Include Copper on the 2025 USGS Critical Minerals List.

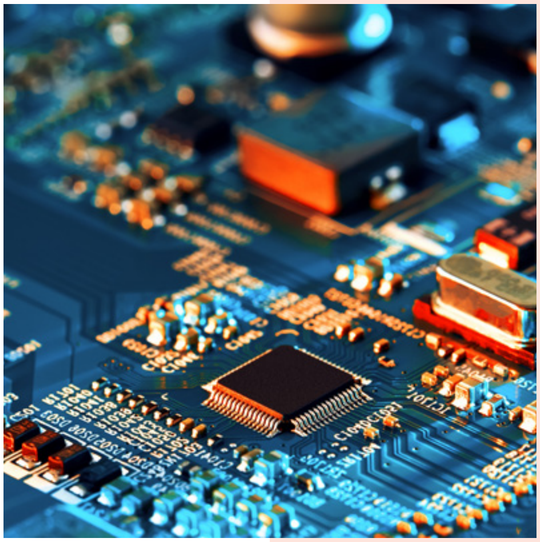
Copper's Updated Critical Mineral Supply Chain Calculations October 2024

BY IAN LITTLEWOOD

Copper Development Association Inc.

EXECUTIVE SUMMARY

The Copper Development Association (CDA) has replicated the USGS methodology, and our analysis shows that for the second year running copper exceeds the criteria for inclusion as a Critical Mineral, owing in part to ever rising import reliance, but also because of the ever-increasing concentration of production in geopolitical adversaries. Copper is and always has been critical to our economic and national security but now to the clean energy transition and the tremendous growth opportunities that AI offers our economy as well. With further abrupt demand growth forecast to meet the growing needs of the energy transition and to augment U.S. dominance in the evolution of AI, the Secretary of the Interior should act to give copper the credit it is due by including it on the 2025 Critical Minerals list rather than putting our growth, economic leadership and defense at risk.



The United States is making tremendous advances in clean energy and electric vehicles, and is on the cusp of an AI revolution that will improve the lives of everyday Americans, while also enabling continued economic and technological leadership. But none of this is possible without the critical role that copper plays in each and every part of this growth, whether that's connecting new energy sources to the grid, driving electric motors or building data centers to power cutting edge technology.

The need for copper to help the U.S. meet clean energy and AI goals is both exciting and challenging. Fortunately, the U.S. has the copper reserves and resources to secure its supply for decades to come. An all-of-the-above approach increasing production and refining, increasing recycling, and continuing to lean on reliable trade partners for imports will all be required. However, none of them alone are enough and all contain risks and hurdles. Without increased domestic production, S&P Global estimates that U.S. net import reliance will exceed 60% by 2035.

One way to meet the challenge is to give copper the credit that it is due for the vital role it plays in our lives and in our future including it on to the official USGS Critical Minerals list. Countries around the world have already designated copper as critical. The U.S. Department of Energy agrees and added copper to their Critical Materials list. USGS must follow suit.

Copper is so critical that when the Energy Act of 2020 defined the uses of a Critical Mineral, **copper was found in each and every one.** The energy transition and AI revolution is forecast to lead to abrupt demand growth, another element of the definition. The Act further states that a Critical Mineral must be essential to the economic and national security of the United States, which of course it is, as the economy, data centers and the military all rely on electricity to function.

A final part of the Energy Act definition references the supply chain being vulnerable to disruptions, including foreign political risk, military conflict, violent unrest and anticompetitive behaviors, which are found in some of the major copper producing countries. Ominously, Russia, China and Iran accounted for 52% of non-U.S. global refined copper production in 2023, up from 42% in 2016 and their share is forecast to continue to increase. At the same time, the U.S. reliance on imports has increased dramatically over the past few years, with the share of refined consumption that is reliant on net imports rising from 31% in 2016 to 41.2% in 2023, yet another slight increase from 41.0% in 2022.

In 2021 when the USGS updated its methodology to determine which metals should be considered a Critical Mineral, copper didn't meet its criteria. Unfortunately, the latest data that the USGS used in its study was from 2018. The data was already considerably out of date and the world has changed dramatically since then. The USGS methodology certainly has some shortcomings but if that is the approach to be followed, at the very least the very latest available data should be used.

