



# Electric power supply chains: Achieving security, sustainability, and resilience

As supply chain disruptions become the new norm, what strategies is the electric power sector adopting to mitigate their impact?

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# Introduction

**O**VER THE PAST two years, multiple disruptions to supply chains have affected operations across most industries. And the electric power sector is no exception. The sector was grappling with numerous challenges within its supply chain networks even before recent disruptions driven by the pandemic and the Russian invasion of Ukraine.<sup>1</sup>

These disruptions—ranging from logistics bottlenecks to shortages of raw materials and components and labor shortages—have resulted in rising costs and a scarcity of essential electric supplies.<sup>2</sup> They have also widened the gap between demand and supplies of electrical equipment and components, slowing the clean energy transition. As a result, many electric power and renewable energy companies are revisiting supply chain strategies and rebooting their approach to supply chain risk management—and their boards

increasingly expect it. Some are integrating supply chain management deeper into business planning and involving supply chain managers in the capital planning process. They are working to develop more secure and sustainable supply chains, while managing third-party risk to ensure resilience in the face of future disruptions.

To better understand the types of supply chain disruptors, their impact on the sector's operations, and the strategies used to overcome these disruptions, Deloitte surveyed more than 50 electric power and renewable sector executives in the United States. The findings were supplemented by interviews with executives and leaders in utilities and other electric power providers. Using these insights, this report takes an in-depth view of how the electric power sector can improve its supply chain security, sustainability, and resilience.

# Multiple disruptors impact the electric power supply chain

A COMBINATION OF DISRUPTORS is driving supply chain gridlock and impacting end-to-end operations in the electric power sector. Prepandemic supply chain vulnerability, due largely to the geographic concentration of component manufacturing and critical minerals mining, has been compounded by the effects of the pandemic and the Russian invasion of Ukraine.

We have divided these disruptors into five categories—environmental, geographic, operational, technological, and macroeconomic—which impacted between 32% and 98% of our survey respondents' supply chain operations (figure 1).

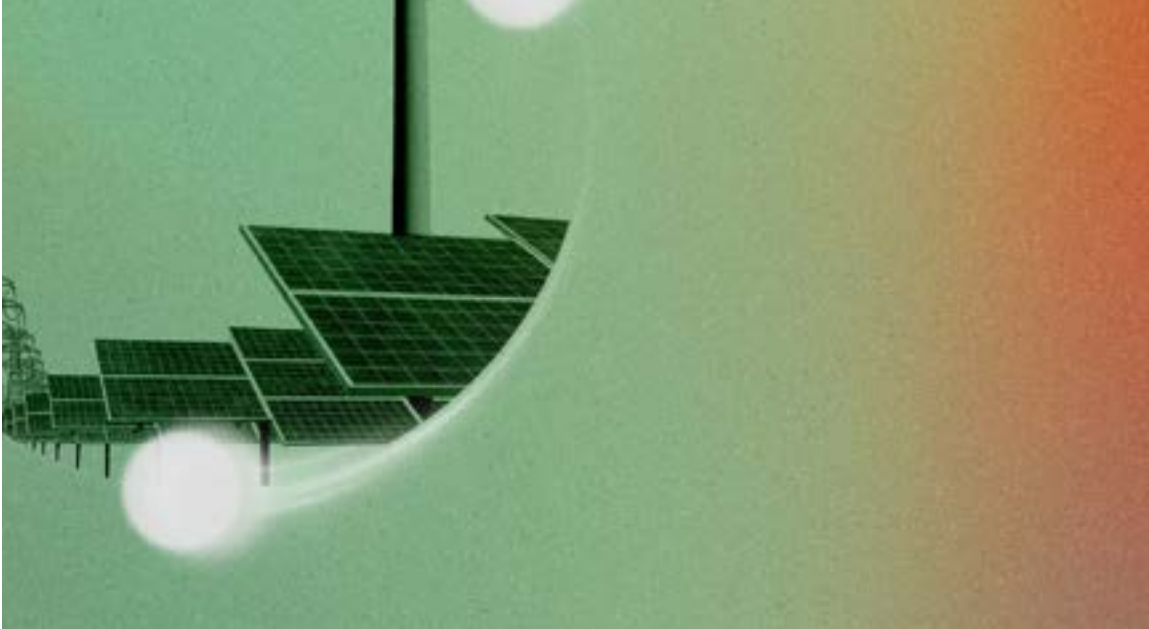
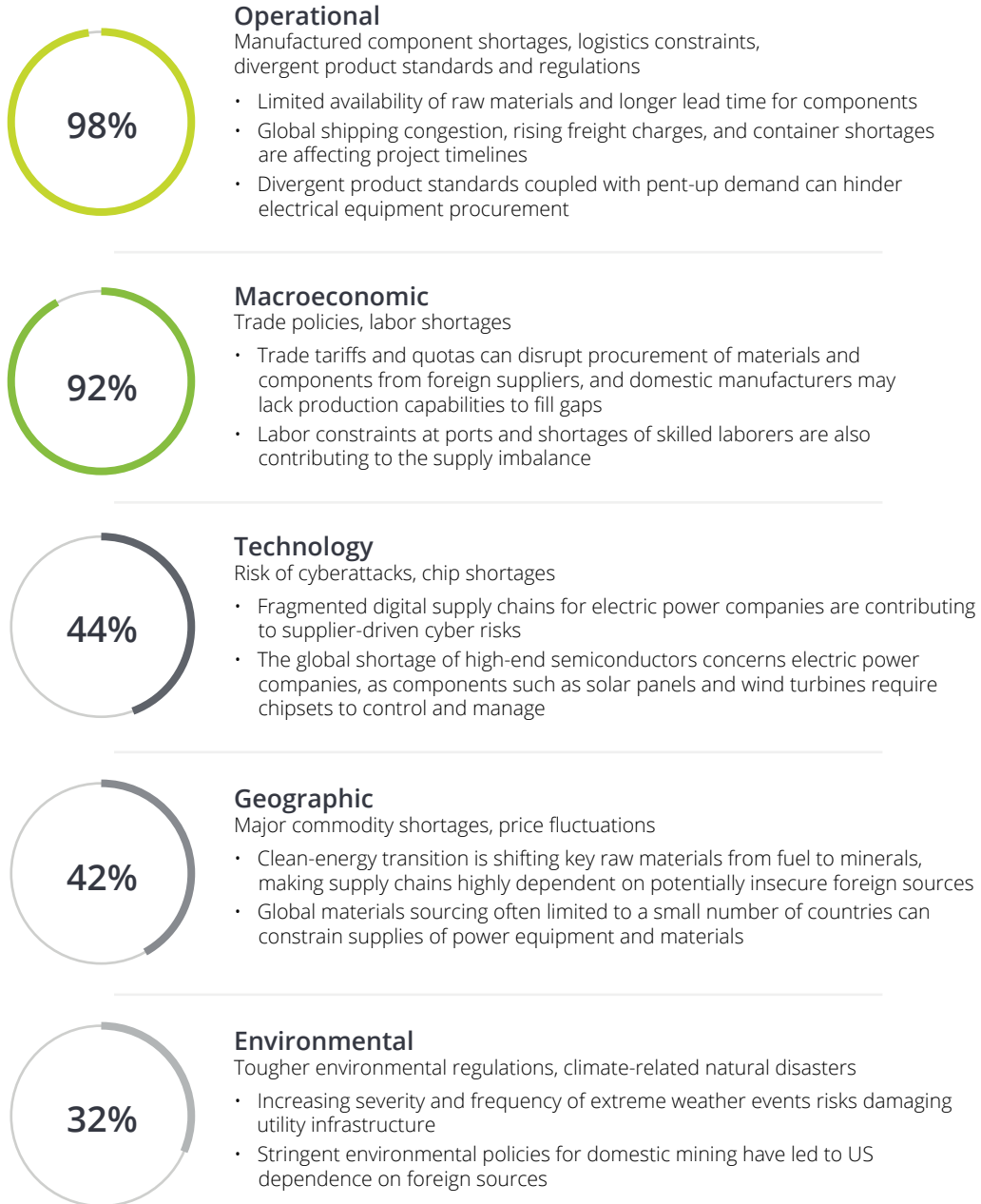


