OXFORD ECONOMICS

ENABLING NORTH AMERICAN GRAPHITE GROWTH

A REPORT FOR THE NORTH AMERICAN GRAPHITE ALLIANCE

FEBRUARY 2024

OXFORD ECONOMICS

ABOUT OXFORD ECONOMICS

Oxford Economics was founded in 1981 as a commercial venture with Oxford University's business college to provide economic forecasting and modelling to UK companies and financial institutions expanding abroad. Since then, we have become one of the world's foremost independent global advisory firms, providing reports, forecasts and analytical tools on more than 200 countries, 100 industries, and 8,000 cities and regions. Our best-in-class global economic and industry models and analytical tools give us an unparalleled ability to forecast external market trends and assess their economic, social and business impact.

Headquartered in Oxford, England, with regional centers in New York, London, Frankfurt, and Singapore, Oxford Economics has offices across the globe in Belfast, Boston, Cape Town, Chicago, Dubai, Dublin, Hong Kong, Los Angeles, Mexico City, Milan, Paris, Philadelphia, Stockholm, Sydney, Tokyo, and Toronto. We employ 600 staff, including more than 350 professional economists, industry experts, and business editors—one of the largest teams of macroeconomists and thought leadership specialists. Our global team is highly skilled in a full range of research techniques and thought leadership capabilities from econometric modelling, scenario framing, and economic impact analysis to market surveys, case studies, expert panels, and web analytics.

Oxford Economics is a key adviser to corporate, financial and government decision-makers and thought leaders. Our worldwide client base now comprises over 2,000 international organizations, including leading multinational companies and financial institutions; key government bodies and trade associations; and top universities, consultancies, and think tanks.

FEBRUARY 2024

The modelling and results presented here are based on information provided by third parties, upon which Oxford Economics has relied in producing its report and forecasts in good faith. Any subsequent revision or update of those data will affect the assessments and projections shown.

To discuss the report further please contact:

Hamilton Galloway: hgalloway@oxfordeconomics.com

Oxford Economics
5 Hanover Sq, 8th Floor
New York, NY 10004
Tel: +1 646-786-1879

TABLE OF CONTENTS

EXECUTIVE SUMMARY

THE GLOBAL GRAPHITE MARKET

Global demand for graphite has expanded 52% in the last five years and is expected to grow another 70% over the next five years. This demand growth has largely been driven by increased demand for lithium-ion batteries (LiBs), driven by electric vehicle production. Demand for anode material—the form of graphite used in LiBs—is projected to almost triple in the next five years.

China currently dominates the global graphite market, and, barring concerted action, it will continue to do so. According to forecasts by Benchmark Mineral Intelligence, China supplied 72% of all graphite in 2023 and is projected to supply 65% of all graphite in 2028,. China accounts for an even larger share of the market for the high-purity graphite anode material used in batteries. In 2023, China controlled 92% of this market, and it is forecast to account for 86% of the anode material market in 2028, according to Benchmark. China dominates the production of both natural graphite, which is mined from the ground and later refined into anode material, as well as synthetic graphite, which is manufactured from petroleum.

According to Benchmark, China's supply of anode material exceeded global demand by 32% in 2023; however global demand is growing so quickly that it will catch up to this supply by 2024. Because of this rapidly rising demand, China continues to invest in graphite manufacturing despite its current overcapacity. The price of anode material made from synthetic graphite fell by 24% from 2022 to 2023 and is expected to fall by 38% from its 2022 peak by 2026. This rapid fall in prices and the convergence of the price of synthetic graphite with that of natural graphite is indicative of China selling its oversupply of graphite at prices that do not reflect the full cost of production.

RATIONALES FOR TRADE ACTION

The general economic argument for free trade is well established; however, trade protections can be justified under several conditions:

1) **Infant industry protections** are justified when nascent industries face cost disadvantages owing to increased scale by established players, or declining costs from learning by doing. North American graphite producers face significant hurdles to obtaining investment in the face of excess Chinese capacity in graphite manufacturing. Securing a reliable source of graphite is also critical to the success of the growing North American LiB and EV manufacturing sectors as well.
2) Trade protection can be justified as a response to **unfair trade practices** by the exporter, including dumping, government subsidies, unfair and harmful regulation, and forced technology transfer. China has a long and well-documented history of these practices across a number of goods, for example, in the case of photovoltaic solar panels in the 2010s. Chinese overcapacity in graphite production, combined with the falling price of graphite in recent years (the price of natural graphite fell 18% in 2023, while that of synthetic graphite fell 24%)

suggest that the price at which China is selling graphite has decoupled from the cost of production.