CDA REPLICATION OF USGS CRITICAL MINERALS METHODOLOGY

The USGS Critical Minerals Methodology aims to quantify supply risk and set a threshold, above which, minerals qualify for inclusion on the critical minerals list. Supply Risk is defined by the USGS as the confluence of the following three factors:

1. the likelihood of a foreign supply disruption (Disruption Potential)
2. the dependency of the U.S. manufacturing sector on foreign supplies (Trade Exposure)
3. and the vulnerability of the U.S. manufacturing sector to a supply disruption (Economic Vulnerability)

Supply Risk (SR), as a score ranging from 0 (low) to 1 (high), was calculated as the geometric mean of three components, as follows:

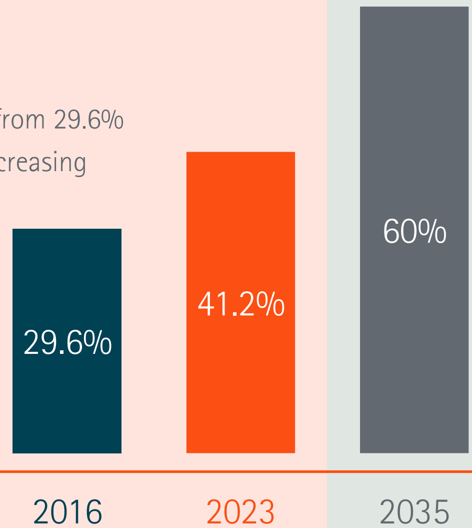
$$SR_{i,t} = \sqrt[3]{DP_{i,t} \quad TE_{i,t} \quad EV_{i,t}},$$

In simple terms, Supply Risk is equal to the cubed root of Disruption Potential multiplied by Trade Exposure multiplied by Economic Vulnerability. The USGS Methodology determines that 0.40 is the cut off for inclusion in the Critical Minerals List. Supply Risk scores for each year were then given a recency-weighted average over a four-year period, with the latest year having a 40% weight, the prior year 30%, the year before that 20% and finally the oldest year, 10%. We have updated the USGS methodology with full year data to 2023.

Import reliance of copper is

ON THE RISE

U.S. net import reliance is up from 29.6% in 2016 to 41.2% in 2023 – increasing the trade exposure risk



S&P Global says net import reliance will grow to 60% in 2035 without new domestic production

OUR UPDATE OF THE USGS METHODOLOGY WITH LATEST DATA SHOWS THAT COPPER CONTINUES TO MEET THE USGS BENCHMARK SUPPLY RISK SCORE OF 0.4 FOR INCLUSION ON THE CRITICAL MINERALS LIST

The key data points are summarized below.

	2015	2016	2017	2018	2019	2020	2021	2022	2023
Economic Vulnerability	0.932	0.921	0.933	0.922	0.931	0.933	0.978	0.971	0.966
Disruption Potential	0.103	0.100	0.145	0.119	0.139	0.144	0.160	0.265	0.291
Trade Exposure	0.317	0.296	0.363	0.333	0.368	0.377	0.447	0.410	0.412
Annual Supply Risk	**0.312**	**0.301**	**0.366**	**0.332**	**0.363**	**0.370**	**0.412**	**0.473**	**0.488**
Recency Weighted Four Year Supply Risk				**0.334**	**0.348**	**0.360**	**0.381**	**0.423**	**0.456**

The major changes that have resulted in copper continuing to meet the threshold for inclusion as a critical mineral relate to much higher scores for Disruption Potential in addition to continued elevated scores for Trade Exposure and Economic Vulnerability. The higher Disruption Potential scores stem from an increasing share of copper production in countries that are adversaries of the U.S. and, in particular, in China. The availability of the Ability to Supply component of Disruption Potential for China, and a sharp increase in these scores, has driven a sharp increase in the overall Disruption Potential because of China's large and increasing share of global copper production. Trade Exposure is a relatively straightforward measure as it captures the share of consumption that is met by net imports. This has increased dramatically over the past few years, from 31% in 2016 to 41.2% in 2023 as imports of refined copper rose to 771 thousand tonnes.

