Supply Chain Considerations for Clean Energy Project Development

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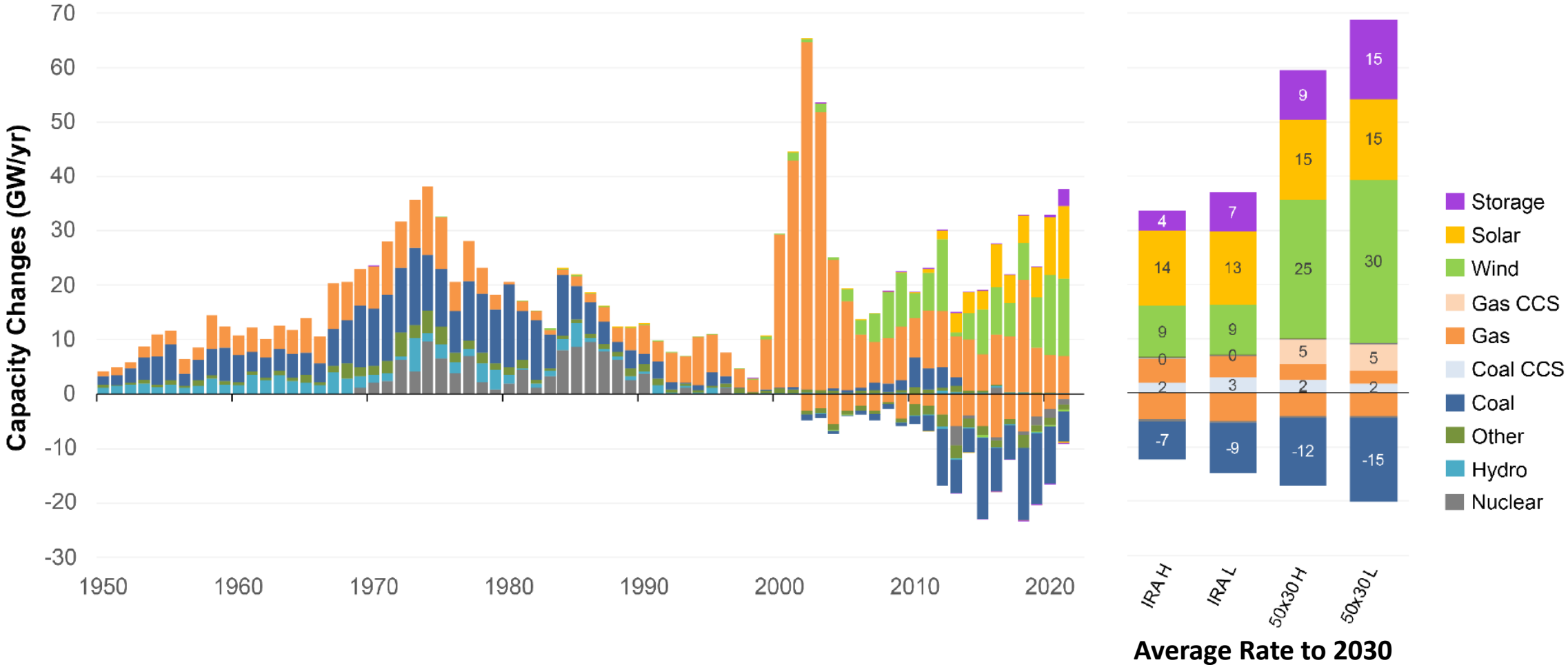
Motivation: Rapid Expected Deployment of Clean Energy Technologies



