

Argus White paper: **Getting graphite prices right**

Argus has launched new price assessments for natural flake graphite to add to its existing coverage of the battery raw materials sector. In this white paper, we examine the less talked about part of the lithium-ion battery and explain why a solid handle on graphite pricing will be needed as the electric vehicle (EV) revolution gains pace.

It was Elon Musk who famously said in 2016 that: “Our cells should be called Nickel-Graphite, because primarily the cathode is nickel and the anode side is graphite with silicon oxide.” Graphite receives far less attention than other battery raw materials such as lithium or cobalt, but graphite is, by weight, the second largest component in lithium-ion batteries. Over half of the carbon anode is based on natural graphite, whereas lithium content makes up less than 10pc of the cathode, which means that graphite is a key component in the price of batteries.

After the graphite market became subject to an exploration boom that started in 2011 on the back of forecasts for heavy demand to meet growth from the EV sector, the trend of reported prices reached a peak in 2013-14. Around this time, a raft of new exploration projects — more than 70 in total — was announced, partly encouraged by high reported prices and over-bullish market sentiment. Following the global commodi-

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In recent months, graphite prices have improved and the long-term fundamentals for the EV market remain promising but as with any developing market, uncertainty remains. Here we explain why a realistic understanding of graphite prices is needed in the market and how Argus can help.

What type of graphite is used in batteries?

Graphite is not a straightforward commodity product, but rather comes in different forms and specifications. The two main forms are natural graphite, which is sourced directly from mines, and synthetic graphite, which is made from petroleum coke. In turn, there are three main types of natural graphite: flake (>85pc carbon), amorphous (60-85pc carbon), and vein (>90pc carbon).

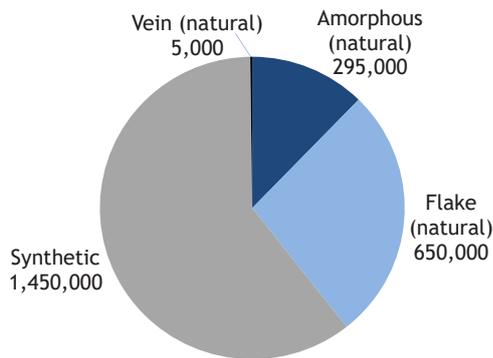
Both natural and synthetic graphite are used for li-ion anode material, but natural flake graphite remains the preferred material with the highest carbon grades (94-97pc) considered best suited for use in batteries. It is this flake graphite that is then upgraded to 99.9pc purity to make “spherical” graphite used in li-ion batteries. Purified natural flake graphite has a higher crystalline structure and offers better electrical and thermal conductivity than synthetic material, while synthetic material has a longer lifespan.

Size is also an important factor when it comes to natural graphite for batteries. Typically, only small and medium flake sizes or fines (with a mesh size of -100) are used in the production of spherical graphite for battery production. Flake sizes that are larger than -100 mesh are not used.

Only 13pc of graphite demand is for batteries

World demand for natural graphite in all batteries remains very small, at around only 120,000t in 2016, accounting for just 13pc of total natural graphite demand. To put this in context, the global graphite market amounted to around 2.45mn t in 2016, of which synthetic graphite accounted for 61pc (1.5mn t) and natural graphite accounted for 39pc (around 950,000t). Out of this natural graphite, flake material was around 68pc (650,000t), amorphous 31pc (295,000t), and vein 0.5pc (5,000t).

Global graphite market 2016



Steel: The main driver of demand

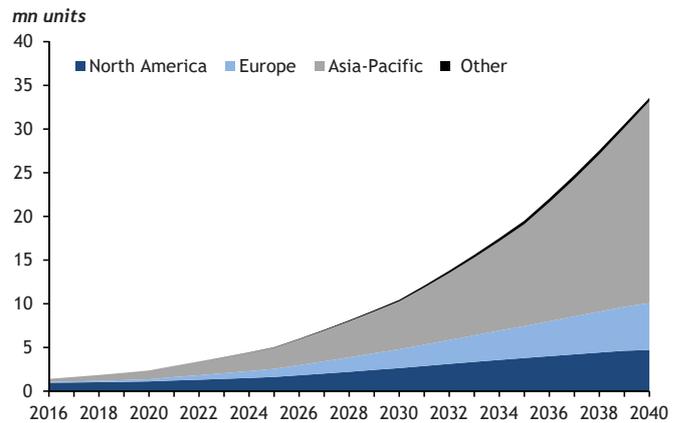
For now, graphite’s primary consumer remains the steel industry. Steel mills account for over half (around 500,000t) of annual demand and use graphite in the production of refractories, which are employed to line steel kilns, and as an additive, or “recarburiser”. In 2018, global steel production provided good support for the natural graphite market, with growth of more than 5pc compared with 2017, according to the World Steel Association.