FIGURE 1

## Respondents report operational and macroeconomic disruptions as the most significant supply chain challenges

Percentage of respondents who identified each disruptor as having significant impact



Source: Deloitte Electric Power Sector Supply Chain Survey.

- Nearly all of the respondents (98%) consider operational challenges as major disruptors in their supply chains.
- In addition, almost all (92%) also see macroeconomic factors, such as labor shortages and trade policy, as significant disruptors. Pandemic-driven labor shortages, on top of preexisting shortages resulting from a rapidly retiring workforce, are further exacerbating supply chain challenges.

Along with other supply chain disruptions, a US trade investigation into solar panel supplies from four Southeast Asian nations has also loomed over the industry, with the potential to further constrain supplies. To mitigate the dampening effect on the market, the Biden administration waived tariffs on panels from the four nations for two years and invoked the Defense Production Act to boost domestic solar panel manufacturing.<sup>3</sup>

<sup>3</sup>Nichola Groom, "US to consider tariffs on solar panels made in Southeast Asia," Reuters, March 29, 2022.

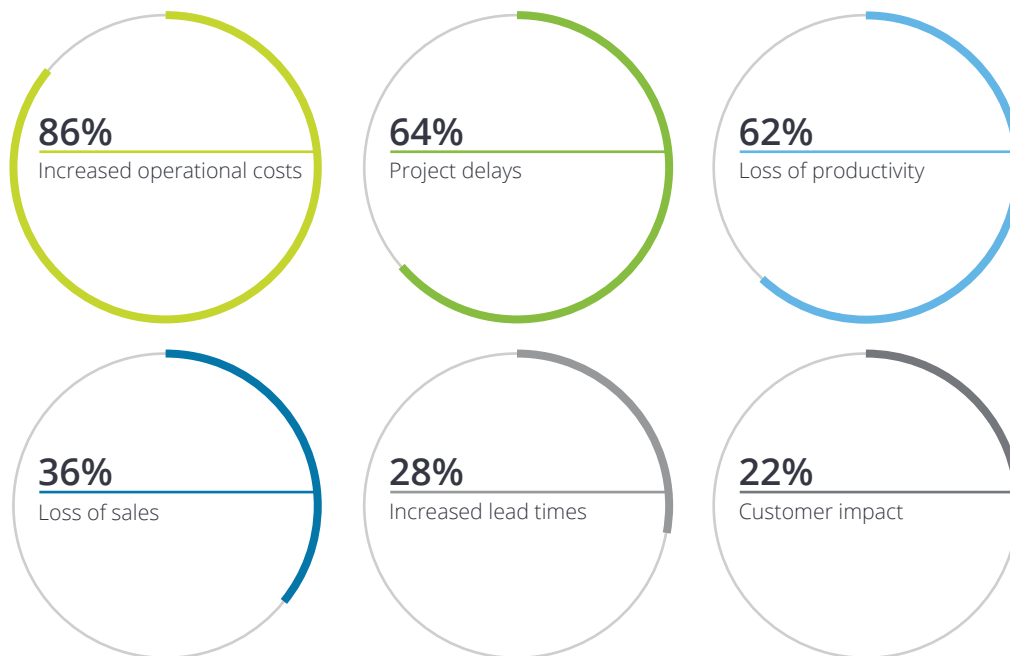
The impact of these disruptors on the electric power sector has been wide-ranging—from increased costs to project delays (figure 2). They're not only impacting grid modernization efforts and clean energy deployment, but also causing service-related delays. Electric power companies are draining inventories as they continue to upgrade equipment, while replacements are often delayed.<sup>3</sup>

And ripple effects are impacting the broader economy, sometimes slowing new home construction due to a lack of electrical equipment—especially distribution transformers and smart meters<sup>4</sup>—and delaying transportation electrification.<sup>5</sup>

FIGURE 2

### Electric power providers highlight multiple consequences of supply chain disruption

Percentage of respondents who selected each consequence



Source: Deloitte Electric Power Sector Supply Chain Survey.

According to our survey, respondents believe increased operational costs (86%), project delays (64%), and loss of productivity (62%) are significantly impacting the industry. Among the industries most acutely affected by these supply chain constraints has been the solar industry, where a third of all utility-scale solar capacity scheduled in the United States for completion in Q4 2021 was delayed by at least a quarter. At least 13% of the planned capacity for completion in 2022 has either been delayed by a year or canceled.<sup>6</sup> This trend will likely continue over the next two years as some utilities have warned they may need to delay 3–4 GW of total solar installations until 2024 due to shortages of solar panels and other equipment.<sup>7</sup>

A severe shortage of key commodities, materials, and labor can create an inflationary cost environment for companies, resulting in increased component costs. Transformer prices have doubled, while the average lead time for delivery has at least tripled from what it was two years earlier, reaching 52 weeks in some cases (figure 3).<sup>8</sup>

FIGURE 3

**Disruptors have significantly impacted components' cost and delivery lead time**

	Cost increase	Lead time
<b>Transformers</b>	20–100%	100–400%
<b>Wire and cables</b>	20–60%	60–300%
<b>Precast manholes (electric)</b>	60%	400–600%
<b>PVC conduits</b>	400–500%	900–1,400%
<b>Stainless steel valves and fittings</b>	5–20%	200–300%
<b>Batteries</b>	15–25%	50–100%
<b>Solar PV</b>	20–30%	30–50%

Note: Cost increases and lead time are calculated from secondary research, examples, case studies, and utility project status reports, using information from the sources listed below.