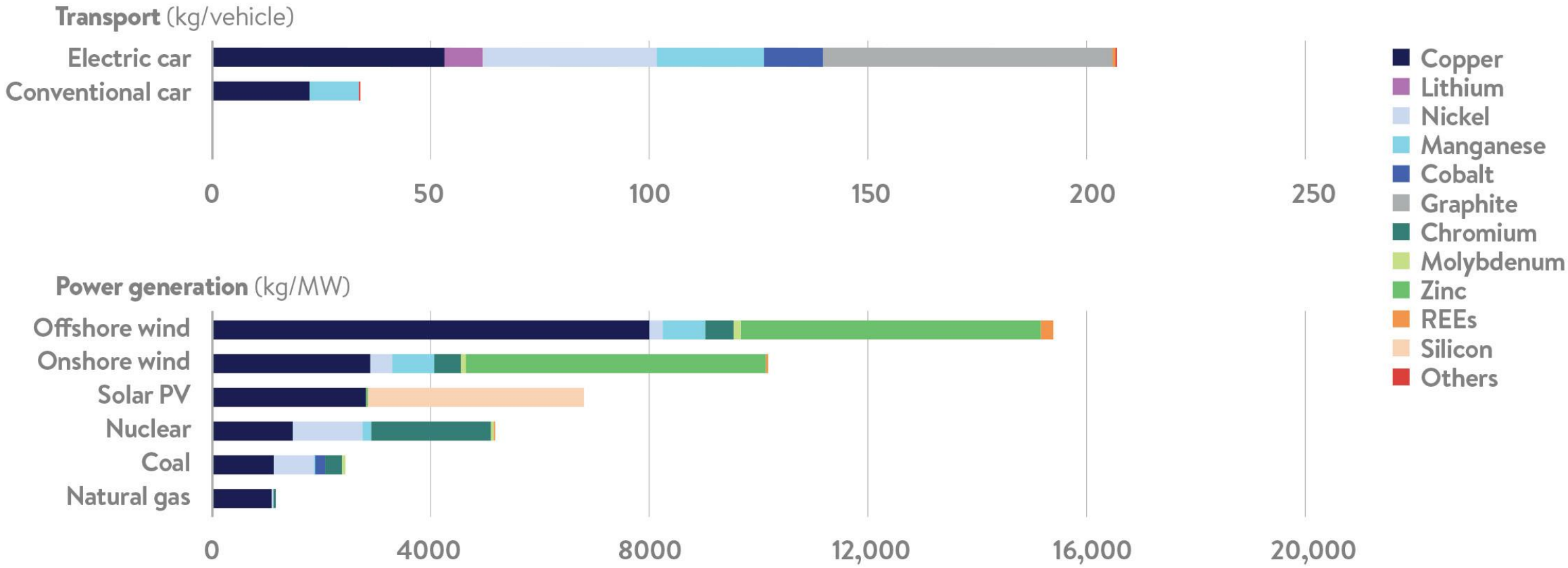
Projected pace of deployment of clean energy technologies that could enable 2030 U.S. decarbonization goals based on EPRI's *Impact of Inflationary Drivers and Updated Policies on U.S. Decarbonization and Technology Transitions* (3002026229), Historical values through 2021 based on Form EIA-860 data

What are the supply chain risks and research opportunities to achieve accelerated deployment?

Supply Chain Risks

- Critical Material Availability
- Manufacturing Capabilities
- Geopolitical, Environmental, and Social Risks
- Transportation and Logistics

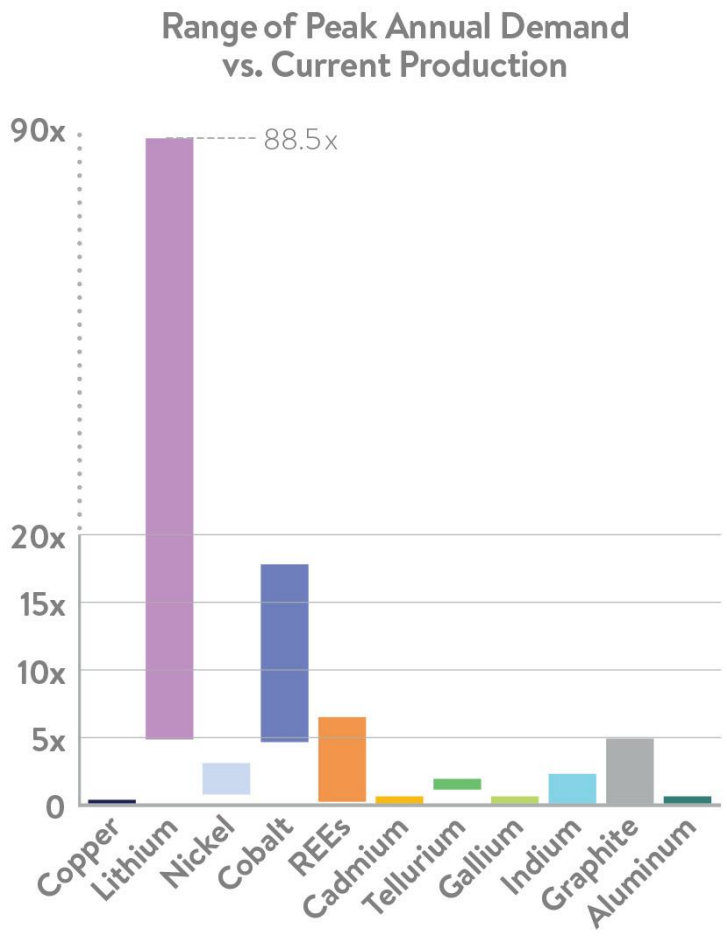
Critical Mineral Availability: A Shift in Energy System Needs

