States must maintain sufficient capacity to produce GOES, transformer laminations and cores, and LPT that can be drawn upon to address sudden disruptions or outages in the electric grid, be they due to natural disasters, physical strikes or cyberattacks. Moreover, extreme reliance on foreign sources for these essential items leaves the United States vulnerable to disruptions in the supply chain, whether due to interruptions in transportation routes, production processes (e.g., pandemics, civil unrest, work stoppages) or foreign government economic sanctions.

With regard to other electrical transformers (dry-type and liquid dielectric transformers with less than 100 MVA power handling capacity) and transformer regulators that were also subject to this investigation, the Secretary does not find that these items are being imported in such quantities or under such circumstances as to threaten

to impair the national security at this time.

Overall, domestic production of these products is sufficient to support critical infrastructure and national security requirements, and U.S. firms remain competitive. However, domestic manufacturers of these products were found to be highly dependent on imported transformer laminations and cores and the foreign-origin GOES contained in them. Robust domestic production capability for these subcomponents, including GOES, will minimize supply chain risks for manufacture of these transformers and transformer regulators and support critical infrastructure requirements across all levels of the distribution system.

#### B. Options

The following are seven non-mutually exclusive options to address the threats to United States national security posed by imports that the Secretary identified in this investigation. A discussion of the potential benefits and drawbacks of each option follows.

1. Negotiate either bilaterally or trilaterally with Canada and Mexico to reduce imports of subject products and/or to utilize more U.S. GOES in their production
2. Impose tariffs or quotas on imports of some or all of the products subject to this investigation
3. Provide direct production subsidies or R&D, capital expenditure loans, or other financial incentives to support domestic production of subject products.
4. Impose domestic content requirements for transformers
5. Establish a Stockpile for some or all of the subject products
6. Change the Harmonized Tariff classification for laminations and cores to the steel HTS category rather than the transformer category
7. Establish a working group to provide further recommendations

#### 1. Negotiate With Canada and Mexico

As this investigation found, Canada and Mexico are the leading sources of imports of products subject to this investigation. Imports of transformer laminations and transformer cores from Canada have increased dramatically since 2015, and with imports from Mexico, account for over 95% of U.S. imports of these products. In addition, Mexico has a substantial transformer manufacturing industry, and is the leading source for LPT for the U.S. electrical grid.

Mexico, and especially Canada, are close allies and trading partners. Per

agreement, Canada is considered part of the U.S. Defense and Technology Base. In addition, both countries have highly interconnected electrical grids with the United States and cooperate on ways to ensure the resiliency and address threats to the North American BPS. Neither country has production capability for GOES that is a key material supporting equipment in the electrical grid. It is therefore not only in the security interests of the United States to maintain a source of GOES, but also in the interests of Canada and Mexico as well.

Thus, negotiate with Canada and Mexico to address the threats to the North American security posed by the potential loss of U.S. GOES production. Seek through negotiations to increase consumption by Mexican and Canadian transformer and transformer component manufacturing sectors of U.S. GOES and sub-assemblies. This option may include purchasing agreements with both countries, as well as voluntary agreements limiting imports from select countries. This option is expected to be budget neutral and ensures continued cooperation on behalf of all parties through the USMCA and other bi- and multi-lateral treaties.

Under this agreement, a purchasing agreement will increase the demand and production for domestic GOES. A purchasing agreement would guarantee a United States market share in both the Canadian and Mexican transformer manufacturing sectors. Canadian and Mexico primarily export their transformers and transformer components to the United States. A purchasing agreement will ensure that domestically consumed transformers will rely on United States GOES production despite their manufacture in Canada and Mexico. Should a purchasing agreement not be feasible, voluntary trade restrictions may be another option.

A voluntary trade agreement to limit the import of GOES from China and Russia by Canada and/or Mexico could encourage demand for U.S. GOES. To complement Executive Order 13920 (E.O. 13920 or Bulk Power Executive Order), limiting GOES, laminations, and core imports from China and Russia will ensure greater security for United States, Canadian, and Mexican BPS. The Secretary of Commerce recommends pursuing both a purchasing agreement and a voluntary limitation on imports from China and Russia.

#### 2. Tariff/Quota/Tariff-Rate-Quota Duties

Extend proclamation 9705 to the following HTS codes: 8504.90.9634, 8504.90.9638, and 8504.90.9642. Should

this option be selected, a 25 percent global tariff rate will be applied to imports of laminations and cores (both stacked and wound) for incorporation into electric transformers. This will result in positive tariff revenues and has the potential to reduce the import of laminations and cores (stacked and wound). The alternative is to issue a new global tariff rate on laminations and cores (stacked and wound) and set it to 100 percent. This rate was requested by the domestic GOES producer as they believe it will incentivize both domestic GOES consumption and lamination and core (stacked and wound) production. In the short term, this does not address the shortcomings of domestic GOES production with regard to all grades of GOES.

Applying a quota, or tariff-rate-quota will negatively impact the transformer industry and could be contrary to national security interests as that sector is also vital. Given that the dependency of the U.S. transformer industry on imported laminations and cores (stacked and wound) for incorporation into transformers, applying a tariff rate to only laminations and cores (stacked and wound) will negatively impact the industry by raising input costs.

Transformer manufacturers are likely to offshore their domestic production facilities in order to avoid the increased costs. In addition, offshoring domestic transformer production will likely decrease the demand for domestic GOES in the longer term, as transformer manufacturers can procure cheaper imports elsewhere.