Source: *Jacksonville Daily Record*; Federal Reserve Bank of St. Louis; Scoop Robotix; Kit Carson Electric Cooperative; *News Herald*; Dawson Public Power District; WUSF Public Media; *Reuters*; Merfish United; *Business Wire*; American Public Power Association; *ETEnergyworld*; and Deloitte analysis.



# Demand growth could widen the gap between climate goals and critical material supplies

**M**EETING A 100% clean electricity standard in the United States between 2035 and 2050 is expected to require tripling or quadrupling each year the 25 GW of wind and solar capacity added in 2021.<sup>9</sup> Renewable developers currently have 282 GW of wind and solar in project pipelines in the United States through 2025.<sup>10</sup> In addition, grid storage deployments would need to increase from an average of 1.6–11 GWh per year in the 2020s to 40–250 GWh per year in the 2040s.<sup>11</sup>

As electric power companies continue to announce decarbonization goals, many will seek to build new renewable energy projects to fulfill them. And demand for renewables could increase even more

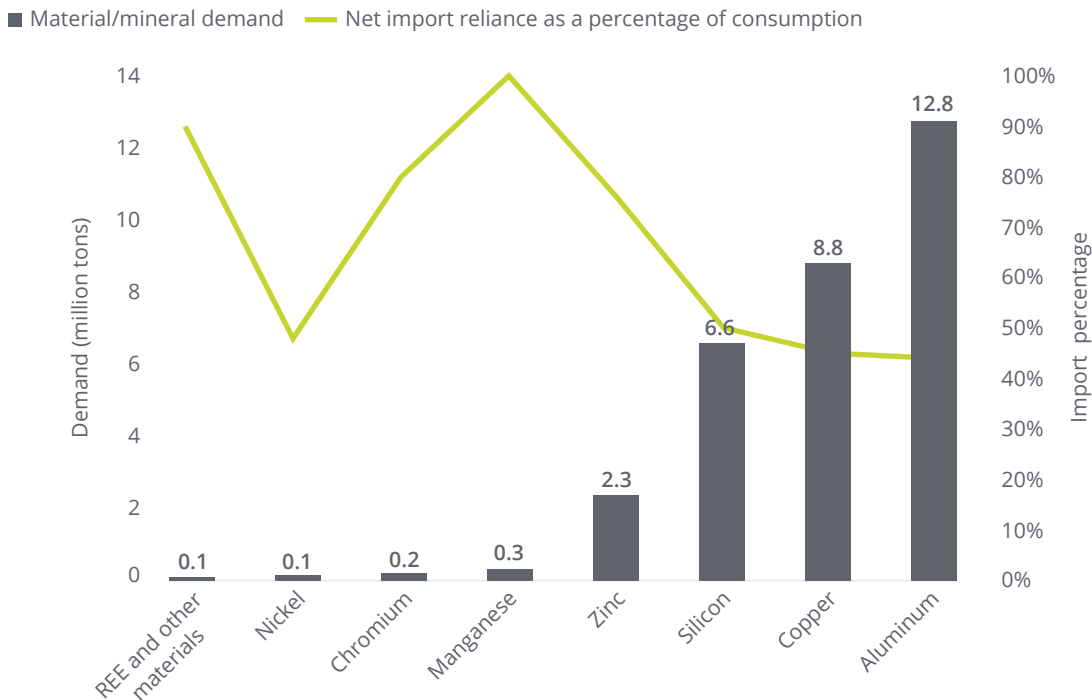
rapidly with enactment of the Inflation Reduction Act and the incentives it provides.<sup>12</sup> But building clean energy technologies such as solar and wind generally requires more minerals, including rare earth elements, than traditional fossil-fuel technologies.<sup>13</sup> Our analysis shows that about 31 million tons of key minerals/materials are required to support solar and wind demand in the United States by 2050 (figure 4). With high reliance on imports for most of these materials—and competing demand from other industries for the same minerals—there’s an imminent mismatch between US climate goals and the availability of critical minerals essential to meet them.



FIGURE 4

### As the push to meet US climate goals increases, demand for the critical minerals necessary to generate more renewable energy is also expected to rise

Estimated US demand and import dependence for key clean energy minerals and materials through 2050



Notes/assumptions: Demand estimates represent the cumulative material demand required for solar and wind technology from 2022 to 2050 based on Wood Mackenzie's *Energy Transition Outlook 2021* projections. Mineral intensity has been considered constant over the period. "REE and other materials" refers to rare earth elements such as molybdenum, neodymium, dysprosium, praseodymium, and terbium. Mineral requirements for solar modules are projected for modules made with crystalline silicon (c-Si) technology, since they constitute 84% of modules used in the United States. These include aluminum, copper, and silicon. For wind, the minerals considered include aluminum, copper, chromium, manganese, nickel, zinc, and rare earth elements.

Sources: US Energy Information Administration; Wood Mackenzie; European Union Joint Research Center; US Geological Survey; and Deloitte analysis.

Further, the clean energy transition will require a significant expansion of transmission and distribution infrastructure, both new and end-of-life line replacements, including power transformers and high-voltage direct current (HVDC) systems, as well as digital equipment such as digital relays, smart meters, and smart inverters.<sup>14</sup> And the raw materials for many of these are highly dependent on a small number of countries, making them vulnerable to disruption.<sup>15</sup>

### The electric power sector is pursuing strategies to overcome these immediate challenges—but are they sufficient?

Electric power and renewable energy companies are taking steps to resolve these supply chain pressures, including using emergency stocks of components such as transformers to address short-term demand, reviewing and planning all

scheduled work, substituting available materials when possible, improving communication with suppliers on the timing and delivery of materials, and digitalizing processes to boost efficiency. Figure 5 highlights the top three strategies our survey respondents are pursuing to overcome supply chain challenges.

Other solutions that companies, end users, and governments are implementing—particularly in the clean energy sector—include developing more domestic component manufacturing, boosting mining and production of critical minerals and

materials, and committing to future demand to incentivize global investment. In June 2022, a group of independent power producers formed the US Solar Buyer Consortium to support expansion of the domestic solar supply chain.<sup>16</sup>

However, to mitigate far-reaching impacts, the electric power sector will likely need to adopt new, holistic approaches. Developing resilient supply chains that are also secure and sustainable will require a cohesive supply chain management strategy.

FIGURE 5

### Power and renewable energy companies surveyed are adopting a number of strategies to overcome supply chain challenges

Percentage of survey respondents who selected each strategy



Source: Deloitte Electric Power Sector Supply Chain Survey.