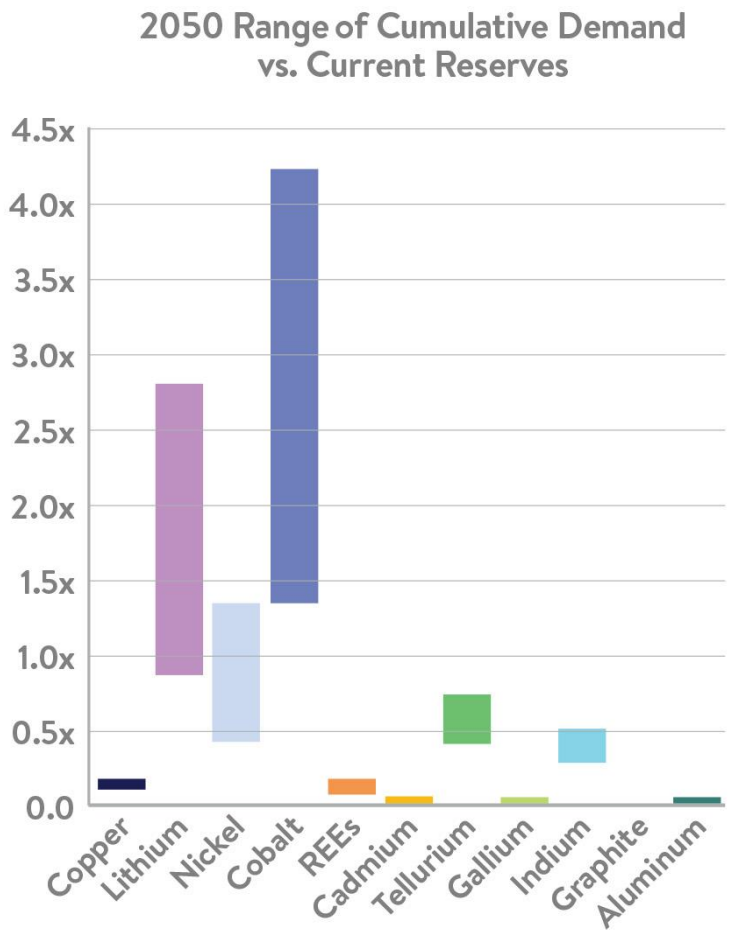


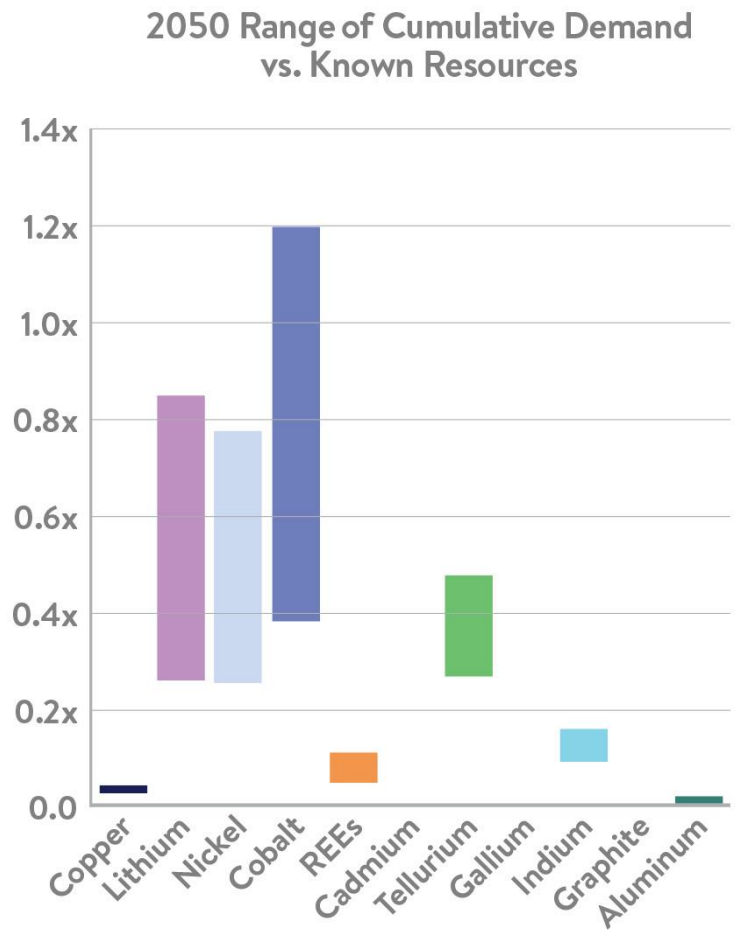
Source: IEA (2021), *The Role of Critical Minerals in Clean Energy Transitions, World Energy Outlook Special Report. All rights reserved.*

