

# The U.S. Needs a Resilience Strategy for Its Transformer Shortage

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## KEY TAKEAWAYS

Transformers are a critical component of a reliable electric grid, and America is facing a shortage and aging equipment.

The U.S. produces a small fraction of needed transformers and relies on other nations for this critical infrastructure component as China increases its market share.

For national and economic security, the U.S. needs to increase domestic production of transformers and severely reduce its reliance on imports.

A reliable electric grid is critical as the nation confronts an era of strategic power competition. In the digital era, America's innovation, leadership, and economic security require an electric grid that supports continued growth while minimizing disruptions. The Department of Homeland Security (DHS), through the Cybersecurity and Infrastructure Security Agency (CISA), leads the nation in understanding, managing, and reducing risks to critical infrastructure sectors, including the energy sector.<sup>1</sup>

A rapidly growing shortage of transformers, however, is threatening the nation's ability to remain a leader in innovation and is undermining long-term economic security. Prioritizing transformer life-cycle management across the electric grid while increasing domestic manufacturing capacity are sound policies that the U.S. must embrace to keep the lights on.

This paper, in its entirety, can be found at <https://report.heritage.org/bg3794>

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## Why Are Transformers in Short Supply?

Transformers are the equipment that switches, or “steps down,” electric currents to low voltages, ensuring that homes, businesses, and military installations can use electric energy safely.<sup>2</sup> Transformers vary in size—some rest on pole tops, while others are as large as railroad boxcars. Regardless of their size, transformers for electric power play a critical role in the U.S. electrical network by regulating electricity voltage, facilitating the transmission and distribution of power over long distances, and supporting the remarkable expansion of the digital era. However, after years of offshoring the manufacture of transformers, the U.S. finds itself facing yet another supply chain–related threat to national security. Absent a reliable domestic or allied production capacity and amidst a growing shortage of industrial transformers, the U.S. has created an imbalanced reliance on importing transformers and their key components from adversarial nations.

The shortage stems from varying sources—pandemic-related supply-chain issues, a rapidly depleting stock of fuel, aging infrastructure, and ongoing demand for grain-oriented electrical steel (GOES). GOES is a soft material, comprised of iron and silicon, used to form the essential magnetic core conduit in a transformer to efficiently distribute electricity.<sup>3</sup>

Arguably, the most important shortage factors are the latter two—demand for GOES and aging infrastructure. Currently, 70 percent of transformers are at least 25 years old, and 15 percent of transformers are more than 40 years old.<sup>4</sup> Estimates suggest that, due to the sheer age of these existing grid components, 3 percent of the world’s energy is wasted through transformer energy losses.<sup>5</sup> To efficiently handle renewable energy sources, transformers must be updated, which takes time and money. The United States has more than 4,500 high voltage (HV) transformers with a 345 kV (kilovolts) rating.<sup>6</sup> These HV transformers have 24-month lead times and replacement costs between \$2 million and \$7.5 million each, making life-cycle management paramount.<sup>7</sup>

Like transformers, electric vehicles (EVs) also rely on GOES to function. New steel factories are scheduled to open next year, but the materials produced will be for EVs, not transformers. Also, transformers are required for producing this steel for EVs, thus exacerbating the supply-chain issues.

What is worse, there is only one GOES manufacturer in the entire United States. All other transformer components are imported, mainly from China. It was not always this way: From the 1950s to the 1970s, the U.S. and Canada manufactured 40 percent<sup>8</sup> of the world’s transformers.

HV transformers constitute 3 percent of all transformers in the U.S., while they carry close to 90 percent<sup>9</sup> of the nation's electricity. A 2014 Congressional Research Service report on grid security referenced an analysis by staff at the Federal Energy Regulatory Commission (FERC) which stated that if nine of the 30 most critical HV transformers were dismantled, the entire grid could be rendered useless, causing a coast-to-coast blackout.<sup>10</sup>

The paradoxical policy priorities of the Biden Administration only hinder and strain grid development. On one hand, the Administration is pushing EVs and the significant expansion of charging ports nationwide, prioritizing raw materials and manufacturing capacity for EVs over the upgrade and life-cycle sustainment needs of grid-related infrastructure. On the other hand, the Administration is undermining the capacity of the nation's energy sector to meet increasing demands through these very initiatives, seemingly welcoming the next energy crisis.

## Reliance on Imports

Despite a heavy reliance on HV transformers, the U.S. has very slim manufacturing capabilities. To meet demand, roughly 85 percent<sup>11</sup> of these HV transformers are imported from South Korea and Germany—however, China is seizing market share and forcing out competition. The German Chamber of Commerce and Industry (DIHK) surveyed 24,000 businesses, 82 percent<sup>12</sup> of which stated that the prices for energy and raw materials created major business risks. Despite the legitimate concerns expressed by these businesses, and with the German economy projected to slump this year, the German energy sector is preparing to either scale back its production rates or shift to manufacturing these same products for the automotive industry, that is, EVs.