3) **Strategic protections** can be justified based on national security considerations. LiBs are a critical component of many emerging advanced technologies, including many with national security applications. Graphite has been designated a critical mineral for LiB production by three US government agencies, and the US government has made significant investments through grants and tax policy changes included in two U.S. laws, the Infrastructure Investment and Jobs Act in 2021 and the Inflation Reduction Act in 2022, in increasing domestic graphite production.
4) Poor **labor and environmental practices** provide another justification for trade action, both to limit the unfair advantage that firms with such practices enjoy, as well as to discourage the practices themselves. Chinese graphite producers generate substantial carbon emissions owing to inefficient industrial processes and an overreliance on dirty energy sources such as coal. They have also been linked to state-sponsored "labor transfer" programs affecting workers in the Uighur Autonomous region that have been described as forced labor.

GRAPHITE AND SECTION 301 TARIFFS

Starting in 2018, the US has applied tariffs (raised to 25% in 2019) on approximately $500 billion of Chinese goods, including many products made from graphite under section 301 of the Trade Act of 1974. These tariffs were not specific to graphite but were part of a broader tariff package in response to unfair trade practices by China.

However, in 2020, the US Trade Representative approved a request from EV manufacturers to exempt most graphite anode material used in batteries from these 301 tariffs since manufacturers argued that they were unable to source an adequate supply of graphite from non-Chinese sources.

While Benchmark forecasts corroborate the Chinese dominance of the global graphite market, this raises a chicken-and-egg problem: domestic graphite manufacturers cannot secure external investments and make the necessary internal investments to increase their future production absent protection from China's significant overcapacity in graphite manufacturing. Absent these protections, therefore, it will continue to be impossible for domestic LiB manufacturers to obtain graphite from non-Chinese sources.

1. INTRODUCTION

Graphite is a non-metallic mineral, which, like coal and diamond, is a form of pure carbon. Graphite is very resistant to heat and is relatively chemically inert, two properties that make it useful in certain types of manufacturing. Traditionally, graphite has been in high demand in the steel industry, where it is used in refractories (bricks that line blast furnaces), and for electrodes in electric arc furnaces; as well as in a number of other industrial processes.

Graphite is also a crucial component of lithium-ion batteries (LiBs), making up about 30% of LiBs by weight,[1] but accounting for only about 12% of their cost.[2] The recent and projected expansion in the demand for LiBs has resulted in a massive increase in both domestic and global demand for graphite. According to forecasts by Benchmark Mineral Intelligence, the demand for graphite is expected to grow 70% in the next five years, while the demand for graphite-derived anode material used in batteries is expected to nearly triple. Ensuring a reliable supply of graphite is critical for the manufacture of LiBs and for the production of electric vehicles (EVs), which are expected to increasingly dominate automobile production in the coming years.

This report, which was commissioned by the North American Graphite Alliance, a coalition of North American graphite producers, reviews the economics of the global graphite market, the arguments for trade restrictions in North America, and the recent institutional trade context. The remainder of the paper is organized as follows:

- Chapter 2 presents a quantitative overview of the global graphite market.
- Chapter 3 discusses the economic rationale for protecting North American graphite production against competition from Chinese graphite imports.
- Chapter 4 reviews this trade history.
- Chapter 5 concludes.

[1] See, for example, https://elements.visualcapitalist.com/the-key-minerals-in-an-ev-battery/. The World Bank Group estimated that graphite accounts for approximately 54% by weight of the "mineral demand" needed for energy storage through 2050. See Kirsten Hund, Daniele La Porta, Thao P. Fabregas, Tim Laing and John Drexhage (2020). "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition." https://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf.

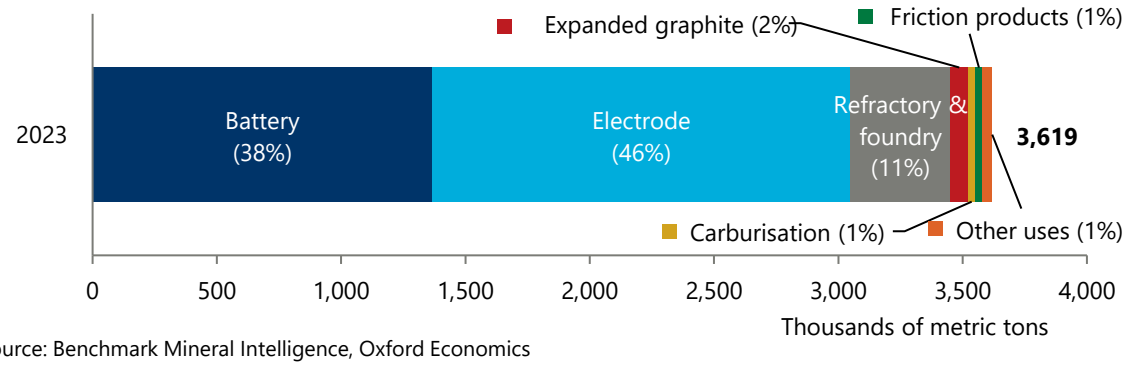
[2] See, for example, https://www.visualcapitalist.com/breaking-down-the-cost-of-an-ev-battery-cell/. Most of the battery's anode is made from graphite, which accounts for most of the anode's approximately 12% share of the cost.