"Shift from a Fuel-intensive to a Material-intensive Energy System"

Critical Mineral Availability: Projected Mineral Demand

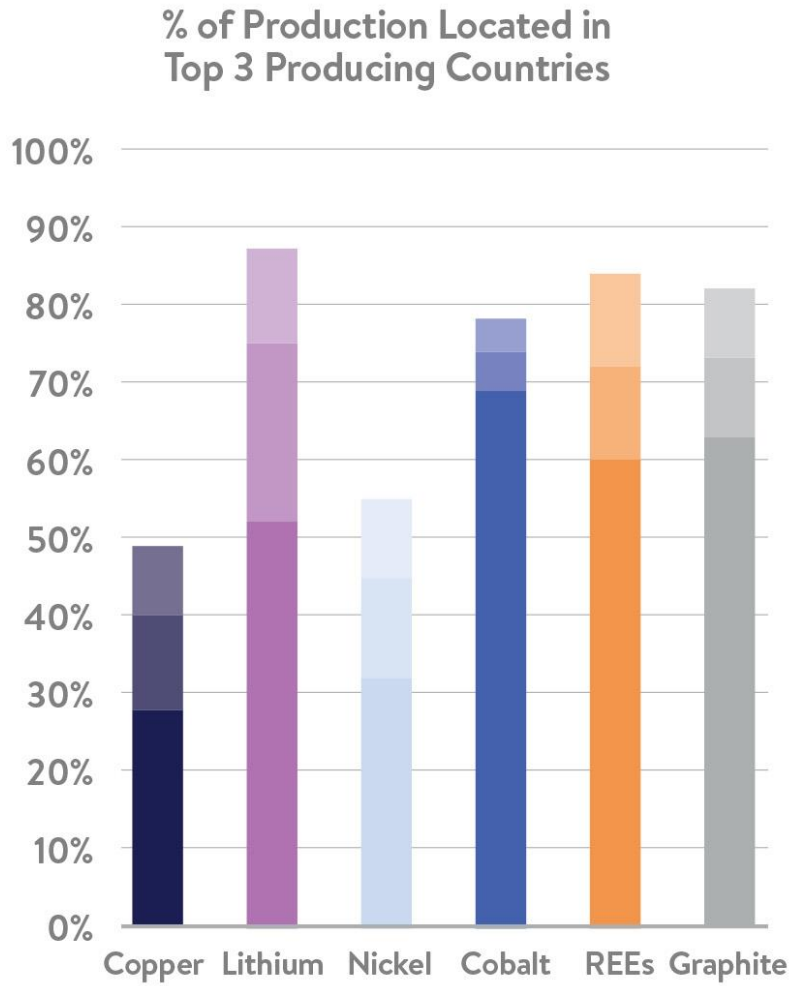


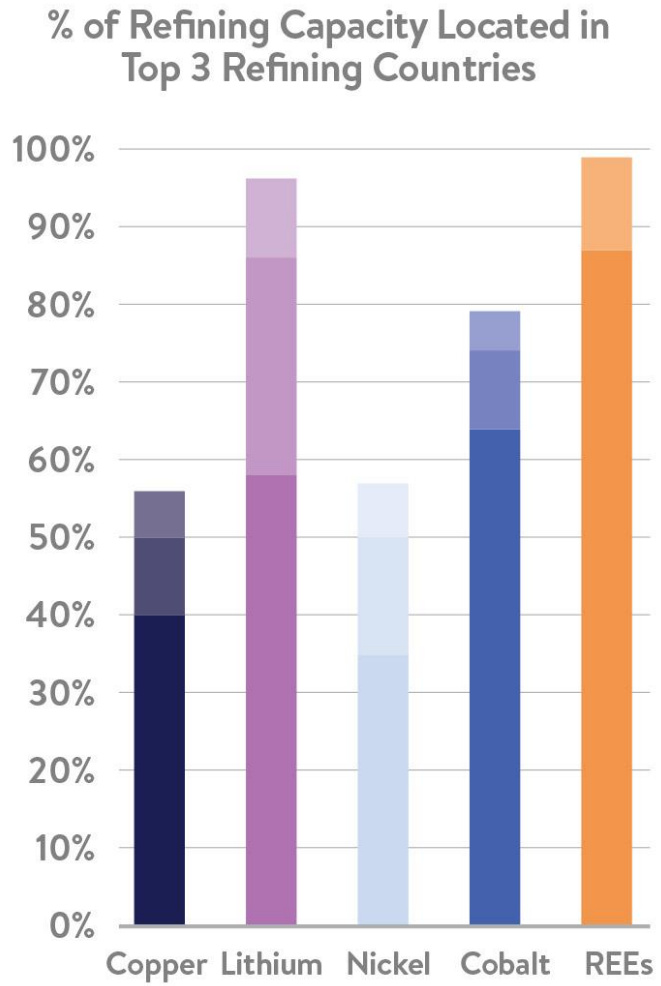