As such, Germany may not be a viable long-term solution. China, meanwhile, continues to grow its share of the industry using a well-worn playbook: introducing cheaply made, subsidized products that price out competition and achieve market domination.

The Trump Administration plainly articulated the threat posed to U.S. national security from reliance on known adversaries for grid-related materials in Executive Order 13920, titled "Securing the United States Bulk-Power Systems."<sup>13</sup> This order effectively limited the import of grid-related materials from foreign adversaries while simultaneously bolstering domestic production capabilities.

Before the order's implementation, utility companies simply awarded contracts to the lowest bidder, creating vulnerabilities that could be

exploited by U.S. adversaries, such as China. Although deemed a “prudent step”<sup>14</sup> by former Secretary of Energy Dan Brouillette, the Biden Administration terminated the order before it could be fully implemented and replaced it with Executive Order 13990, titled “Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis.”<sup>15</sup>

Rather than focusing on the national security implications associated with imported transformers, President Joe Biden views the entire electricity industry through the optics of climate change, “equity,” and the environment. In hindsight, the repeal and replacement of Executive Order 13920 should have served as an early indicator of how misaligned the “woke” national security priorities are for the current Administration, especially because they benefit China and jeopardize U.S. security.

Beyond the risk of relying on adversaries for critical infrastructure equipment, a report in *The Wall Street Journal* noted that some Chinese-manufactured transformers contained “electronics that should not have been part of the transformers.”<sup>16</sup> This follows a pattern inherent in electronic equipment from China—be it laptops,<sup>17</sup> cellular devices,<sup>18</sup> or drones<sup>19</sup>—each have included conduits for interfacing with China.

Cybersecurity expert J. William Middendorf, in reference to this report and the termination of Executive Order 13920, stated that “Joe Biden just made it easier”<sup>20</sup> for foreign adversaries to hack the nation’s electric grid—in the name of climate. Middendorf also noted the damaging security implications of secret “back doors” planted within the transformers. If engaged, China or Russia could monitor and disable transformers, thus rendering the grid useless.

## Misguided Tax Policies

The current U.S. tax system is biased against most capital-intensive manufacturers because it does not allow companies to deduct the full cost of capital investments in the year the costs are borne. Similarly, companies are required to amortize research-and-development costs over a five-year period. This effectively forces manufacturers and innovators to pay taxes on an accelerated schedule compared to other businesses. Especially in a period of high inflation, this can act as a large disincentive to invest; by the time companies are allowed to claim these deductions, inflation has diminished their value.

Specific industries benefit greatly from subsidies provided through the tax code, such as manufacturers of solar panel and wind turbine components, renewable energy producers, and EV makers who take advantage of

hundreds of billions of dollars in special tax incentives. When the federal government steers investments into these companies, it is simultaneously steering investments away from other, less favored businesses, such as transformer manufacturing.

## Lack of Action Despite Heightened Awareness

The supply-chain issues did not happen overnight. The Biden Administration has long known of the dangers associated with weakened grid security yet has taken no distinct action to respond to (let alone mitigate) this escalating issue. Rather, the Administration chooses to double down on policy that does not account for, or address, the aging grid infrastructure and the vulnerability it represents to national security. This is not a new phenomenon.

In a 2008 report titled “More Fight—Less Fuel,”<sup>21</sup> the Department of Defense emphasized the alarming vulnerability of military installations and homeland defense missions due to their heavy reliance on a fragile and vulnerable power grid. The report aptly pointed out that this dependence poses an unacceptably high risk of extended disruptions. Despite that the report is 15 years old, its findings remain valid as limited mitigation tactics have been implemented since its publication.

Also in 2008, the DHS developed RecX,<sup>22</sup> a transformer designed to “enable recovery from transformer failure within days.”<sup>23</sup> Three RecXs were installed in Texas, proving to be lighter, more adaptable, and significantly cheaper than conventional transformers. But after successful field testing, the Obama Administration ceased funding for the program and began focusing on green initiatives, such as wind and solar power, instead,<sup>24</sup> thus failing to prioritize the U.S. Department of Energy’s (DOE’s) role in leading initiatives to mitigate the risks associated with the shortage of transformers.

The previously mentioned 2014 Congressional Research Service report shed light on the grid system’s intensifying vulnerabilities. In response to these vulnerabilities, including the looming transformer shortages, the private sector established Grid Assurance,<sup>25</sup> a group comprised of the American Electric Power Company, Berkshire Hathaway Energy, and FirstEnergy Corporation. In 2016, Grid Assurance began pre-emptively purchasing large stockpiles of replacement transformers as emergency backup components for its subscribers.

Utility companies have implemented innovative approaches, such as the Spare Transformer Equipment Program (STEP).<sup>26</sup> STEP promotes equipment sharing and stockpiling, ensuring that the nation’s grid is reliably supplied. Grid Assurance partners with STEP and other companies should follow suit.