2. THE GLOBAL GRAPHITE MARKET

2.1 GRAPHITE DEMAND

Global demand for graphite is robust and has been rising over recent years. According to data from Benchmark Mineral Intelligence,[3] demand totaled approximately 3.6 million metric tons in 2023 (Fig. 1). The bulk of this demand was for three uses: almost half is for electrodes used in steel production, more than a third for use in batteries, and around a tenth for refractory and foundry materials. Other smaller uses for graphite included expanded graphite, which is used as a flame retardant; carburization; friction products; and graphite shapes, lubricants, and carbon brushes.

Fig. 1. Global graphite demand by use, 2023

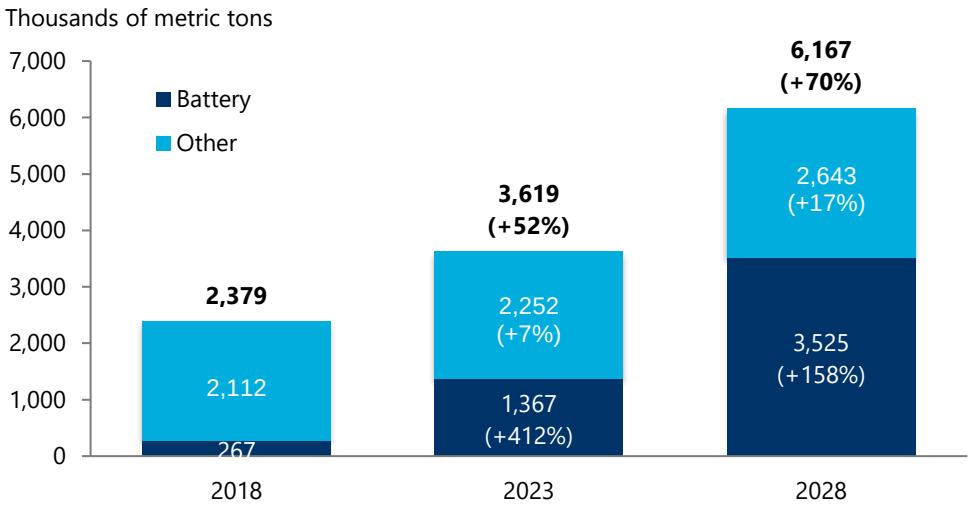


Source: Benchmark Mineral Intelligence, Oxford Economics

Global demand for graphite grew by 52% over the five years period between 2018 to 2023 and is forecast to grow 70% over the five-year period from 2023-2028 (Fig. 2). Most of this growth (89% of the growth over the last five years and 85% of the forecast growth over the next five years) is the result of increased demand for graphite in battery production.

[3] Benchmark Mineral Intelligence forecasts, January 2024.

Fig. 2. Global graphite demand by use, 2018-2028



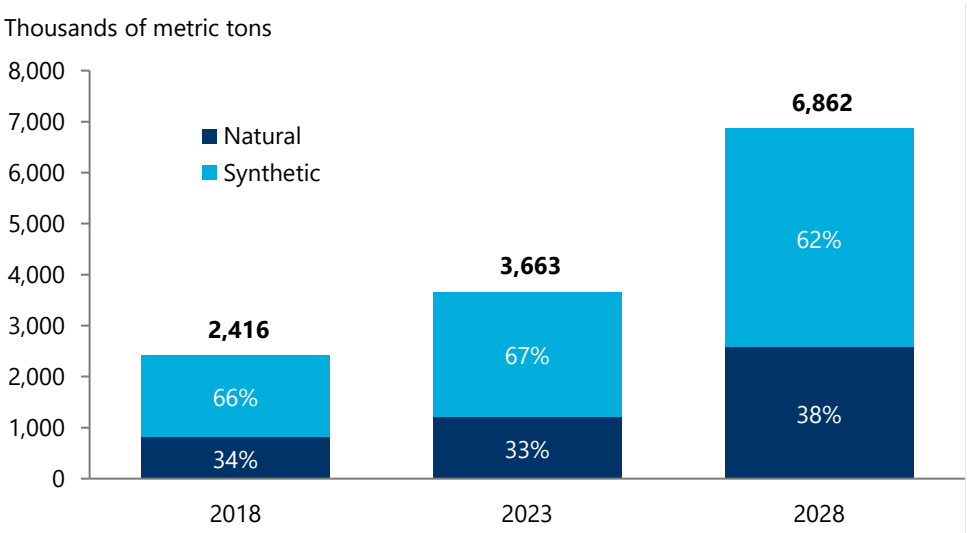
Source: Benchmark Mineral Intelligence, Oxford Economics

2.2 GRAPHITE SUPPLY

There are two sources of graphite: natural and synthetic. Natural graphite is mined from the ground as flake graphite and later processed in various ways depending on the specific chemical properties required. Synthetic graphite is manufactured from petroleum coke, which is a byproduct of the oil refinery business. Typically, synthetic graphite is of a higher purity than natural, although natural graphite can be processed to high levels of purity. Synthetic graphite is also typically more expensive than natural graphite. For this reason, synthetic graphite is used in the two applications of graphite that require the highest purity: electrodes used in steel production, which use exclusively synthetic graphite, and battery production, which makes use of both natural and synthetic graphite. The other end uses of graphite depicted in Fig. 1 typically use only natural graphite.