Demand for key minerals, especially those currently used for lithium ion batteries, is expected to increase significantly between now and 2050

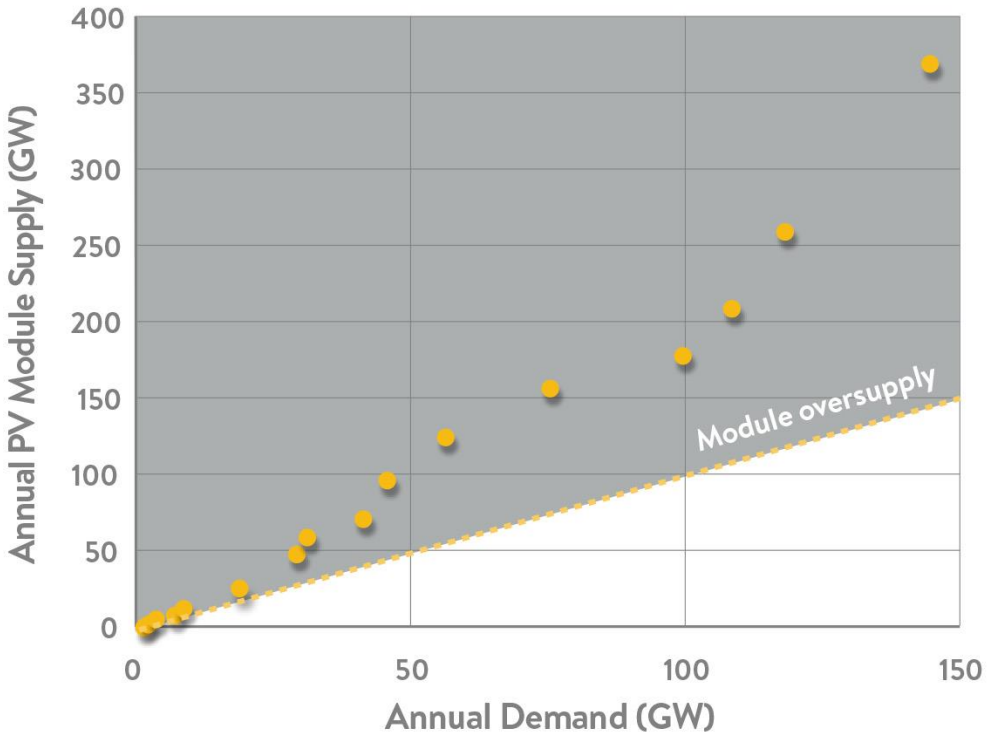
Critical Mineral Availability: Concentration of Supply Production and Refining

