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EPRI Insights

Supply Chain Considerations for the Energy Transition

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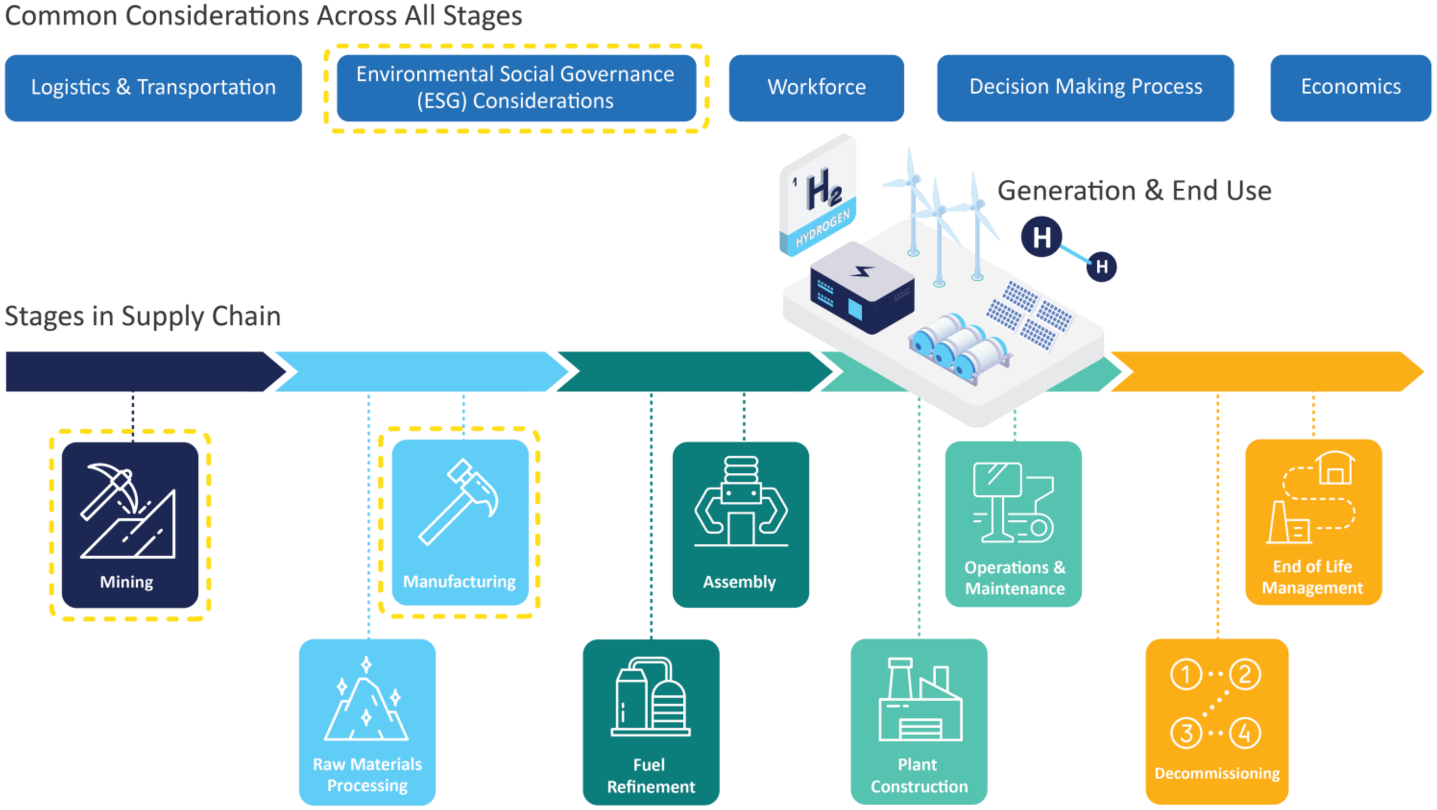
SUPPLY CHAIN OVERVIEW

The specific challenges of each stage in the energy supply chain should be considered alongside considerations common to all stages.

Meeting 2030 U.S. decarbonization goals could require robust deployment of clean energy technologies, with large capacity additions in wind, solar, and storage technologies [1]. Meeting this increased demand could require expanding and strengthening supply chains, while addressing challenges associated with each stage. Although supply chains might vary across technologies, there are typical stages for energy technology supply chains, as illustrated in the bottom half of the figure. The important considerations for every stage are included in the top half. Mining, manufacturing, and environmental, social, and governance (ESG) considerations (highlighted in the figure) are described here in more detail.