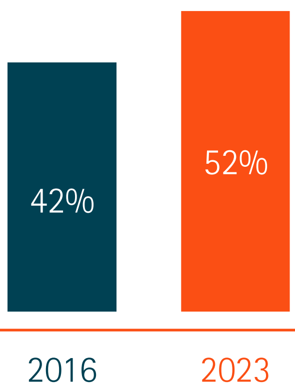
During the same period, U.S. refined copper production slumped, declining from 1,180 thousand tonnes to 881 thousand tonnes, the lowest level in over a decade. The combination of an ever-increasing reliance on overseas imports, amid declining domestic production, at the same time as higher potential for disruptions, in addition to an elevated economic vulnerability, has resulted in copper meeting the threshold for inclusion as a critical mineral in for the second year running in 2023.

The only notable departures from USGS methodology relate to the calculations for Trade Exposure and Economic Vulnerability. Instead of using the USGS' own trade data from the excellent USGS Mineral Industry Surveys, the authors of the USGS Critical Minerals study aggregated their own data but in doing so erroneously included various items that are not typically considered to be refined copper. To correct for these errors, refined import and export data was sourced directly from USGS Mineral Industry Surveys in this updated CDA study. In recent comments and attempted rebuttals of the CDA's work, the USGS does appear to have quietly dropped their prior misuse of import data and now appear to be using data consistent with industry norms.

Supply disruption potential of copper is

ON THE RISE

Foreign adversaries China, Russia & Iran accounted for 52% of all non-U.S. global refined copper production in 2023, up from 42% in 2016

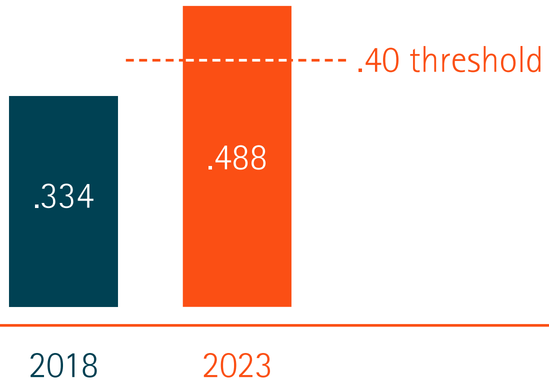


With regards to Economic Vulnerability, key input data was not available for the most recent years so an alternative approach was used. The Economic Vulnerability calculation measures the extent to which commodities contribute to the U.S. economy, for which expenditures were high but where operating profits are low. In essence, the calculation is designed to show how changes in the price of a commodity affect industries where metals are widely used, and consequently, the economic vulnerability score for copper is highly correlated with copper prices. In this study, a regression with the copper price was used to estimate economic vulnerability scores from 2019 to 2023. Even if the lowest USGS sourced calculated economic vulnerability score for the period 2015-2018 was used as an input to our study for 2019-2023, copper would still meet the threshold for inclusion as a critical mineral.

Copper's USGS supply risk score is

ON THE RISE

The result of these is that copper's USGS supply risk score has grown from .334 in 2018 (timeframe when USGS last calculated scores) to .488 in 2023 **– well above the .40 threshold score to be added to the list.**



CONCLUSION

As copper continues to meet the threshold for inclusion based on the very latest available data, we need to give copper the credit it is due now to enable the copper industry to provide the essential inputs that copper provides to our national defense and economic security.

This will allow us to build new and renewable energy sources, invest in data centers to support advancements in technology that will enable leadership in AI, in addition to upgrading the U.S. electrical grid to support the energy transition, without having to rely on geopolitical adversaries. By including copper on the 2025 Critical Minerals list, policymakers will make it easier for copper to provide a step change in our economy that reduces pollution through investment in green energy, helps hard pressed consumers by cutting their bills, and gives our industries a new competitive advantage through new technologies and lower energy costs.

We provide more detail on the USGS methodology and input data in the appendix attached.