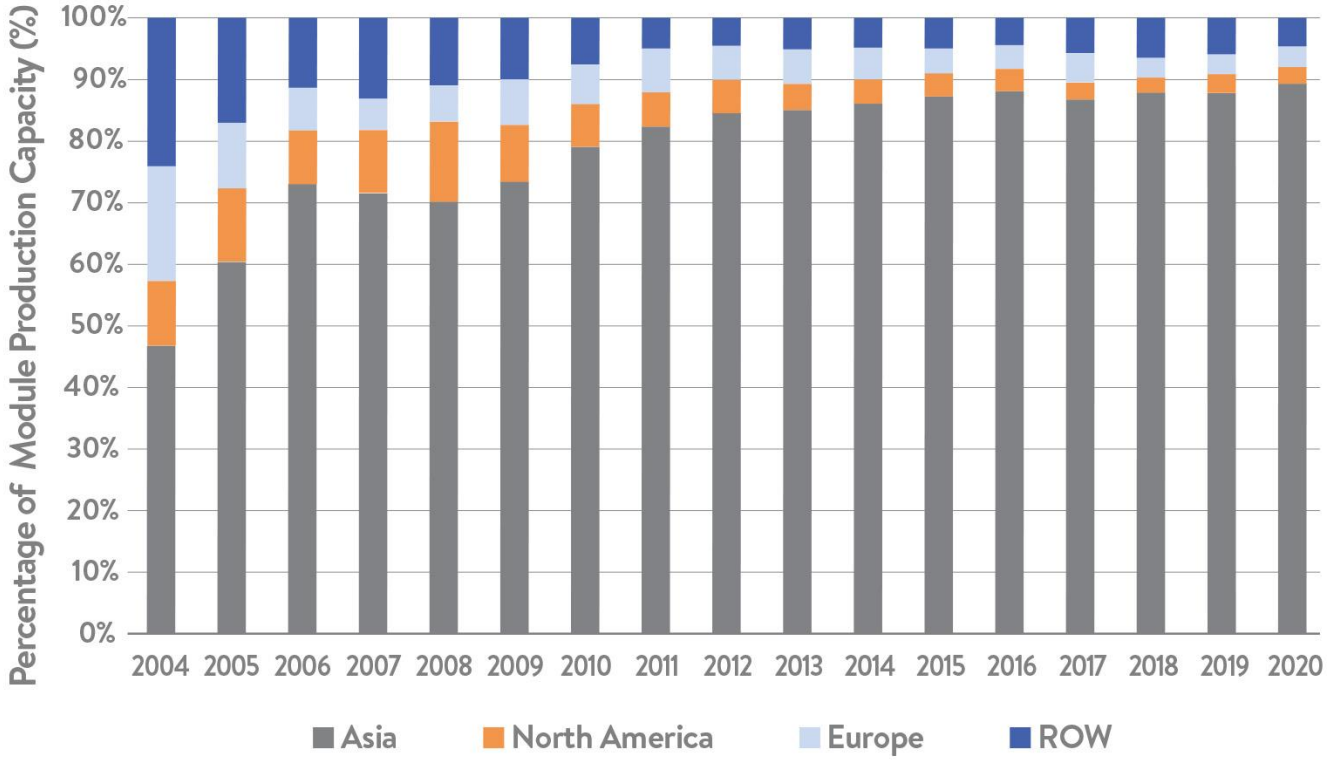




Nearly 70% of cobalt production is in DRC and 60% of REE production is in China; China accounts for over 60% of cobalt refining and 85% of REE refining capacity