In 2020, the Commerce Department released its report “The Effect of Imports of Transformer Components on the National Security,”<sup>27</sup> noting that the “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.”

The DOE’s February 2022 report titled “Electric Grid Supply Chain Review: Large Power Transformers and High Voltage Direct Current Systems”<sup>28</sup> highlighted concerns about insufficient GOES production, aging infrastructure, and the ever-growing consumption rates of energy, yet stated that “high capital investment costs and reluctance to replace aging infrastructure are the two dominant restraints to growth.”

In June 2022, President Biden “invoked the Defense Production Act (DPA) to accelerate the domestic production of clean energy technologies, including distribution transformers and grid components.”<sup>29</sup> The Administration then sought public input to help to gauge how the DOE can use the DPA to increase domestic production, bolster grid reliability, and distribute clean energy.<sup>30</sup> The American Public Power Association (APPA) released a statement in November 2022 urging the Biden Administration to use the DPA and for Congress to appropriate \$1 billion for the domestic manufacture and distribution of transformers. The idea is to stimulate investment in manufacturing capacity; however,<sup>31</sup> to use DPA authorities, the DOE needs funding appropriated for, or authorized transfer to, the DPA fund.

Lastly, in November 2022, the North American Electric Reliability Corporation (NERC) released its “2022–2023 Winter Reliability Assessment.”<sup>32</sup> NERC stated that “as a result of production not keeping pace with demand,” there is a significant shortage of transformers. Although the Biden Administration sought public input, and federal agencies have noted vulnerabilities within the energy sector for years, Congress has not funded the DOE to address the transformer shortage.

President Biden’s fiscal year 2024 budget proposal would increase CISA’s budget to more than \$3 billion;<sup>33</sup> however, it prioritizes modernizing its information technology and investigating gender-based cybercrimes. CISA funds should go to its core mission—addressing the genuine exigencies of the nation’s critical infrastructure.

Even those in favor of Biden’s aspirational goals, such as the National Renewable Energy Laboratory, have stated<sup>34</sup> that a zero-carbon grid will not be possible without tripling generation and power line capacities. It is hard to rationalize the Administration’s policy priorities. The priority should be to build resilience and security into America’s grid infrastructure.

## Recommendations for Congress and the Private Sector

In order to protect and strengthen the country's power grid, Congress should:

- **Prioritize domestic manufacturing of GOES through the DOE's Office of Energy Efficiency and Renewable Energy.** Congress should consider legislation that would spur the expansion of domestic production of GOES, reducing the reliance on overseas capacity and returning jobs to the United States. Senator Mark Rubio (R-FL) introduced the Facilitating the Reshoring of Energy Grid Component Manufacturing Act of 2022 (S. 4626)<sup>35</sup> to achieve such ends.
- **Ensure secure and resilient grid infrastructure by prioritizing U.S. and allied production of transformers.** To combat China's practice of unscrupulously taking market share, in this case, of transformer manufacturing, through illegal collusion, price-fixing, and product-dumping, Congress should enact a prohibition on the purchase of covered transformers similar to Section 889 of the 2019 National Defense Authorization Act or Executive Order 13920. Congress should use the definition for bulk-power systems as defined by 16 U.S. Code § 824o-1 to catalyze domestic and allied production of transformers and encourage the re-establishment of Western and allied supply chains.
- **Exercise its oversight authority.** Congress should hold oversight hearings to ensure that the DOE is adequately prioritizing and implementing the requirements that Congress has established in law and that the Executive Office of the President has delegated to the DOE.
- **Enact commonsense tax policy reforms.** Congress should return to allowing full expensing of capital investments and research-and-development costs. It should also return to the system that was in place prior to 2022, in which companies were allowed to deduct interest expenses of up to 30 percent of earnings before interest, taxes, depreciation, and amortization (EBITDA).<sup>36</sup>

The private sector should:

- **Improve life-cycle management and resilience for large transformers.** The establishment of Grid Assurance is a positive step

toward enhancing the electric power industry's resilience. However, the industry as a whole is behind schedule in managing transformer life cycles. With the average age between 30 and 40 years, utilities are keeping transformers online far beyond their intended life span of 25 years. In addition to planning the replacement of transformers, utility companies should consider innovative approaches to managing emergency replacement capacity such as STEP.

## Conclusion

CISA, as part of the DHS, assumes a crucial role in leading the nation's efforts to comprehend, manage, and mitigate risks to both cyber and physical infrastructure, which form the backbone of American society.<sup>37</sup> Throughout administrative and policy changes, one constant remains: Transformers are fundamental components of the nation's electric grid, and grid resilience hinges on securing a consistent, secure, and reliable supply chain.<sup>38</sup>

A coordinated assault on the American grid would not only affect civilians but would also critically harm essential military installations. The cascading effects could jeopardize homeland defense missions, posing a grave threat to national security.

The proposed policy recommendations in this *Backgrounder* offer practical solutions to supply chain challenges, increase domestic production, and protect the grid's infrastructure from adversarial tampering.

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