Typical supply chain stages cover the extraction of raw materials, the conversion of these into equipment or components, the operation of this technology, and end-of-life management. Overarching challenges might include aligning multiple stakeholders when making decisions, acting on varying economic signals, and developing a skilled workforce. The December 2022 issue of *EPRI Insights* [2] explores the workforce requirements of the clean energy transition.

Supply Chain for Clean Energy Technologies: Considerations, Challenges, & Physical Stages

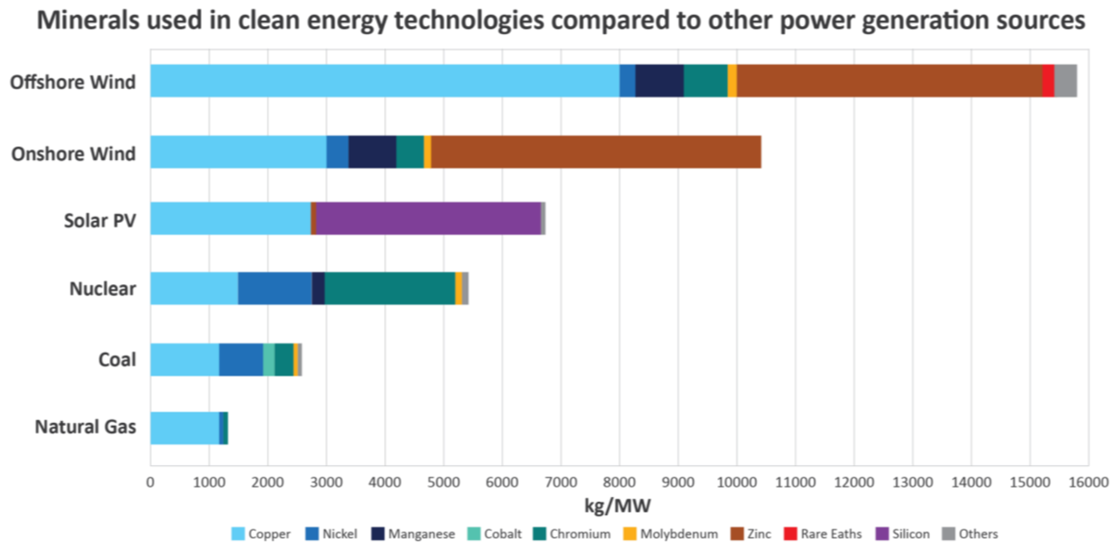


EPRI's white paper *Understanding Generation and Storage Technology Supply Chain Risks and Needs to Support Electric Utility Sector Decarbonization* [3] identifies areas of risk to supply chains and opportunities to support rapid clean energy technology deployment.

MINING

The energy transition is driving a change in the quantity and types of minerals used in and by energy technologies, which might present new challenges to the affordability, accessibility, and quality of materials.

New power generation capacity is increasingly being created with technologies that are more mineral-intensive than certain forms of traditional thermal plants, as illustrated in the figure below. Since 2010, the average amount of minerals needed for a new unit of power generation capacity has increased by 50% [1]. Demand for these minerals is also increasing from outside the power sector; for example, unlike traditional cars, electric vehicles require nickel, lithium, and cobalt, placing further pressure on supply chains outside the control of utilities.



For certain critical minerals, the projected demand outstrips known reserves. In other cases, the main supply chain issues relate to reliable and sustainable supply across exploration, mining, and processing rather than physical scarcity. Because the extraction of many of these minerals is currently more geographically concentrated than that of oil or gas, any region-specific supply chain issues, such as political instability or export restrictions, could have a disproportionate impact on buyers compared to more geographically diverse mineral markets.

Raw material costs now account for a higher proportion of the cost of producing various energy technologies than previously seen. One example of this is batteries, whose raw materials accounted for 40–50% of production prices five years ago, compared to 50–70% now [1]. Although there is increased demand for certain minerals, in many cases, supply cannot be simply ramped up in a sustainable manner without significant planning. Other impacts from the mismatch of supply and demand include longer project time leads and delivery delays as well as the potential for reduced choice in procuring minerals and less buyer control over resource quality [2].

To account for longer lead times, buyers might identify new reserves, open new mines, or expand processing facilities. Diversification of production can also mitigate region-specific supply chain risks. Because projecting mineral demand may involve considerable uncertainty and many of the planning steps mentioned require significant investment of time and capital, this issue has the potential to persist for several years. Besides increasing the supply of minerals, options to mitigate supply chain risks include identifying substitute materials or recycling more.