## **STAKEHOLDERS COME TOGETHER TO BUILD US OFFSHORE WIND INDUSTRY SUPPLY CHAINS**

Achieving the US national offshore wind (OFW) energy target of 30 GW by 2030 is expected to require a significant ramp-up in domestic manufacturing, infrastructure, and workforce. Industry stakeholders are tackling this goal on three fronts:

- **Shipping and port infrastructure:** Offshore wind logistics require specialized infrastructure, particularly ports and installation vessels, which does not currently exist. The industry is bringing wind component manufacturing facilities to ports, supporting redevelopment of existing ports, and building domestic ships to comply with US trade policies. Recently, OFW vessels were designated as “national interest,” making them eligible for financial support through a federal ship financing program.<sup>17</sup>
- **Wind turbine production:** The industry is creating opportunities to establish an OFW Tier 1 (nacelle, towers, blades) supply chain and manufacturers plan to begin production at US facilities in the coming years. Siemens Gamesa Renewable Energy announced that it will invest in a new blade production facility for OFW turbines in Virginia.<sup>18</sup> Additionally, US companies are partnering with European companies both to procure manufactured components and develop those capabilities domestically.<sup>19</sup>
- **Workforce training:** Approximately 10,500–42,500 domestic full-time equivalent jobs will likely be needed over the next 10 years to support the OFW industry. Companies are including workforce training and outreach as part of their project development plans and using new technologies to train professionals. A partnership between Siemens Gamesa Renewable Energy and VinciVR uses virtual reality programs to train and certify OFW professionals.<sup>20</sup>

# Securing the electric power supply chain is increasingly critical

FOR ELECTRIC POWER companies, the number of suppliers and contracted laborers providing expertise and skills has expanded over the years to meet a wide range of industry needs.<sup>21</sup> For example, from 2015 to 2020, Exelon's supplier pool had grown by 18%, to 8,000 suppliers, and its spending rose by 13% to US\$9.5 billion.<sup>22</sup> In the case of clean energy technologies, concerns about supply chain security affect not only manufactured components but also go deeper into the key materials and critical minerals needed to build those components (see [Renewable transition: Separating perception from reality](#)). To manufacture a solar panel, about 40 components must get to the factory, including rare earth elements,<sup>23</sup> making analyzing not just Tier 1, but also Tier 2 and Tier 3 suppliers increasingly important to diversify supply risk.

While having such a vast breadth and depth of suppliers can help mitigate supply constraints caused by natural disasters, pandemics, trade policies, and more, it can also open the door to more noncompliance and safety risks, especially without adequate supplier qualification and risk management controls. Understanding these multitier supplier dependencies and vulnerabilities better can help power and renewable energy companies address not only the physical but also the cybersecurity risks that the sector is increasingly facing.

Consequently, many companies are expanding their supply chain management approach and

integrating it into total third-party risk management (TPRM). In fact, their third-party networks now go well beyond suppliers of goods and services to include affiliates and joint venture partners, research and development (R&D) organizations, technology incubators, retailers, distributors, and sales agents that can cause disruptions in the supply chain.

Until recently, companies in the electric power sector often addressed supply chain risk management in siloes, separating risks related to policy, technology, finance, corruption, cybersecurity, suppliers and other stakeholders, and more. And supply chain owners often had sole responsibility. But siloed approaches to TPRM can result in check-the-box exercises in which a business unit or function narrowly focuses on a single part of the business, without considering the effects on other areas of supply chain. Today, there's increasing coordination between functions in a more integrated, cross-risk approach. Executives across the organization, from chief financial officers to chief operating officers, are increasingly involved, and some companies are combining supply chain with TPRM. These programs are continuously monitored to enable proactive management of emerging risks. A senior supply official at a Midwestern utility noted that they recently integrated supplier relationship management into their supplier quality team and aligned it with the supply chain function.

Companies can manage these risks by improving supply chain visibility—illuminating each tier of the supply chain from primary supplier (Tier 1) through their supplier’s supply chain (Tier 2 and beyond). With greater visibility, they can better understand the potential risks involved with each supply chain partner, across all tiers. For example, a company might think it is diversifying risk by procuring solar panels from four to five suppliers, but if those suppliers were all purchasing a critical element for producing solar panels, such as polysilicon, from the same supplier, the risk may be insufficiently managed. Most of our survey respondents reported limited visibility into their supplier network beyond Tier 1 or Tier 2 (figure 6).

## Managing cybersecurity risk in electric power supply chains

Cyberattacks targeting energy systems have increased over the last five years,<sup>24</sup> and power

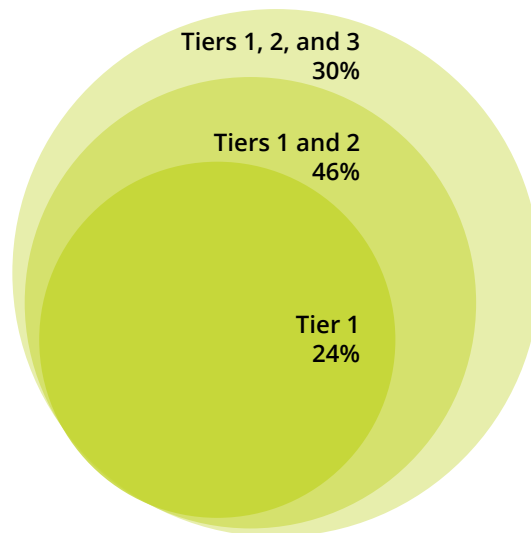
sector vulnerability may be rising as renewable and distributed energy resources (DERs) are added and systems become more complex, digitalized, and decentralized. What’s more, these attacks are more frequently targeting operational technology (OT) and industrial control systems (ICS), and the software used to connect information technology (IT) and OT.<sup>25</sup> These cyber criminals often see ICS as attractive targets for ransomware thinking operators might pay up to avoid downtime.

Digitalizing resources and connecting them to operating systems can create new vulnerabilities, including supply chain risks for digital components such as software, virtual platforms and services, and data. Several cyberattacks specifically targeting the energy sector have exploited supply chain vulnerabilities in trusted third-party suppliers with less secure networks (see *Managing cyber risk in the electric power sector* for additional details).

FIGURE 6

### Less than one-third of respondents have visibility beyond Tier 2 suppliers

Percentage of survey respondents who selected each level of visibility



Notes: Tier 1 includes partners with whom companies directly conduct business, including contracted manufacturing facilities or production partners; Tier 2 includes companies that produce and supply parts to Tier 1 from the material obtained via Tier 3; Tier 3 includes raw material providers. Source: Deloitte Electric Power Sector Supply Chain Survey.

The supply chain for digital components is complex, fragmented, and virtual. Software development is often sourced globally to save costs, and parts of the process may be subject to control by adversaries who could insert malicious code or otherwise interfere with software or data sets. Similarly, virtual platforms and services hosted in data centers within adversary nations are subject to the same types of collection and interference.