In 2023, approximately two-thirds of the graphite used globally was synthetic in origin, with the remaining third being natural. Natural graphite's share of the global graphite market is forecast to increase modestly from 33% in 2023 to 38% in 2028.

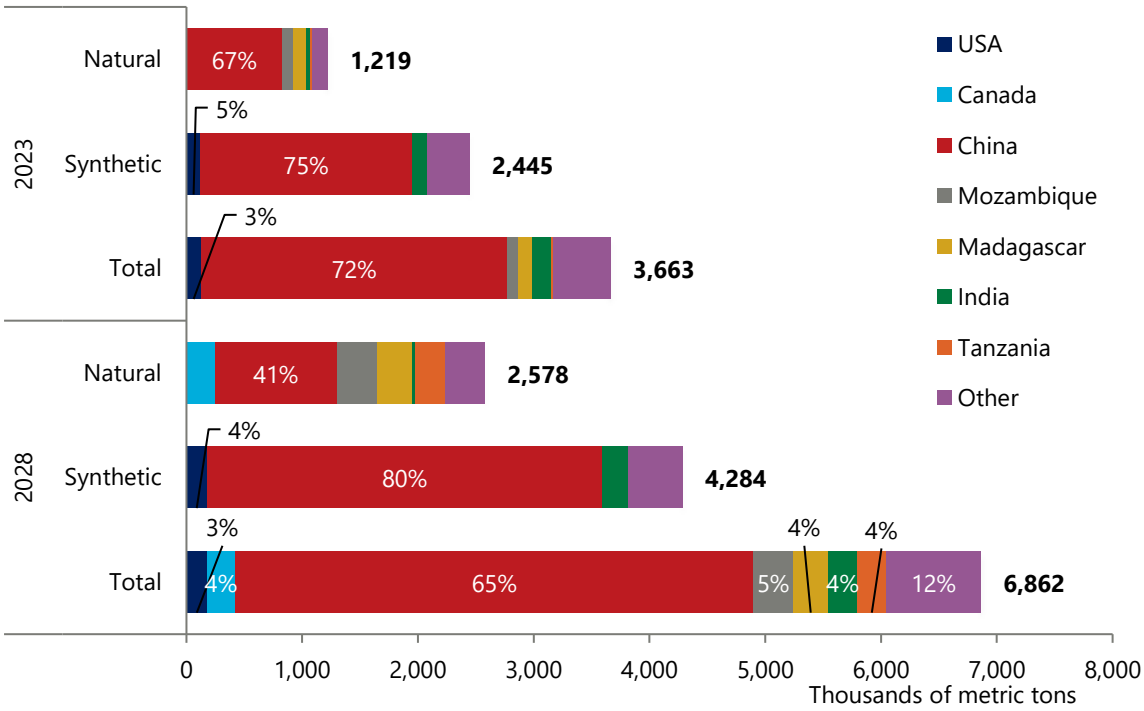
Fig. 3. Graphite supply by chemistry, 2018-2028



Source: Benchmark Mineral Intelligence, Oxford Economics

China dominates the supply of both natural and synthetic graphite (Fig. 4). In 2023, China supplied 67% of the natural graphite used globally and 75% of the synthetic graphite; or 72% of graphite overall. According to Benchmark's forecast, China's share of the global graphite market is expected to fall only slightly by 2028, to 65%, with its share of the synthetic graphite increasing slightly. The US's share of graphite production is expected to remain steady at 3% from 2023 to 2028, while Canada is forecast to increase its share of global graphite production from less than 1% to 4%

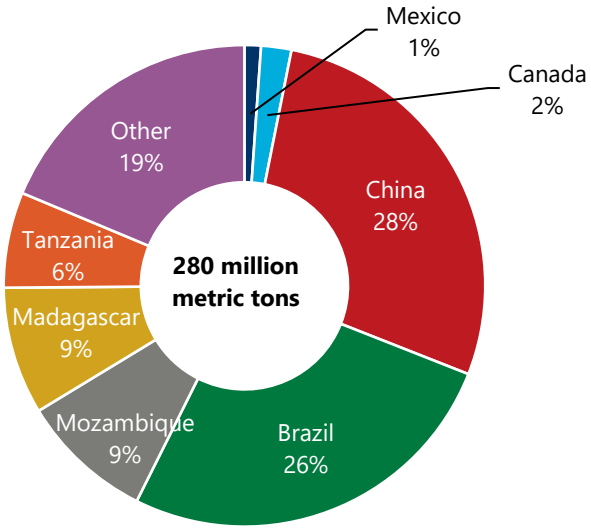
Fig. 4. Graphite supply by chemistry and geography



Source: Benchmark Mineral Intelligence, Oxford Economics

While China's status as the largest producer of natural graphite reflects significant deposits in the country—approximately 28% of global graphite reserves according to the US Geological Survey (USGS)—several other countries boast significant natural graphite deposits. However, graphite reserves in the US are believed to be small (and are not reported by the USGS), and other North American deposits account for only about 3% of global reserves (Fig. 5).