APPENDIX - EXPLANATION OF METHODOLOGY

Disruption Potential

The Disruption Potential Component of Supply Risk is defined by the USGS Methodology as the sum of the squares of each producing country's share of global production (excluding the United States), weighted by each producing country's willingness or ability to continue to supply using the following equation.

$$DP_{i,t}^{raw} = \sum_{c} \left(PS_{i,t,c}^{2} \cdot \max \left(ASI_{t,c}, WSI_{t,c} \right) \right)$$

This equation takes the share of global production of each country then squares it, before multiplying that by the highest value of either the Ability to Supply Index or the Willingness to Supply Index. The methodology then adds the values for each country to get a "Raw" Disruption Potential value. The Raw Disruption Potential scores for each commodity for each year were normalized to a common 0-to-1 scale based on the observed minimum and maximum scores across all commodities and all years, as follows.

$$DP_{i,t} = \frac{DP_{i,t}^{raw} - DP_{min}}{DP_{max} - DP_{min}}$$

In simple terms, this takes the Raw Disruption Potential and subtracts the observed minimum Disruption Potential score from this analysis of all commodities and all years and divides that by the maximum observed Disruption Potential value minus the observed minimum Disruption Potential.

The Ability to Supply Index (ASI) component of Disruption Potential is based on the Fraser Institute's Policy Perception Index, a composite index that measures the effects of government policy on attitudes toward exploration investment. The Policy Perception Index scores range between 0 and 100, with 0 being bad and 100 considered good. The USGS Methodology reverses the scores and scales them between 0 and 1, with higher scores reflecting a worse ability to supply and creates a higher Disruption Potential score.

The ASI is not an appropriate measure for the refining stage of copper production that the USGS uses in its calculations. In essence, the Fraser Institute measures friendliness to mining investment and not the industrial process of smelting and refining. Moreover, more than half of the countries that smelt and refine copper do not have an ASI score at all.

The Willingness to Supply Index (WSI) assesses the trade, ideological, and defense ties that a producing country has with the United States to provide a proxy for the likelihood that it may deliberately disrupt its supplies to U.S. manufacturers. **It is comprised of Trade Ties (TT), Shared Values (SV), and Military Cooperation (MC)** and is calculated as the average of Trade Ties and Shared Values minus 0.1 for Military Cooperation. Countries that have are considered to cooperate militarily are: Australia, Canada, Finland, Italy, Norway, Spain and Sweden.

Trade Ties (TT) refers to the extent of trade that a country has with the United States as is measured as the monetary sum of its imports and exports with the United States each year relative to its Gross Domestic Product (GDP). It uses the following equation.

$$TT^{raw}_{t,c\leftrightarrow USA} = \frac{\sum\left(I_{t,c\leftarrow USA}, E_{t,c\rightarrow USA}\right)}{GDP_{t,c}}$$

In case any reader was lulled into the feeling that Trade Ties appears to be a relatively straightforward calculation, the USGS Methodology adjusted the raw scores using the equation below.

$$TT^{norm.}_{t,c\leftrightarrow USA} = \max\left(1 - \log_{10}\left(100 * \left(TT^{raw}_{t,c\leftrightarrow USA} + 1\%\right)\right), 1\%\right)$$

In simple terms, this normalization limits Trade Ties scores such that a country with a total trade value with the United States that is greater than or equal to 9% of its GDP yields a score of 1 and no country receives a TT score lower than 0.01.

Shared Values (SV) refers to the extent to which a country shares similar ideological values with the United States and Freedom House's Freedom in the World (FIW) reports are used to assess this. The reports assess the political rights and civil liberties of over 195 countries and 14 territories through 25 indicators that are aggregated to several subcategories: Electoral Process, Political Pluralism and Participation, Functioning of Government, Political Rights, Freedom of Expression and Belief, Associational and Organizational Rights, Rule of Law, Personal Autonomy and Individual Rights.

To determine how "close" a specific country is to the United States, the euclidean distance between the country in question and the United States is calculated across all Freedom In the World subcategories. The raw SV scores are then scaled such that the maximum observed value across all countries and years is given a score of 1. In simple terms, the equation takes the country sub-index score and subtracts the United States sub-index score and takes the square root of that, before summing the total of all the subcategories.

$$SV^{raw}_{t,c\leftrightarrow USA} = \sum\left(Subcategory_{s,t,c} - Subcategory_{s,t,USA}\right)^{\frac{1}{2}}$$

APPENDIX - EXPLANATION OF METHODOLOGY (CONT.)