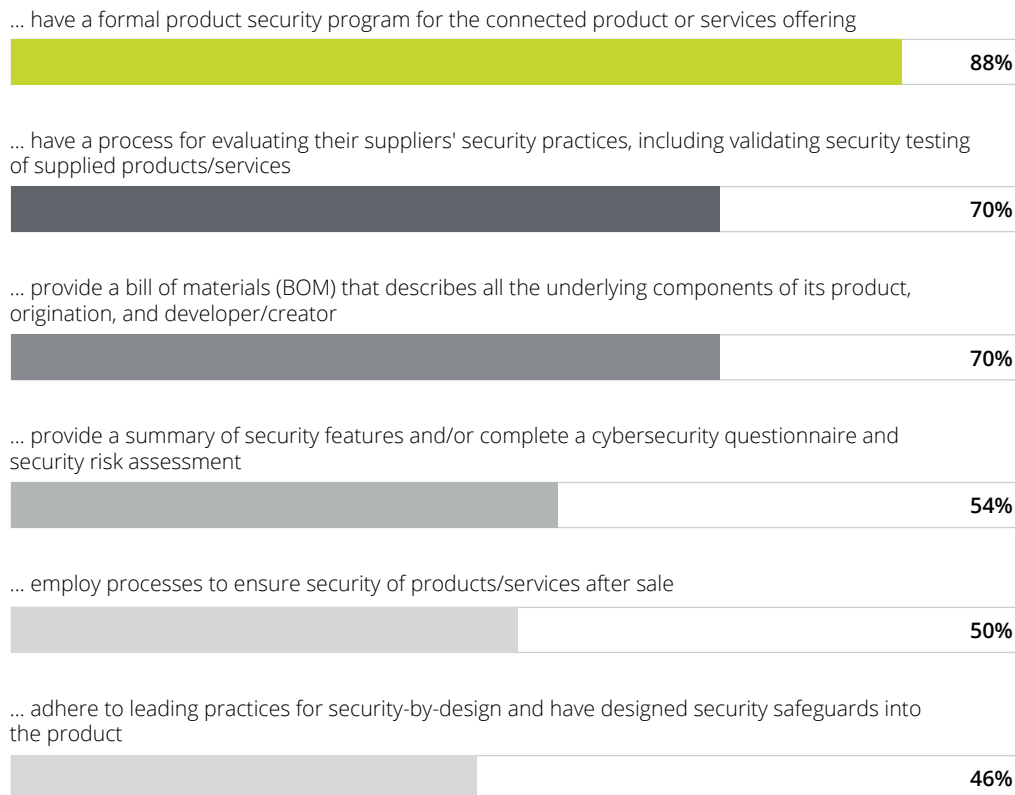
To prevent or limit the impact of future cyberattacks, electric power and renewable energy companies can also enhance visibility into their suppliers' cybersecurity profiles and require that they meet certain minimum standards. For example, they could require that suppliers have a

formal cybersecurity program for the product or services offered or provide a "bill of materials" detailing the provenance of all product components. Figure 7 indicates how widespread selected vendor requirements currently are among our survey respondents.

Notably, some power and utility companies are applying lessons learned from compliance with the North American Electric Reliability Corporation's Critical Infrastructure Protection (NERC-CIP) standards. While NERC-CIP standards are mandated only for bulk electric system assets, some power companies are expanding their enhanced cybersecurity supply chain risk management to other parts of their businesses.

FIGURE 7

### Many electric power sector survey respondents require third-party suppliers of connected products and services to ...



Source: Deloitte Electric Power Sector Supply Chain Survey.

# Building sustainability into the electric power supply chain is becoming a priority

COMPANIES IN THE electric power sector are increasingly committing to putting environmental, social, and governance (ESG) considerations at the core of their decision-making process and integrating it into their strategies and operations. And supply chains are becoming an important focus area. Since supply chains are outside a company's core operations, they can create some of the highest ESG compliance exposure. The sector's vast breadth and depth of suppliers also means that ESG risks, especially for the clean energy sector, reach multiple value chain partners and sectors, including manufacturing, mining, and construction. As investors, customers, regulators, and other stakeholders begin demanding sustainable and ethical practices across the production cycle of clean energy, ESG considerations in the supply chain will likely multiply.

Electric power companies can benefit from a thorough understanding of potential ESG risk exposure across their supply chains—from raw material procurement through production and, ultimately, the entire product life cycle. They can also gain from incorporating traceability into the supply chain to track the provenance of products and components from the point of origin through delivery to the end user, providing supply chain transparency for investors and customers. For example, many solar developers adhere to the Solar Energy Industries Association's Solar Supply Chain Traceability Protocol—a set of guidelines intended to trace the origin of solar materials, especially to

prove their procurement is free from unethical labor practices.<sup>26</sup>

## The ESG agenda for electric power supply chains

In 2020, Scope 3 emissions for the global electric power sector accounted for, on average, 110% more than Scope 1 and Scope 2 emissions combined.<sup>27</sup> And supply chain emissions are a significant contributor to these emissions.<sup>28</sup> In March 2022, the US Securities and Exchange Commission (SEC) proposed requiring US-listed companies to disclose greenhouse gas emissions generated by suppliers and partners if they are material or included in any company's emission reduction targets.<sup>29</sup> Companies in the sector have started prioritizing environmental issues in their supply chains, and approaches include gathering information on suppliers' sustainability performance through the request for proposal (RFP) process, supplier scorecard reviews, and asking suppliers to voluntarily fill out annual sustainability surveys. However, only 13 utilities have committed to reducing some or all Scope 3 emissions.<sup>30</sup> According to our survey, only 36% of respondents have specific sustainability metrics in their supplier procurement process.

In the social sphere, electric power companies have often been at the forefront in developing their local communities economically—and momentum is growing for developing local supply networks. Two



areas are especially important across electric power sector supply chains:

- **Building a diverse supplier base:** As in many other sectors, supplier diversity, equity, and inclusion (DEI) is a strategic focus for the electric power sector. The share of diverse supplier<sup>31</sup> spending has been growing over time and is a substantial portion of the total supplier spend for many electric power companies. For example, PG&E's annual diverse supplier expenditures increased 36% over 2016–2020, constituting about 39% of its total supplier spend.<sup>32</sup> For some companies, supplier diversity is a corporate-level goal tied to executive compensation, and management reviews monthly diverse spend reports to monitor performance against established annual organizational unit goals.<sup>33</sup> Further, some companies support their prime suppliers in developing a stronger supplier diversity program for their own suppliers/subcontractors. One utility executive mentioned that they are seeking to better understand and influence subsupplier qualifications and the selection process.
- **Ensuring adoption of ethical labor practices across the supplier base:** Unethical labor practices, especially for clean energy technologies, have been a contentious issue impacting the sector's growth. Examples include allegations of unethical labor practices in the mining and processing of raw materials for solar panels and poor human rights and environmental practices in cobalt mines.<sup>34</sup> Some electric power companies have begun to ask manufacturers to demonstrate that their products do not contain materials from areas using forced or involuntary labor.