Fig. 5. Graphite reserves

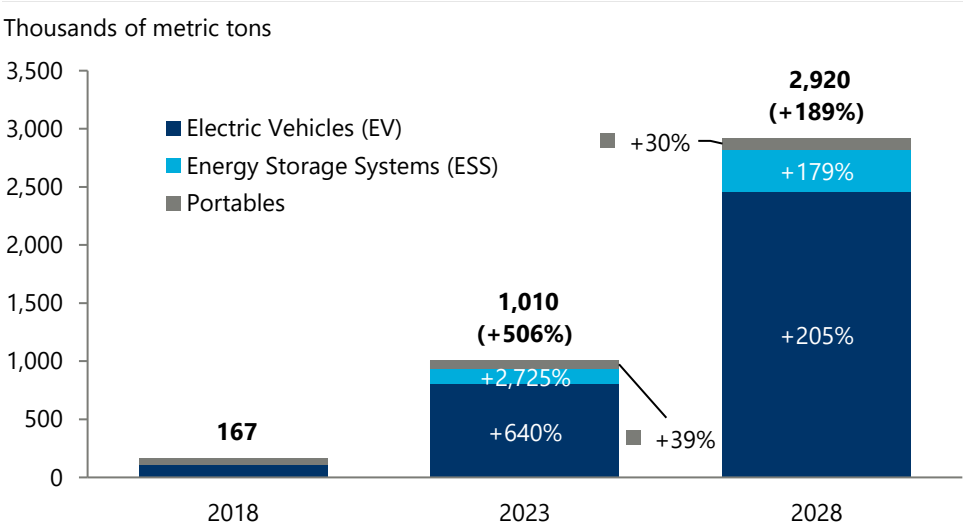


Source: USGS, Oxford Economics

2.3 ANODE MATERIAL

In this section, we focus on graphite that has been processed for use in batteries, referred to as "anode material."[4] The demand for graphite anode material grew just over six-fold from 2018 to 2023 and is expected to more than triple between 2023 and 2028, according to Benchmark forecasts (Fig. 6). Most of that increase is the result of increased demand for EV batteries, although the demand for energy storage systems (ESS or grid storage) and for portable devices like cell phones also contributed to the increased demand. Beyond our five-year forecast window, some experts predict that graphite demand for ESS may exceed demand for EVs.

Fig. 6. Anode material demand by end use, 2018-2028

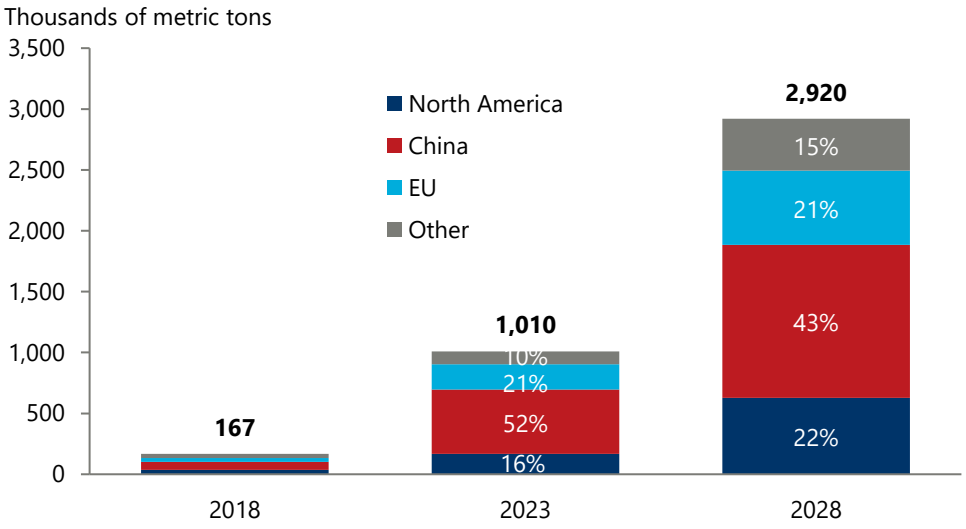


Source: Benchmark Mineral Intelligence, Oxford Economics

China currently represents just over half (52%) of the global demand for anode material, which is essentially its share of the market for manufacturing LiBs (Fig. 7). China's share of this demand is expected to fall modestly to 43% by 2028, with North America's share of the anode material demand increasing from 16% to 22%. However, these forecasts are dependent on these regions' continued ability to obtain the critical raw materials necessary for battery production, including graphite.