Example: Copper

Demand for copper is projected to double between now and 2035, outpacing the growth in supply by 2025 [3]. Existing mines have been operating at peak capacity and producing declining ore quality for several years. Accessing more reserves requires opening new mines, and there is a 16-year lead time on fully developing a new mine [3]. To some extent, this demand can be met through innovations in recycling and aluminum substitution. However, existing and planned mines will supply only 80% of demand by 2030 [2]. Clear policy objectives to improve efficiencies in regulation and financing may be needed in certain countries to expedite commissioning new mines to meet this demand [3].

MANUFACTURING

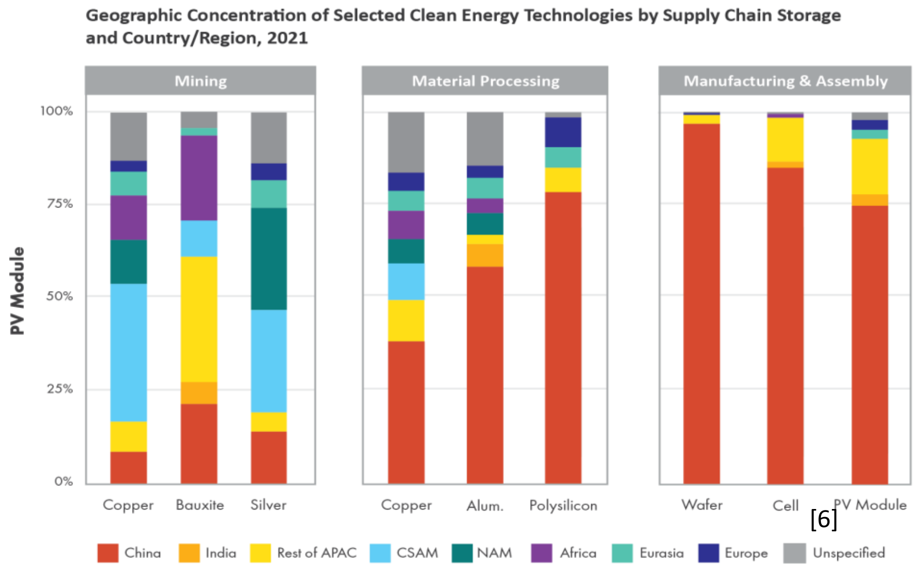
Building robust, qualified, and geographically diverse manufacturing capacity for clean energy technology components might mitigate a category of supply chain risks.

Growing demand for energy technologies could require scaling up manufacturing facilities to produce subcomponents and final equipment, such as photovoltaic (PV) modules, turbine blades, generators, inverters, batteries, or other key equipment. Historically, equipment manufacturers have kept pace with demand while paying particular attention to risks such as the manufacturing capacity of clean energy technology components concentrated in a few key regions and the limited availability of manufacturers with proven quality performance and safety standards [1].

Example: Solar PV

Manufacturing capacity for PV modules has increased by more than 10 times since 2010. Despite higher demand, the global annual manufacturing capacity for PV modules has been in oversupply over the last 17 years. However, production capacity is concentrated in a few countries, which could raise geopolitical, environmental, and social risks. For example, looking at the subcomponents of a solar module, 14% of global polysilicon wafer production took place in a single factory. China accounts for 97% of global wafer manufacturing capacity and 85% of global cell production [2].

In the United States, efforts are underway to increase local manufacturing capacity. First Solar announced plans in 2022 to build a new factory in the southeast United States and upgrade and expand manufacturing capacity in their Ohio-based facilities. Enel North America has also announced plans to build a solar PV factory in the United States [3, 4].



[6]

The manufacturing sector for energy technologies is poised to potentially benefit from the Inflation Reduction Act of 2022 which includes incentives and tax credits for clean energy technology component manufacturers in the United States [5]:

- Section 45X Advanced Manufacturing Tax Credit
- Section 48C Advanced Energy Project Investment Tax Credit: incentive to purchase and commission property for a manufacturing facility before 2025
- Increased production and investment tax credits for projects meeting domestic content requirements, potentially increasing demand for U.S. manufacturing

The CHIPS and Science Act also directs $53.7 billion for semiconductor manufacturing, R&D, and workforce development, and $24 billion worth of tax credits for semiconductor production [7]. Semiconductors are used in solar PV, wind turbines, electric vehicles and their chargers, and electric grid components [8].

2050 AND BEYOND: SUPPLY CHAIN WORKSHOP FOR STRUCTURAL COMPONENTS IN ADVANCED ENERGY SYSTEMS

EPRI's Advanced Manufacturing Methods and Materials (AM3) initiative is addressing common supply chain challenges for emerging advanced technologies.

