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Chairman Westerman, Ranking Member Huffman, Subcommittee Chairman Stauber, and Subcommittee Ranking Member Ansari, thank you for inviting me to testify on this important and timely topic.

Ever since Thomas Edison's enterprise laid 80,000 feet of copper wires under streets in Lower Manhattan in 1882, lighting up one square mile, copper has proved its mettle as the metal of electrification. In the century and a half since then, as copper has gone on to wire the world, the staggering growth in consumption has turned it into one of the most important materials of modern civilization. But, without significant adjustments, copper supply faces a growing challenge of keeping up with the accelerating pace of electrification.

The importance of copper has been underlined over the last half decade as a number of countries have deemed it a "critical metal", including, in 2025, the United States. And with good reason. Copper is the connective artery linking physical machinery, digital intelligence, mobility, infrastructure, communication, and security systems. All of this has made the future availability of the metal a matter of strategic importance. The United States' designation of copper as a critical mineral underlines its essential role in enabling the infrastructure, technologies, and security systems that will shape the coming decades.

Recently, S&P Global published a comprehensive study entitled, *Copper in the Age of AI: Challenges of Electrification*.[1] Our study identifies a transformative trajectory for copper demand, projecting a surge from 28 million metric tons in 2025 to 42 million metric tons by 2040. This 50% increase underscores the metal's pivotal role in multiple technological and economic domains. However, meeting the call on copper confronts significant supply obstacles both above and below ground. The study projects a potential 10 million metric ton copper shortfall by 2040 without meaningful supply expansion.

[1] S&P Global, *Copper in the Age of AI: Challenges of Electrification* (New York 2026).

But what is driving this demand? It arises from the fact that copper is essential for the generation, transmission, and use of electricity. But the demand for copper will outrun supply unless there is major adjustment across the copper supply system.

Here, in short, is the quandary: copper is the enabler of electrification, but the accelerating pace of electrification is an increasing challenge for the metal.

In S&P Global's base case, global electricity demand will increase by nearly 50% by 2040. And this surging electrification is advancing around the world. In the United States, for a quarter century, electricity consumption hardly rose year over year, but it is now beginning to grow at what could be 2.5% annually. In China – with an electricity market more than double that of the United States – it will grow at 3.2% per year between now and 2040. In India, it will be 4.2% per year.

Five Vectors of Demand

The demand for copper is growing along five vectors, each of which adds to the pyramiding call on copper. The newest to emerge is one that was not even evident four years ago and yet today is highly visible in terms of global transformation for both work and life. That, of course, is artificial intelligence (AI). While AI has long been in development, it only "broke through" in November 2022, with the debut of ChatGPT. That launched the "AI Race". It is a race that his powered by electricity. In 2025, AI spending played a significant role in U.S. GDP growth.

This explosive growth of AI and data centers has introduced a new, rapidly expanding vector of copper demand. Data centers are electricity-intensive, and their proliferation is driving massive investments in both direct copper use (for power delivery, cooling, and IT infrastructure) and in the electric grid infrastructure that supports them. By 2030, data centers alone could rise, we estimate, from today's 5% to 14% of US electricity demand, with copper a critical enabler all along the way. What is still to play out is the indirect impact of AI in terms of the electric infrastructure needed to meet the enormous demands of users – and the impact that AI will have in generating industrial, commercial, creative, and personal applications that will lead to further cycles of copper demand.

While AI is creating a new vector of copper demand, it is not the largest. But the reason that we call our paper "Copper in the Age of AI" is because the requirements of AI underline the essential and foundational role of expanded electricity supply – and thus the need for more copper.

It is “core economic demand” that we cite as the first vector – from appliances and computers to construction and manufacturing. And this vector of demand – the largest – continues to grow. In the developing world, a combination of urbanization, rising incomes, and changing building practices means electricity use and thus more copper. One vivid example: the developing world is projected to add as many as two billion new air conditioners by 2040. In the United States, the reshoring of manufacturing and the resulting growth in electricity consumption are driving electric utilities to add more generation, more transformers, and more transmission and distribution lines.

A second vector of copper demand has only emerged over the last decade – “energy transition and addition.” Electric vehicles (EVs) require 2.9 times more copper than a conventional car, and the population of EVs is growing. The number of electric cars sold worldwide in 2025 was 25% greater than total new cars sold in the United States, the world’s second largest new car market. Solar and wind require a lot of copper, and over 90% of the new electric generating capacity installed in 2025 worldwide was solar and wind. Another new demand for copper is for the batteries being deployed to store renewably generated electricity. Transmission and distribution systems are being expanded worldwide.

But energy transition takes another form as well – it is also populations in the developing world moving from wood and waste for their heating and cooking to commercial energy, including electricity. Africa is home to almost 20% of the world’s population but is grossly underserved in terms of electricity. Copper will be integral to the systems that are rolled out to meet the need for electricity across that continent.

The third vector of demand is, as already mentioned, AI and data centers.