[4] Natural graphite requires significant refining to be used in batteries. In this refining process for natural graphite, approximately half the graphite by weight is lost. Synthetic graphite is manufactured to need, so it does not experience this loss of material. Careful reading of the figures in this chapter will make this clear. Fig. 2 shows that, in 2023, the demand for graphite (both natural and synthetic) in batteries was approximately 1.367 thousand metric tons. Fig. 6, however, shows a 2023 demand for anode material of 1,010 thousand metric tons. The difference largely reflects the loss of material when natural graphite (which supplies approximately a quarter of the anode material—see Fig. 8) is processed into anode material.

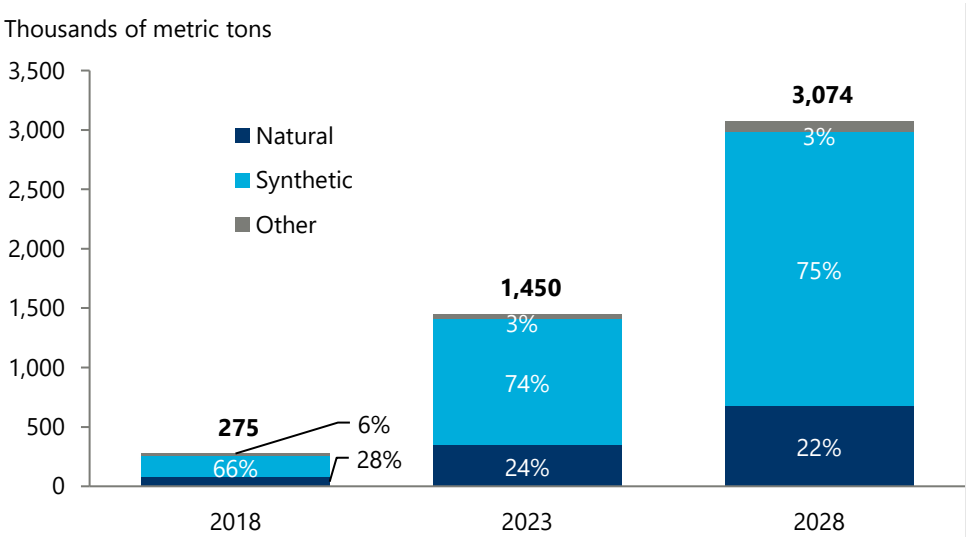
Fig. 7. Anode material demand by region, 2018-2028



Source: Benchmark Mineral Intelligence, Oxford Economics

In 2023, approximately 24% of the global anode material supply was made up of natural graphite, with 74% being synthetic graphite (Fig. 8). The remainder of the anode material market was made up of other anode materials, including graphite-silicon.

Fig. 8. Anode material supply by chemistry, 2018-2028[5]



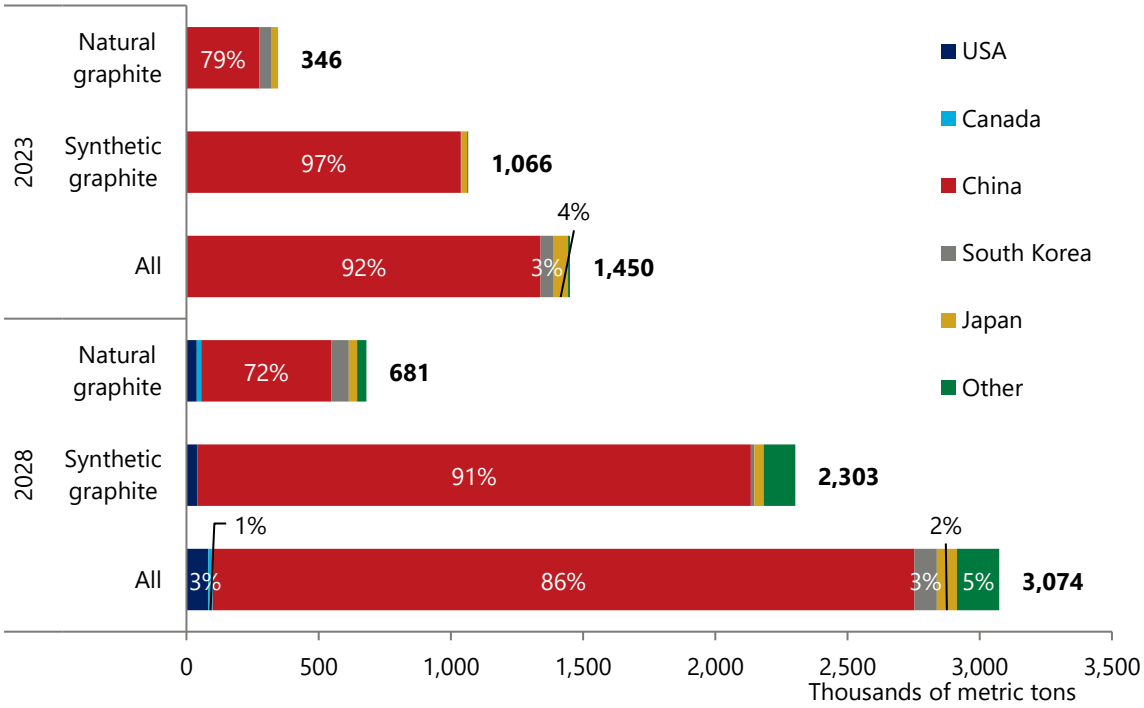
Source: Benchmark Mineral Intelligence, Oxford Economics