While many companies have set a code of conduct for their suppliers that requires them to adhere to environmental standards, ensure DEI in their supply chains, safeguard employee health and

safety, and maintain ethical labor practices, compliance is not universal. Creating meaningful ESG progress within the supply chain requires an engagement journey that moves from setting aggressive emissions reduction goals, to implementing initiatives to help suppliers meet goals, and creating additional value-added opportunities for suppliers. Figure 8 illustrates five steps that can help electric power and renewable energy companies build a strategic relationship with their suppliers to boost ESG engagement.



FIGURE 8

## A five-step process can help power and renewable energy companies boost their supplier ESG engagement

- 1 Onboard supplier**
  - Use ESG KPIs/metrics to evaluate and select suppliers
  - Share supplier code of conduct

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- 2 Understand supplier behavior**
  - Collect supplier data on their ESG practices through request for proposals (RFPs) and annual sustainability assessments

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- 3 Increase supplier awareness**
  - Share industry best practices
  - Create training programs for suppliers to amend their ESG practices

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- 4 Modify supplier behavior**
  - Develop tools to help suppliers monitor and adhere to ESG targets
  - Help benchmark supplier practices with industry

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- 5 Create supplier opportunities**
  - Identify product and service strategies to improve ESG profile
  - Develop additional value creation activities with strategic suppliers

Source: Deloitte analysis.

# A circular economy can boost supply chain security, sustainability, and resilience

THE LINEAR NATURE of most electric power industry supply chains makes them highly susceptible to disruption. While traditionally associated primarily with recycling waste, applying circular economy (CE) initiatives across all phases of product and service life cycles can help power and renewable energy companies develop more secure, sustainable, and resilient supply chains. Embedding these initiatives into their business models can help companies reduce costs, optimize resources, and create added value through new products and services.

**Companies in this sector can also play a significant role in developing circular economies in related industries, such as automotive and manufacturing, helping advance their energy transitions.**

Deloitte's CE framework (figure 9) for the electric power sector shows how products and materials move through the supply chain. It consists of three dimensions related to product/service flow that integrate circular strategies. It also involves cross-

sector collaboration between public and private stakeholders. These dimensions/strategies give rise to new business models that enable multiple benefits for supply chains.

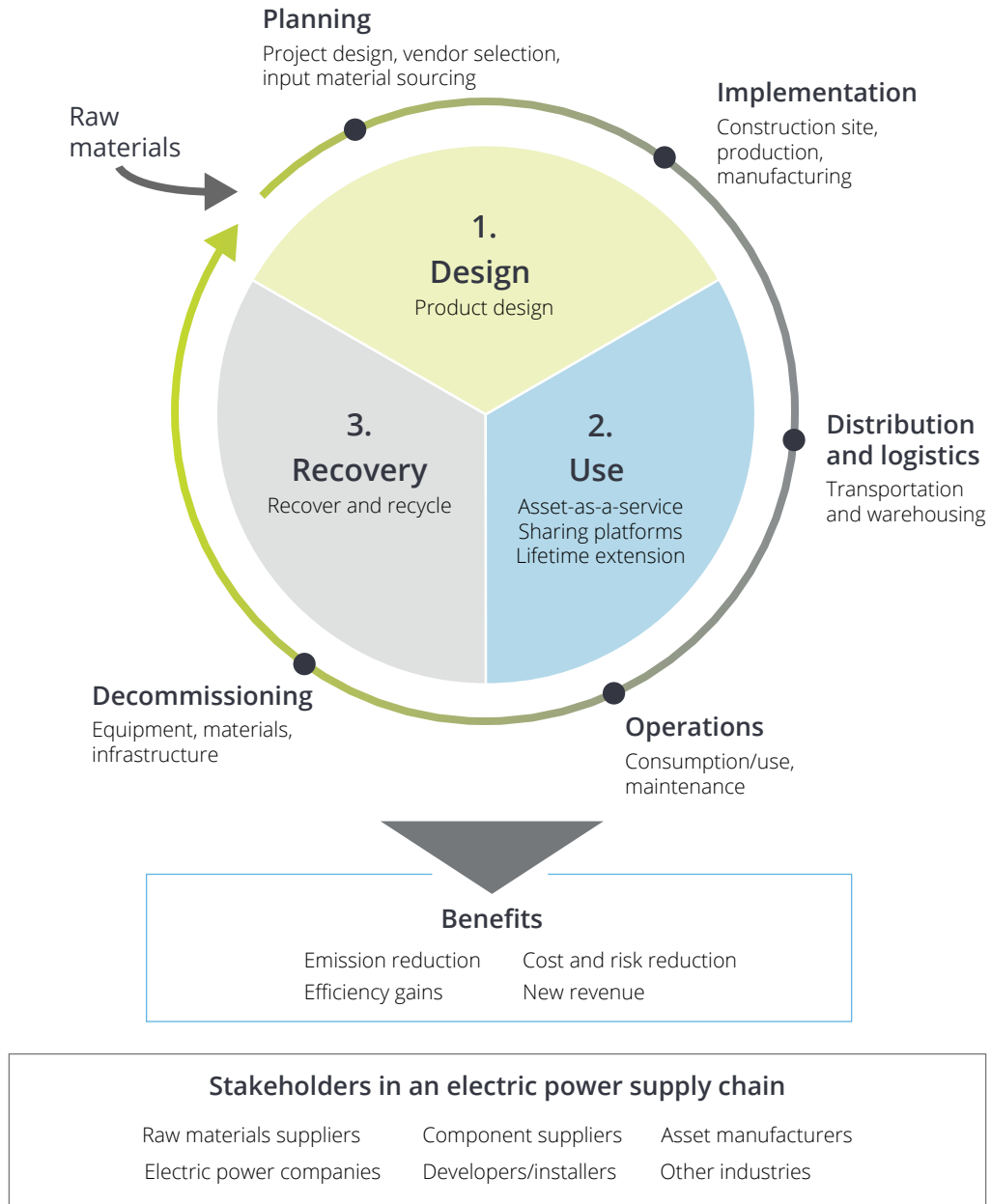
- **Strategic dimensions:** The circular supply chain's primary focus is on keeping resources in the product life cycle at their highest value for as long as possible, which can be achieved by including any or all three dimensions:<sup>35</sup>

1. *Circular design:* Reducing resource and material intensity requirements during production, use, or disposal.  
**Strategies:** Rethink, reduce, and redesign
2. *Circular use:* Extending and optimizing product life and slowing the resource transition to waste or resource recapture.  
**Strategies:** Repurpose, reuse, refurbish, and repair
3. *Circular recovery:* Reintegrating waste or production byproducts back into the manufacture of new products.  
**Strategies:** Recover and recycle

- **Circular business models:** Several business models emerge around the three dimensions that use circular strategies and support moving to circular supply chains. They generally coexist and coevolve to create a circular supply chain, providing multiple benefits to the stakeholders in the ecosystem. These business models include:

FIGURE 9

## Circular supply chains can benefit the electric power sector and create new opportunities



Source: Deloitte analysis.