The fourth vector of the increased copper demand is defense. Rising geopolitical tensions and the electrification of military systems and the battlefield itself are driving up spending on defense and the push for new technologies. The investment in these technologies and systems is “inelastic” – given the national security stakes. Notable is the pledge by NATO members to increase defense spending to five percent of GDP. Modern weaponry, communications, and infrastructure are increasingly copper-intensive, and defense-driven demand is projected to triple by 2040.

And now a fifth new vector of demand is on the horizon – humanoid robots. There is much variance in projections for their scale by 2040 – varying from tens of millions to hundreds of millions to a billion or more. Whatever the actual number, these humanoids will not just be wired – but heavily wired – with copper.

Demand versus supply

Even as global demand is accelerating along these vectors, current supply is on course to decline as existing resources age. Without meaningful expansion of supply, the result could be a 10 million metric ton shortfall by 2040.

Copper supply is a global story, where the U.S. has a major role to play. For decades, the U.S. was both the largest copper miner and the largest copper refiner in the world. In 1990, US copper production represented 18% of global mined production, and 19% of global refined production. Now the picture is starkly different: 4% and 3% respectively for 2025.

However, the U.S. has over 230 million metric tons of copper in reserves and resources underground waiting to be mined. It remains the second largest country in reserves and resource potential, behind Chile – so unlocking that supply is key.

Meeting the growing demand is fraught with challenges both above and below ground. The supply response is multi-faceted but constrained:

- **Mined copper – "primary supply":** Mining faces declining ore grades, rising costs, and increasingly complex extraction conditions. Without significant new investment, output from existing mines will decline, and the pipeline of new projects is hampered by long development timelines – averaging 17 years globally – resulting from permitting delays, and above-ground risks such as regulatory uncertainty, public opposition, shifting government terms in countries around the world, and rising costs.

- **Recycling – "secondary supply"**: While copper's recyclability offers additional supply, such secondary supply alone cannot close the gap. Even with very aggressive improvements in collection and processing, recycling could meet about a quarter of global demand by 2040, leaving a substantial shortfall.

- **Processing criticality:** Smelting and refining capacity, especially concentrated in China, have become critical nodes in the supply chain. The economics of processing are increasingly precarious, with treatment and refining charges under pressure and with regional disparities in operating costs and regulatory environments. The geographic concentration – estimated at 40% to 50% of total capacity – amplifies systemic risks and exposes the supply chain to geopolitical shocks.

Substitution and trade risks

What distinguishes copper from other metals is its exceptional conductivity of electricity – exceeded only by a precious metal, silver. This conductivity, along with the metal's durability and recyclability, makes substitution difficult in most applications.

While aluminum, plastics, and fiber optics compete in select uses, copper remains the preferred and/or essential material for safety, performance, heat management, and sustainability. Substitution, miniaturization and "thrifting" (using less copper per application) are limited by technical and economic factors, and the bulk of feasible substitutions are considered to have already occurred. The price ratio of copper to aluminum remains elevated, but further displacement may be limited without major technological breakthroughs.

Governments are increasingly recognizing the strategic importance of stable and competitive mineral supply chains. Emerging modes of international cooperation and the growing role of sovereign wealth funds are offering new approaches to secure and diversify critical mineral supplies.

Policy, innovation, and the path forward

These challenges underscore the urgency of policy action, investment, and innovation across the copper value chain. Meeting rising demand in the coming decades will require considerable effort and innovation across the entire value chain:

- **Accelerating mine development**: Streamlining permitting and rationalizing judicial reviews, fostering stable investment frameworks, and leveraging new technologies are essential to shortening development timelines and unlocking new supply. Reforms in permitting and judicial review are critical.

- **Expanding processing capacity**: Diversifying smelting and refining capacity beyond current hubs, incentivizing innovation, and aligning tariffs and industrial policy are critical to reducing systemic vulnerabilities – but also come with challenging economics and additional costs as well as regulatory obstacles.

- **Enhancing recycling**: Investment in collection infrastructure, regulatory incentives, and international cooperation can boost recycling rates, but cannot replace primary supply growth.

- **Talent and skills**: Addressing the talent gap in mining and processing is vital, as the industry faces a wave of retirements and declining enrollment in technical programs.

Copper's role as the linchpin of electrification, digitalization, and security in the age of AI is both an opportunity and a challenge. The intersection of accelerating demand, constrained supply, and concentrated processing capacity creates systemic risks that require responses from policymakers, regulators, industry, and investors. The choices made in the coming years will determine whether copper remains an enabler of progress or becomes a bottleneck to growth and innovation.

Thank you again for inviting me to testify and the opportunity to contribute to this timely and important dialogue.

Daniel Yergin is vice chairman of S&P Global and chairman of the CERAWeek conference. He co-chaired the new S&P study, *Copper in the Age of AI: Challenges of Electrification*. His most recent book is *The New Map: Energy, Climate, and the Clash of Nations*. He received the Pulitzer Prize for his book *The Prize: The Epic Quest for Oil, Money and Power*. He was awarded the inaugural James Schlesinger Medal for Energy Security from the U.S. Department of Energy.