### 3. Production Subsidies, R&D, Capital Expenditure Loans, or Other Financial Incentives

Issue a capital expenditure grant or loan to the domestic GOES manufacture to upgrade facilities in order to reduce operating costs and increase production capacity for high grade GOES. This option is the most direct way to address shortcomings identified in this investigation with regard to domestic the GOES industrial capabilities and has the potential to increase the competitiveness of domestic GOES in both U.S. and foreign markets in the medium to long term. Any production subsidy should consider and account for the different grades of GOES to ensure that subsidies are in fact making domestic GOES price competitive with imports across all grades. In addition, a production subsidy should have a clear termination date in order to avoid overreliance on financial assistance.

Production subsidies however are not solely limited to the existing domestic GOES manufacturer. New entrants

could take advantage of such subsidies in order to better compete on price while increasing their production capacities. As production subsidies are directly targeted towards GOES manufacturers, downstream costs are not expected to increase.

This option is expected to be budget negative in the short run, however, it has the potential to be budget neutral, or positive in the long run. Budget neutrality or positivity can be achieved by preferable interest rates or combining a capital expenditure loan with a strategic stockpile option (which can be liquidated at a future date for profit). This option is not expected to explicitly increase the costs for electrical steel or transformer-related products.

Improving the domestic GOES manufacturer's facilities are expected to reduce operating costs. More importantly, upgrading their machinery can increase capacity for certain GOES grades which would address concerns raised by industry. New entrants into the market may also take advantage of a production subsidy or capital expenditure loan to subsidize their startup costs and encourage future domestic GOES demand and competition. A capital expenditure loan is more preferable than a production subsidy as it has set terms which expire. Special attention, however, will need to be given to the underlying factors which will support this option.

In order for a capital expenditure loan to succeed in reducing operating costs, demand for domestic GOES has to increase. Should demand not increase, there is no guarantee that the loan can be recouped. In addition, low-priced imports may pose a threat as there is no guarantee that after the facilities are upgraded, they will be able to compete with imports on price. Further review into regulations and other agreements may be necessary to further reduce domestic operating costs. The Secretary of Commerce recommends combining the capital expenditure loan with establishing a strategic stockpile to ensure long-term budget positivity.

### 4. Enact Domestic Content Requirements

Enact a domestic content requirement through the Defense Federal Acquisition Regulations (DFAR) and Federal Acquisition Regulations (FAR) to require that all electric transformers purchased by the U.S. government are compliant with the Buy American Act. This option is expected to increase demand for domestic GOES, which will in turn increase demand for transformers produced domestically. This option is expected to be budget

neutral and will not explicitly increase the cost of GOES or transformer-related products. Special provisions will have to be implemented in order to avoid explicitly increasing costs.

The main drawback of this option is that direct Department of Defense and U.S. Government purchases of transformers account for only a small percentage of transformer production, and so will have limited impact on domestic GOES production unless the domestic content requirement can be extended to purchases of transformers by public and private utility companies that make up the majority of the market.

### 5. Establish a Strategic Stockpile of GOES

Establish a strategic stockpile of domestic GOES and subsequent transformer-related products to satisfy U.S. defense and essential civilian transformer demand in case of a national emergency. In fact, the Defense Logistics Agency is seeking funding for inclusion of GOES in the National Stockpile. This option is expected to be budget negative in the short run, however, it can be budget neutral or positive in the long run. This option will ensure that the domestic GOES producer retains business in order to support the stockpile in the short run.

In the long run, a strategic stockpile on its own does not guarantee success for the domestic GOES producer. Should the stockpile be comprised of GOES, a domestic lamination and core (stacked and wound) industry is necessary in order to process the GOES. Should the stockpile include both GOES and laminations and cores (stacked and wound), multiple gauges and specified products will need to be stockpiled to ensure ample coverage. The risk of stockpiling outdated or mismatched GOES also increases as new developments and efficiency standards are implemented. Long lead times may further complicate the stockpiling process in order to balance current U.S. demand and stockpile demand.

### 6. Reclassify the Lamination and Cores HTS Codes

Reclassify the HTS codes for laminations and cores (stacked and wound) from chapter 85 to chapter 72. This option is expected to be budget positive as reclassifying the HTS codes to 72 would mean that proclamation 9705 (which imposes tariffs/quotas on steel imports) would apply to laminations and cores (stacked and wound). This option is similar to extending proclamation 9705 to laminations and cores (stacked and wound) (the Tariff/Quota option)

however, it is a more permanent shift as HTS codes will have to be re-harmonized. This would forgo the need to apply tariffs on downstream transformer products.

Reclassifying the HTS codes for laminations and cores (stacked and wound) can prove challenging given the re-harmonization efforts required. Given that a 25 percent tariff rate is guaranteed, downstream product costs are expected to increase. This option does not guarantee new entrants into the market as transformer manufacturing will likely offshore in order to avoid the increased costs.

7. Establish a Working Group To Provide Further Recommendations

Establish a working group comprised of the Department of Defense, Department of Energy, Department of Homeland Security, Department of State, Department of Commerce, and industry stakeholders to conduct further negotiations and research in order to recommend further options. This option is expected to be budget neutral and will not explicitly increase costs across the industry. It will also encourage further dialogue at the USG and industry level in order to recommend other solutions and provide more specific actions.

Establishing a working group, however, does not address the immediate threat of imports of electrical steel, transformer laminations and cores, or LPT. As a consequence of this, the domestic GOES manufacturer will likely continue to face financial hardships, and new entrants into the market are unlikely. The United States will continue to be threatened by imports and have insufficient capacity to produce transformer laminations, cores, and LPT.

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