- *Product/process design*: Design an asset, product, or service using less, recycled, or sustainable/renewable inputs and modular/recyclable designs.
- *Asset-as-a-service*: The customer purchases a service for a limited time, while the manufacturer maintains the ownership.
- *Sharing platforms*: Employ common management among multiple users of products.
- *Lifetime extension*: Repair, upgrade, reuse, or recondition to extend product life.
- *Recover and recycle*: Recover embedded materials, energy, and resources from products at the end of use.
- **The stakeholder ecosystem**: CE supply chains require collaboration across the value chain and cross-sectoral partnerships to create joint value and deliver impact at scale. This can foster innovation and overcome challenges such as lack of capital, knowledge, and tools for efficient operations.

Figure 10 provides examples of circular business models the electric power sector is implementing across the three dimensions.



FIGURE 10

### Examples of circular business models

Dimension	Enabling business model	Benefits	Examples
<b>Circular design</b>	Product/process design	<ul style="list-style-type: none"> <li>• Efficiency gains</li> <li>• Optimization</li> </ul>	<ul style="list-style-type: none"> <li>• In 2021, Siemens Gamesa launched the RecyclableBlade, a wind turbine blade that can be recycled at the end of its life cycle.<sup>a</sup></li> </ul>
<b>Circular use</b>	Sharing platforms	<ul style="list-style-type: none"> <li>• Cost and risk reduction</li> </ul>	<ul style="list-style-type: none"> <li>• Microgrids, virtual power plants, community solar, and energy market platforms enable sharing of clean energy technologies.</li> </ul>
	Asset-as-a-service		<ul style="list-style-type: none"> <li>• Energy storage-as-a-service can provide power during outages, ensure consistent power quality, and help industrial and other large electricity customers reduce demand charges. Fotowatio Renewable Ventures, in collaboration with Energy Toolbase and Ecopulse, launched “energy storage-as-a-service” for industrial customers who will not pay upfront for the battery installation, but will share their electricity savings with the project partners.<sup>b</sup></li> </ul>
	Lifetime extension		<ul style="list-style-type: none"> <li>• In 2022, EDP Renewables North America LLC completed a wind turbine repowering project in the United States at the Blue Canyon II Wind Farm, increasing the capacity from 151 MW to 162 MW, thereby extending wind farm life.<sup>c</sup> Several additional repowering projects are underway or being planned, including work on wind farms that are only about a decade old.<sup>d</sup> In 2020, 33 projects were partially repowered, involving 1,827 turbines that totaled 3,087 MW prior to repowering.<sup>e</sup></li> <li>• In 2021, Duke Energy diverted 87,700 tons of solid waste through recycling and beneficial reuse. It also remanufactured and repaired 22% of its scrap transformers, significantly reducing the need to purchase new equipment.<sup>f</sup></li> </ul>
<b>Circular recovery</b>	Recover and recycle	<ul style="list-style-type: none"> <li>• New revenue</li> <li>• Minimize emissions</li> </ul>	<p>In 2021, Southern Company repurposed and recycled its former coal sites in Alabama and Mississippi to recover 2.4 million pounds of copper, 2.85 million pounds of aluminum, and 137 million pounds of ferrous metals.<sup>g</sup></p> <p>In 2020, GE Renewable Energy signed an agreement with Veolia to recycle onshore wind turbine blades in the United States and turn them into a raw material for use in cement manufacturing.<sup>h</sup></p> <p>Used transformer oil (UTO) can be processed to “as new” quality for reuse as insulating fluid.<sup>i</sup></p>

Sources: <sup>a</sup>Siemens Gamesa, “Siemens Gamesa pioneers wind circularity,” press release, September 07, 2021.

<sup>b</sup>Andy Colthorpe, “Energy storage-as-a-service’ launched in Mexico by Fotowatio Renewable Ventures and partners,” *Energy Storage News*, March 1, 2022.

<sup>c</sup>Ariana Fine, “EDPR concludes its first wind farm repowering in the US,” *North American WindPower*, January 25, 2022.

<sup>d</sup>Kent Knutson, “Wind farm repowering and decommissioning is big business,” *Energy Central*, November 5, 2019.

<sup>e</sup>US DOE, *Land-based wind market report: 2021 edition*, 2021, p. vii.

<sup>f</sup>Duke Energy, *2021 ESG report*, 2021, p. 62.

<sup>g</sup>Southern Company, *Just transition report: Engaging with transparency*, 2021, p. 20.

<sup>h</sup>Mary Laurence, “Recycling wind turbine blades,” Northwest Renewable Energy Institute, March 30, 2021.

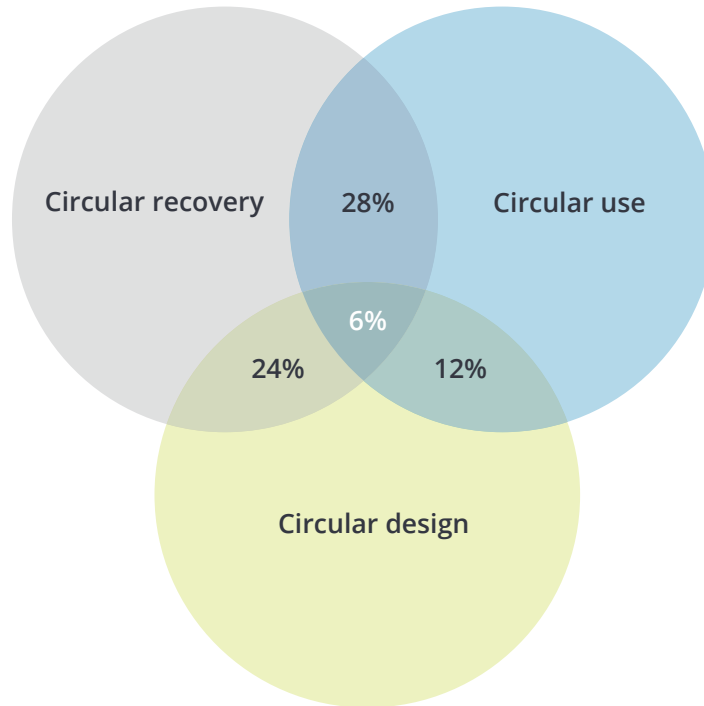
<sup>i</sup>Electrical Oil Services, “Circular economy: Stop wasting valuable transformer insulating oil,” *Transformers Magazine*, January 7, 2019.

Although many electric power companies are undertaking circular supply chain initiatives for more than one dimension, very few are taking comprehensive action across all three dimensions.

According to our survey, only 6% of respondents are implementing CE activities across all three dimensions (figure 11).

FIGURE 11

### Few electric power companies are implementing circular economy activities across all three dimensions



Source: Deloitte Electric Power Sector Supply Chain Survey.