China dominates the production of both natural and synthetic graphite anode material. In 2023, China produced approximately 79% of the anode material made from natural graphite, and approximately 97% of the anode material made from synthetic graphite. According to Benchmark, absent intervention, these shares are expected to fall only slightly by 2028, by which time the US is expected

[5] "Other" includes graphite-silicon.

to account for about 3% of global graphite anode material production, and Canada for an additional 1% (Fig. 9).

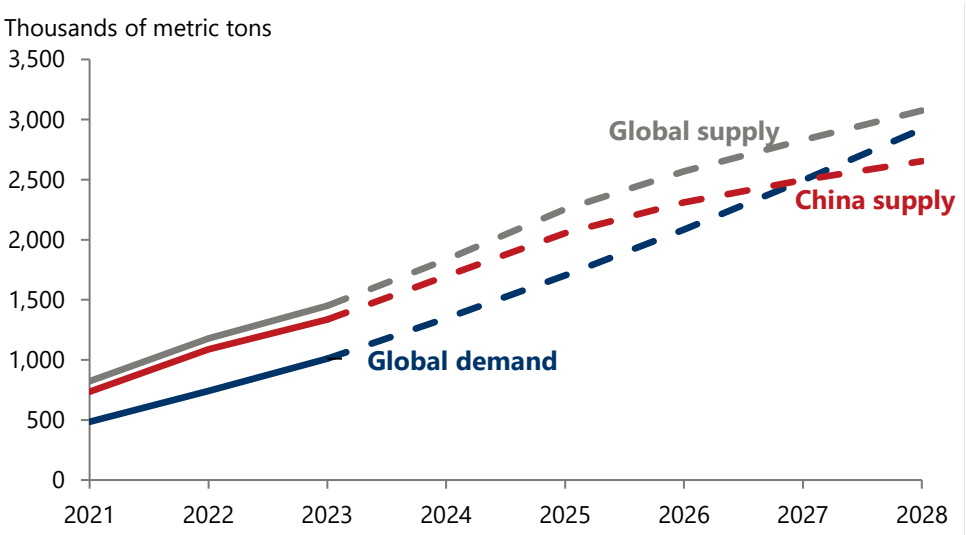
Fig. 9. Anode material supply by chemistry and geography, 2023-2028



Source: Benchmark Mineral Intelligence, Oxford Economics

Note that, in 2023, the supply of anode material of 1,450 thousand metric tons (see Fig. 8), significantly exceeded the demand for anode material of 1,010 thousand metric tons (Fig. 7), according to Benchmark data. While this large discrepancy may in part reflect measurement issues, it is indicative of oversupply in the anode material market in recent years, as China has invested to meet expected future demand for graphite (see Fig. 10). While Chinese supply of anode material was estimated to exceed global demand by 32% in 2023, demand is growing so rapidly that it is expected to exceed China's 2023 supply of anode material by the end of 2024. Thus, China continues to invest in graphite manufacturing despite its overcapacity in anticipation of dominating rapidly growing future demand.

Fig. 10. Supply, demand for anode material, 2021-2028



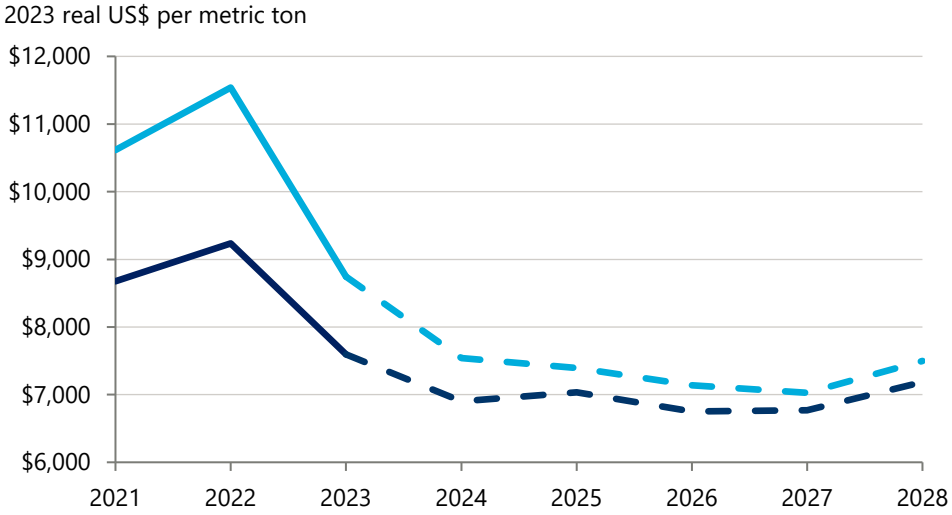
Source: Benchmark Mineral Intelligence, Oxford Economics