Manufacturing Capabilities: Solar PV

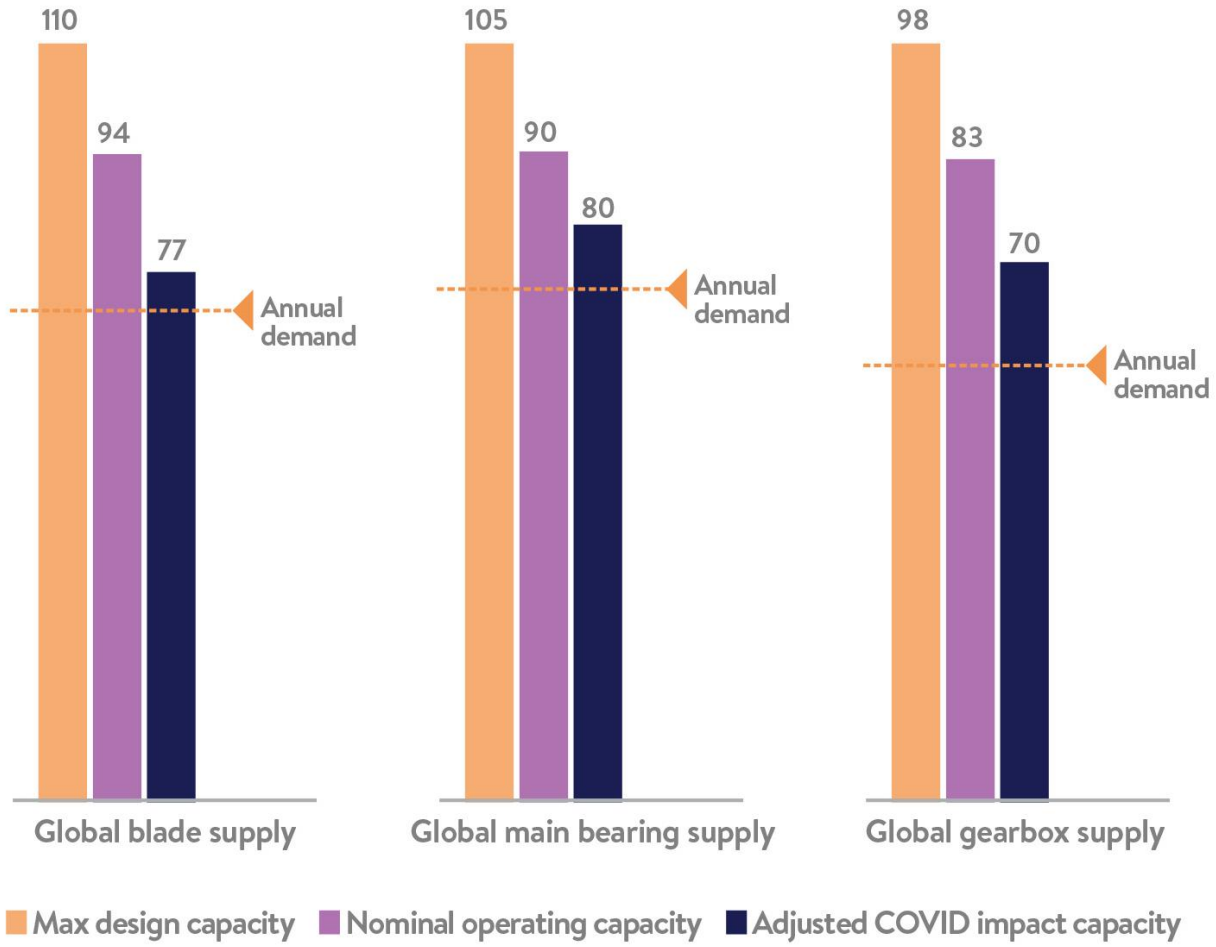




Historic oversupply of global annual PV module manufacturing capacity, production capacity concentrated in China