# Creating robust electric power supply chains: The road ahead

COMPANIES IN THE electric power and renewable energy sectors should consider committing to circular economy principles and developing a longer-term vision for security, sustainability, and resilience. Below are some considerations for companies looking to realize this vision:

- **Digitalize to increase 360-degree supply chain visibility.** Digitalization can enable complete visibility throughout the supply chain and improve the transparency and traceability of materials and products. Blockchain technology can enable authenticated data communication between supply chain stakeholders, thus increasing supply chain transparency. Digital twin and advanced analytics can help improve decision-making by ordering and tracking inventory, collecting, and storing performance data more efficiently, and proactively addressing maintenance issues before a failure occurs.
- **Advance procurement departments' role from enabling savings to creating value.** Sourcing in a circular supply chain requires greater planning and coordination that may supersede organizational boundaries. Therefore, procurement's role as an interface to stakeholders in the upstream supply network

should become more strategic. Procurement departments can improve their understanding of materials, affect the circularity of the final product, and become trusted advisors, especially on supplier knowledge.<sup>36</sup> Instead of just chasing savings, the environmental and social footprint criteria become increasingly important in sourcing decisions.

- **Standardize for effective collaboration with stakeholders.** Standardization of products, processes, or procedures ensures all stakeholders in a supply chain are on the same page. It can enable lower production and procurement costs through economies of scale, easier and less expensive repair and replacement, as well as recycling. For example, in the case of solar, it would mean a more consistent method of designing products and assembling photovoltaic panels to make end-of-life recycling simpler and safer.

Supply chain disruptions will likely continue to occur, possibly with higher frequency. It is therefore increasingly important for the electric power sector to build resilient supply chains that are secure and sustainable, and can not only withstand such disruptions, but also emerge stronger.



## Endnotes

1. Jim Thomson and Marlene Motyka, "Global supply chain disruptions could slow grid modernization and decarbonization," *POWERGRID International*, October 27, 2021.
2. Ibid.
3. Mason County Public Utility District, "Material shortages and supply chain disruptions are causing delays," Mason PUD, September 16, 2021.
4. Austin Krohn, "Electrical supply chain issues slow new construction," *Columbia Missourian*, December 2021; American Electric Power Company, "Supply chain management and diversity," accessed June 24, 2022.
5. Claudio Vittori, Graham Evans, and Matteo Fini, "Electrical steel—Another temporary supply chain shortage or a threat to OEMs' electrification plans?," *IHS Markit*, December 14, 2021.
6. Wood Mackenzie, "Solar growth trajectory remains uncertain as federal legislation stalls," press release, March 10, 2022.
7. Nichola Groom, "US solar industry warns of slowdown due to supply chain disruptions, tariff uncertainty," *Reuters*, April 29, 2022.
8. Hugh G. Willett, "Utilities face supply-chain issues," *News-Herald*, May 25, 2022; Jennifer Hiller and Katherine Blunt, "Power companies enter peak hurricane season lacking enough transformers," *Wall Street Journal*, August 1, 2022; Sorin, "Tackling lengthy transformer lead time on solar projects," *Solar Scoop*, April 2019.
9. Hana Colwell, "Clean energy in America reaches milestone in 2021, but installation pace must accelerate to reach emissions goals," American Clean Power Association, February 16, 2022.
10. S&P Global, "Capital," accessed June 24, 2022.
11. US Department of Energy, *Grid energy storage: Supply chain deep dive assessment*, February 24, 2022.
12. The Inflation Reduction Act aims to incentivize renewable energy investment by extending and expanding the production tax credit (PTC) for electricity produced from renewable sources and the investment tax credit (ITC) for energy property, and by expanding eligibility to stand-alone energy storage, electricity transmission, and other clean energy investments; [Democrats.senate.gov](https://democrats.senate.gov), "Inflation Reduction Act of 2022," legislative text, accessed August 19, 2022.
13. International Energy Agency, *The role of critical minerals in clean energy transitions*, 2021, p. 26.
14. EUKOR, *Transformer market outlook: Supporting the growth in the power industry*, June 24, 2021.
15. US Department of Energy, *Electric grid supply chain review: Large power transformers and high voltage direct current systems: Supply chain deep dive assessment*, February 24, 2022; US Department of Energy, *Cybersecurity and digital components: Supply chain deep dive assessment*, February 24, 2022.
16. Clearway Energy Group, "Leading US solar companies announce consortium to spend over \$6bn on solar modules and support expansion of domestic supply chain," press release, June 21, 2022.
17. Marine Link, "Offshore wind vessels get 'vessel of national interest' designation by US MARAD," June 28, 2022.
18. John Engel, "World's first offshore wind workers certified with virtual reality," *Renewable Energy World*, July 19, 2022.
19. US Department of Energy, *Wind energy: Supply chain deep dive assessment*, February 24, 2022.

20. Siemens Gamesa, "Global leadership grows: Siemens Gamesa solidifies offshore presence in US with Virginia blade facility," press release, accessed August 23, 2022.
21. Justin Tuttle, "The future of supply chain management for energy and utility companies," Siemens, accessed June 24, 2022.
22. Exelon Corp, *Corporation sustainability report*, 2020, p. 123.
23. Material Handling and Logistics, "5 key supply-chain challenges that clean energy sector faces," June 29, 2021.
24. US Department of Energy, *Cybersecurity and digital components*, p. 1.
25. US Department of Energy, *Cybersecurity and digital components*, pp. 5–6.
26. Solar Energy Industries Association, "Solar supply chain traceability protocol," accessed June 24, 2022.
27. Climate Disclosure Project, *Global supply chain report*, 2020, p. 14.
28. US Environmental Protection Agency, *Emerging trends in supply chain emissions engagement*, accessed August 23, 2022, p. 22.
29. US Securities and Exchange Commission, "SEC proposes rules to enhance and standardize climate-related disclosures for investors," sec.gov, March 21, 2022.
30. Karin Rives, "Path to net-zero: Utility execs insist 'we can'," S&P Global, June 9, 2022.
31. Diverse supplier includes women, minorities (including Hispanic, African American, Asian American, Indian (subcontinent), and Native American), LGBTQ+, veterans, and service-disabled veterans.
32. PG&E Corp, "Supplier diversity info," accessed June 24, 2022.
33. Southern California Edison, *Moving forward, together and stronger: Supplier diversity 2021 annual report/2022 annual plan*, accessed August 23, 2022.
34. Source Intelligence, "6 unregulated materials that cause ethical sourcing risks in your supply chain," September 24, 2021.
35. Deloitte, *The case for a circular economy*, accessed August 23, 2022, p. 2; figure 9 in this report is adapted from content in the report cited.
36. Nina Schmid and Marcus Kutzner, *Procurement in a circular economy: Benefits beyond sustainability*, Deloitte, accessed August 23, 2022, p. 6.

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