This Chinese overcapacity in the production of anode material is reflected in the price for anode material shown in Fig. 11.[6] After peaking in 2022, the price of anode material from natural graphite fell 18% in 2023 and is expected to fall by 27% from its peak by 2026. The price of anode material from synthetic graphite fell even more, by 24% in 2023, and is expected to fall by 38% by 2026. Within this category of high-capacity grade graphite anode material, the price premium for synthetic graphite—which is typically more expensive to manufacture than natural graphite is to extract and refine—fell from 25% in 2022 to 15% in 2023 and is expected to fall to 5% by 2025.

While a detailed analysis of the cost of production of anode material in China is not possible owing to the closed nature of Chinese industry, this rapid fall in prices and the convergence of the price of synthetic graphite with that of natural graphite—alongside the estimates of Chinese overcapacity shown in Fig. 11—is indicative of China selling graphite at prices that do not reflect the full cost of production, as part of an effort to capture future demand, as well as to dispose of excess supply. This is discussed further in the following chapter, especially in section 3.2 on unfair trade practices.

[6] This price represents the price for high-capacity grade anode material, which is the most widely used grade of graphite in LiBs. The price shown here is that prevailing in China, which, because of China's dominance of the anode material market (see Fig. 9), is the most representative price series for the global graphite anode material.

Fig. 11. Real price for high-capacity grade anode material by chemistry, 2021-2028 in China



Source: Benchmark Mineral Intelligence, Oxford Economics

3. RATIONALES FOR TRADE ACTION

The general economic benefits of free trade are long established. Notably, free trade between nations allows nations to specialize in sectors where they enjoy a comparative advantage and increases competition between producers. This results in benefits for consumers (lower prices[7] and more product variety[8]) and higher levels of productivity.[9]

There are, however, several conditions under which trade protection measures can be justified to benefit domestic businesses and consumers. These include infant industry protection, protection against unfair trade practices, and protections due to strategic concerns. Each of these rationales for trade protection is relevant to the case of the North American graphite industry:

1) **Infant industries.** The North American graphite industry is in its nascency compared with the more mature Chinese graphite industry. During these early stages of development, domestic graphite producers may need temporary support and protection from Chinese competition in order to grow into self-sustaining competitive firms. A reliable supply of graphite is also key for North America's graphite, EV, and defense industries.
2) **Protection against unfair trade practices.** The Chinese government has a well-documented history of engaging in unfair trade practices that harm US industry, and graphite is no exception. In 2017 the USTR conducted an investigation which determined that China engaged in trade practices which burdened US commerce across hundreds of products, including graphite. More recently, between 2021 and 2023 Chinese graphite supply has exceeded global demand and the price for high-capacity grade anode material fell sharply. This excess production and sharp fall in global prices are suggestive of subsidies and dumping in Chinese graphite and make it difficult for US companies to enter and operate in the market.
3) **Strategic concerns.** Graphite is a key mineral for the rapidly growing EV industry and lithium-ion batteries which have important applications to military and advanced technologies. As such, tariffs are important to ensure the US develops and maintains domestic production capacity of graphite.
4) **Labor and environmental protection**. Chinese graphite producers have higher greenhouse gas emissions than Western competitors owing to their greater use of coal power and relatively cheap, inefficient production processes. Firms in the Chinese battery supply chain have also been tied to state-sponsored "labor transfer" programs, which critics say amount to forced labor.

The remainder of this chapter explores each of these rationales for trade action in more detail.

[7] Xavier Jaravel, and Erick Sager, 'What are the Price Effects of Trade? Evidence from the U.S. and Implications for Quantitative Trade Models' (August 2019). CEPR Discussion Paper No. DP13902, Available at SSRN: https://ssrn.com/abstract=3439455
[8] David Atkin, Benjamin Faber, and Marco Gonzalez-Navarro, 'Retail globalization and household welfare: Evidence from Mexico', Journal of Political Economy, 126(1), pp.1-73, 2018
[9] Daniel Trefler, 'The long and short of the Canada-US free trade agreement', American Economic Review, 94(4), pp.870-895, 2004