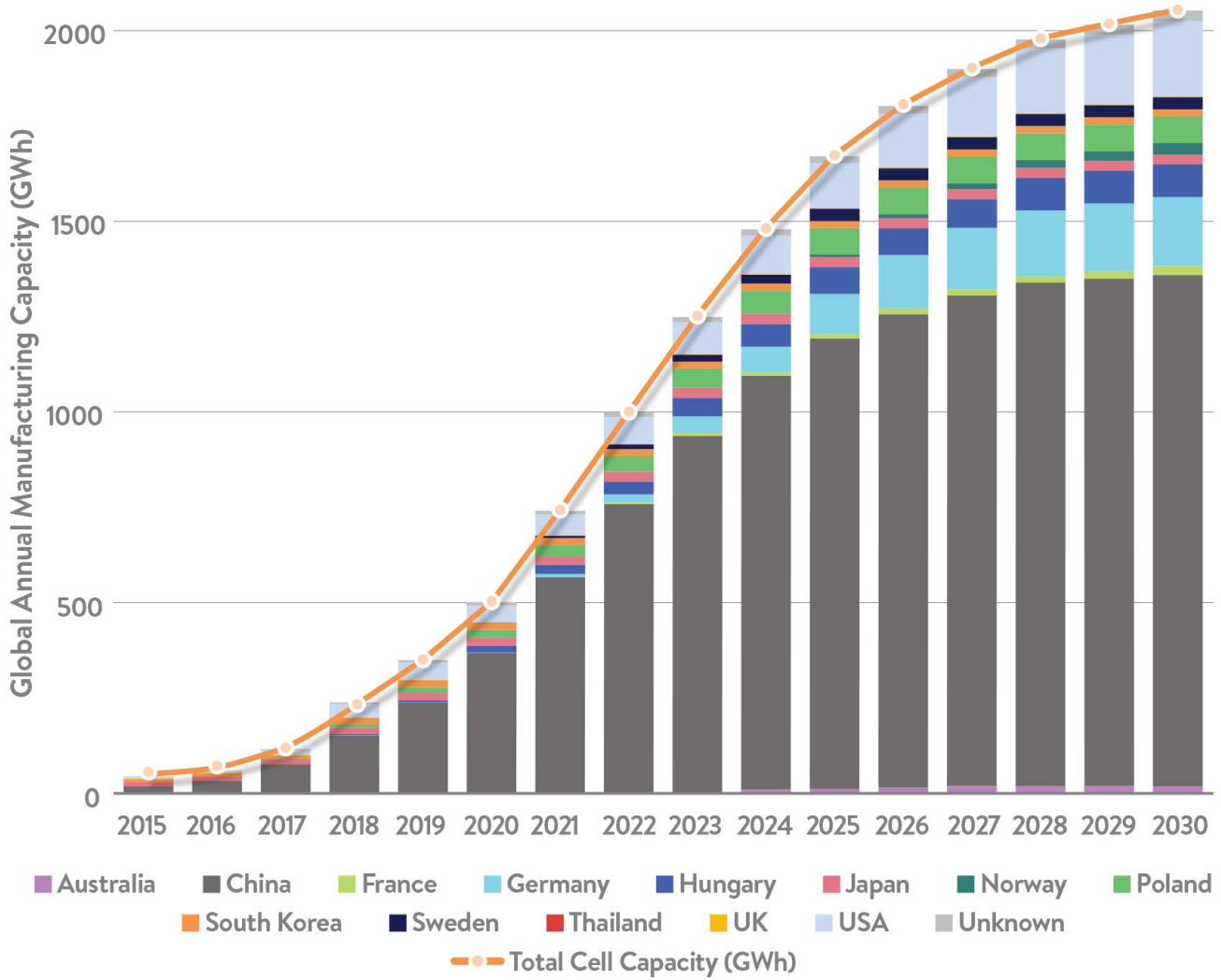
Manufacturing Capabilities: Wind

Global wind equipment production capacity exceeds demand, but supply-demand margins could continue to narrow, especially as seen with disruptions to manufacturing and shipping during the pandemic



Source: Wood Mackenzie (April 2020), *Coronavirus Impact to Wind Energy Supply Chain*

Manufacturing Capabilities: Lithium Ion Batteries



Global battery manufacturing capacity expected to double between 2020 and 2022 and increase fourfold by 2030

Availability of batteries from "Tier 1" manufacturers viewed as a challenge

Competition between EVs and stationary storage

Source: Wood Mackenzie (2021), *Global Energy Storage Outlook H2 2021*

Geopolitical, Environmental, and Social Considerations

Trade Tariffs and Import Restrictions

Human Rights, Labor Issues, and Health and Safety

Environmental Impacts of Materials Extraction and Manufacturing

Transportation and Logistics

Challenges transporting materials and equipment from source to interim and final destinations

Increased shipping costs

Increased time from procurement to commercial operations and project delays

Opportunities to Improve and Strengthen Supply Chain Resiliency

- Decreasing Material Usage Intensity
- Increasing Recycling
- Diversifying and Expanding Supply Chains
- Establishing Global Environmental and Social Standards

Insights from EPRI's Recent White Paper

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