Trade Exposure

Trade Exposure (TE) is based on net import reliance as a percentage of apparent consumption of the United States. It was calculated as follows:

$$TE_{i,t} = \frac{I_{i,t} - E_{i,t} + \Delta S_{i,t}}{AC_{i,t}}$$

In simple terms, it is the Imports (I) of refined copper to the United States, minus Exports (E) plus the change in Stocks (S). This figure is then divided by Apparent Consumption (AC). Apparent Consumption is calculated as Primary Production + Secondary Production + Imports – Exports + the change in Stocks.

Refined copper is typically considered to include HS trade codes 740311, 740312, 740313 and 740319. The USGS has been collecting copper trade data for many years following similar principles but for some reason the USGS failed to source trade data from within its own organization and opted to use various other trade codes in their critical minerals study. These included various copper and alloy semi-fabricated products and even stretched so far as to consider the copper content of some steel products. In the case of trade data, the authors of USGS critical minerals study were wrong. We corrected for this by using the USGS copper imports and exports helpfully provided in the excellent USGS Mineral Industry Surveys. In prior comments to CDA's work on copper's criticality, the USGS does now appear to have quietly conceded that they were wrong, albeit without admitting as such, and seem now to be using data as published in USGS Mineral Industry Surveys and in line with industry norms.

Economic Vulnerability

To calculate economic vulnerability, each mineral commodity's uses were linked to a set of manufacturing industries that used that commodity, as defined by the North American Industry Classification System (NAICS). Commodities for which expenditures were high in industries with low operating profits but that contributed greatly to the U.S. economy were given higher economic vulnerability scores, as follows:

$$EV_{i,t}^{raw} = \sum_j \left(\frac{VA_{t,j}}{GDP_t} \cdot \frac{EXP_{i,t,j}}{OP_{t,j}} \right),$$

EXP is industry's expenditure on a commodity in a year, OP is that industry's operating profit, and VA is the industry's value added (i.e., its contribution to GDP). The ratio of EXP to OP provides a measure of each industry's vulnerability, while that of VA to GDP provides a measure of that industry's economic importance to the economy. The raw Economic Vulnerability scores were normalized to range from 0 to 1, with higher scores indicating greater vulnerability, based on the observed minimum and maximum scores across all commodities and years using the equation below.

$$EV_{i,t} = \frac{\ln\left(EV_{i,t}^{raw} \cdot 10^9\right) - \ln\left(EV_{min} \cdot 10^9\right)}{\ln\left(EV_{max} \cdot 10^9\right) - \ln\left(EV_{min} \cdot 10^9\right)}$$

The economic vulnerability calculation measures the extent to which commodities contribute to the U.S. economy, for which expenditures were high but where operating profits are low. In essence, the calculation is designed to show how changes in the price of a commodity affect industries where metals are widely used and consequently, the economic vulnerability score for copper is highly correlated with copper prices. In the CDA study, a regression was used to estimate economic vulnerability scores from 2019 to 2023. The input price used in the CDA study was the same U.S. producer cathode price that the USGS used it its methodology. It is worth noting that even if the lowest economic vulnerability score for the period 2015-2018 was used as an input to the CDA study in the years 2019-2023, copper would still meet the threshold for inclusion as a critical mineral.

ABOUT THE AUTHOR:

Ian Littlewood has worked in the metals and mining industry since 2007 and is an expert in the analysis and forecasting of copper and aluminum markets. He has expertise in building models to forecast end use demand for metals, along with their supply and prices. During his career, he has been at the vanguard of analysis and modelling of aluminum and copper scrap supply and use and has been invited to present at conferences in this area as a result. He also has extensive knowledge of the U.S. copper and aluminum industries with particularly strong insight into the secondary copper and aluminum market and its participants. Mr. Littlewood now works at Paragon Global Markets, where he helps metals producers, consumers and traders to manage price risk as a member of the metals hedging team. Prior to that he worked as an Independent Commodity Analyst, working with various clients such as the CDA to help improve understanding of metals markets. Ian was the head of metals and mining research at Barclays until June 2019, before which, he worked at RUSAL, where he led market analysis and strategy in the Americas region. He has also worked at a commodity focused hedge fund, in addition to metals and mining research consultancies Wood Mackenzie and CRU. He is a Business Economics (BA, Hons) graduate from Middlesex University in the UK and is also a CFA charter holder.

Copper Development Association Inc.

info@copperalliance.us | copper.org