Looking beyond near-term decarbonization commitments, industries might need to deploy advanced energy systems (AESs), such as small modular reactors, advanced reactors, concentrated solar power, thermal energy storage, low-/no-carbon power cycles (hydrogen, for example), and supercritical carbon dioxide power cycles. Developing strong supply chains for emerging technologies can help address near-term deployment challenges so that these technologies may serve deep decarbonization roles in the 2030s–2050s and beyond.

Because many AES technologies are currently first-of-a kind devices or have limited operational experience, low demand means that traditional supply chains for certain AES components might not exist. These components could require advanced materials to withstand the different environments found in AESs, such as higher temperatures. Advanced manufacturing could reduce costs and allow for procurement and design options, but challenges remain for the use of advanced materials and manufacturing methods in AESs [1].

In June 2022, EPRI's AM3 initiative hosted a Supply Chain Workshop for Structural Components in Advanced Energy Systems to identify needs and priorities across AES developers. A full summary of the workshop can be found here.

Key challenges identified in the workshop include:

- Hesitation to invest in capabilities and infrastructure without clear market signals and limited demonstration
- Limited skilled workforce, particularly in machining and welding
- Material and component qualification in nuclear applications

Key needs identified in the workshop include:

- Developing material and component qualification programs, particularly for nuclear applications
- Advanced manufacturing methods approved by the American Society of Mechanical Engineers (ASME) Codes and other standards for production purposes
- Developing skilled labor, including a machining and welding workforce
- Test facilities for demonstration and qualification
- Improved collaboration across AES developers and supply chain partners

A second EPRI Supply Chain Workshop for Structural Components in Advanced Energy Systems is scheduled for April 12–13, 2023.

ENVIRONMENTAL, SOCIAL, AND GOVERNANCE

Increasing stakeholder focus on corporate supply chain sustainability practices and performance, and the evolution of best practices in this area, indicate that a focus on ESG has the potential to mitigate and reduce risk at any supply chain stage.

ESG (Environmental, Social, and Governance) considerations refer to the potential sustainable and ethical impacts of an organization's practices. Whereas methods for quantifying an organization's performance in this area for potential financial investors (known as ESG scores) exist, ESG priorities tend to be industry-specific. Sustainability priorities for the North American electric power industry as identified by EPRI in 2022 [6] included:

Interest in ESG performance related to supply chains is relatively recent and priorities are evolving. This is highlighted in the results of previous surveys with North American energy companies regarding material sustainability issues conducted by EPRI in 2013 [1], 2017 [2], and 2021 [3].

EPRI survey results from 2013 did not identify supply chains as an issue to be addressed, but rather found them to be a tool in addressing other sustainability issues. However, more recent survey results indicate that diverse ESG performance expectations were increasingly expanding beyond direct company-owned operations and into relationships with suppliers. In 2021, results indicated that supplier sustainability and human rights performance, as well as supply chain resiliency, were major issues for North American energy companies.

One reason for this shift may be that the link between supply chain sustainability and a company achieving its overall sustainability goals is becoming stronger. Also, ESG considerations are receiving more attention from internal and external stakeholders. Energy companies have noted ESG-related requests from corporate customers, investors, internal leadership, and internal dedicated sustainability teams [3–5]. Notably, governmental and non-governmental organizations are not primarily driving this change [4].

Some organizations have established policies and procedures to engage with their suppliers to collect sustainability data, include sustainability in procurement decision-making, and track performance [6]. As pressure to report more information from further down the supply chain grows, EPRI's Strategic Sustainability Science Program is conducting additional research on supply chain sustainability aspects and measures to address them.

CONCLUSION AND EPRI NEXT STEPS

EPRI's supply chain project continues to identify potential solutions for energy sector supply chain challenges.

Rapid deployment of clean energy technologies might present challenges for energy sector supply chains, such as increasing mining production, diversifying manufacturing approaches and geographies, and consideration of potential ESG issues. EPRI also has explored other supply chain challenges, including supply chain considerations for battery storage, wind, solar, and AES technologies.

EPRI plans to continue research into energy system supply chains to address developing issues as the energy sector evolves and new needs emerge. Topics may include:

- Comprehensive white papers exploring supply chain needs for electricity delivery infrastructure and clean energy generation technologies to reach decarbonization goals for 2050 and beyond
- A second EPRI Supply Chain Workshop for Structural Components in Advanced Energy Systems
- Tracking supply chain signposts
- Accelerating supply chain–related projects across EPRI programs
- Convening internal and external experts to discuss supply chain research and identify opportunities for collaboration.

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While based on sound expert knowledge from research programs across EPRI, they should be used for general information purposes only and do not represent a position from EPRI.

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