Looking ahead, demand from the steel industry is expected to remain flat given the maturity of this market. Demand for graphite from the lithium-ion battery market holds a lot more growth opportunity and is set to pick up more speed once much-anticipated EV demand really reaches a tipping point. The question is when will this revolution really get going?

Argus’ EV forecast

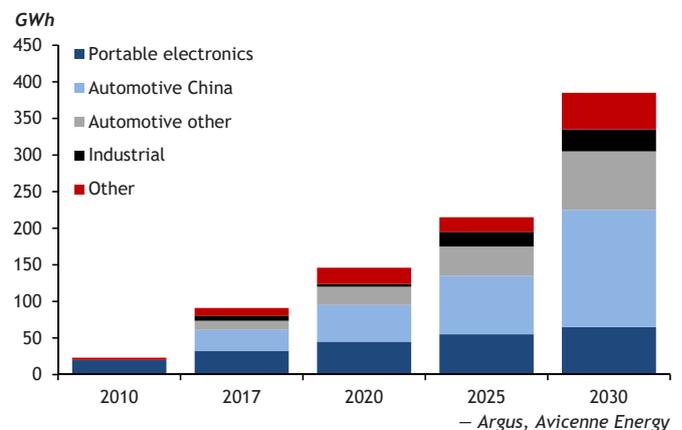
Forecasts for EV penetration vary from the more cautious to the overly optimistic. According to the more conservative Argus transport model for all alternative fuel vehicles (AFVs) — almost exclusively electric and hybrid electric vehicles — total AFV registrations are forecast to increase from around 1.6mn units in 2017 to 2.4mn units in 2020, 10.4mn units in 2030 and 33.6mn units in 2040. Compound annual growth rates (CAGR) are 14.5pc for 2017-20, 16pc for 2020-25, 16pc for 2025-30, 13pc for 2030-35 and 11.5pc for 2035-40.

Forecast for global alternative fuel vehicle registrations



Should the battery market grow at these forecast rates, consumption of flake graphite for li-ion anode production has to substantially increase.

Forecast lithium-ion battery market by application



Should the battery market grow at these forecast rates, consumption of flake graphite for li-ion anode production has to substantially increase. As shown in the chart opposite, the overall market for li-ion batteries is expected to increase from around 90GWh in 2017 to 145GWh in 2020, 215GWh in 2025 and 385GWh in 2030, which would represent CAGRs of 17pc, 8pc and 12pc, respectively. The EV sector becomes ever more dominant, increasing its market share from 45pc in 2017 to 51pc in 2020, 56pc in 2025 and nearly 65pc in 2030.

China dominates graphite supply

As with many other minerals, China dominates production for graphite, accounting for 67pc of the world’s total in 2017. As China continues to swiftly move up the global value chain

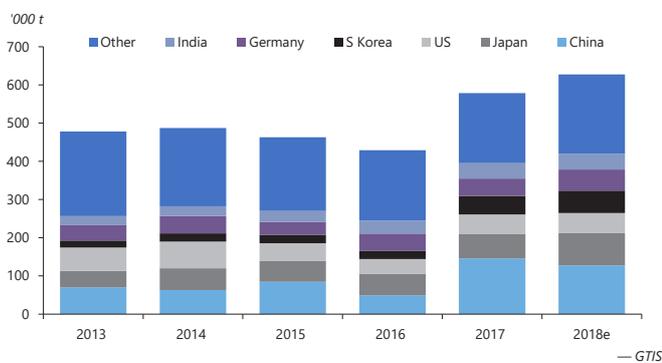
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and focus on value-added exports, there is an expectation in the industry that it is unlikely to remain a low-cost supplier of natural flake graphite of a consistent quality to the global EV sector.

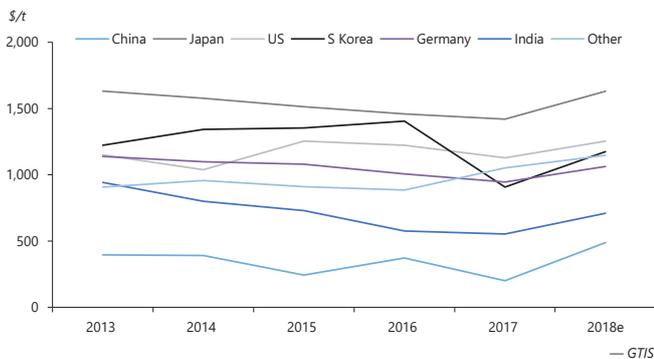
Naturally, global buyers are also keen to diversify supply sources away from one country. This geopolitical dimension was underlined last year when graphite was listed among Chinese products targeted by the US for an initial 10pc tax. Although this tariff never materialised, it nevertheless highlighted the risk of relying on one country for world supply of such a critical raw material.

Already 70pc of natural graphite production in China is amorphous, and only 30pc flake. Most production is sourced from small to medium-sized mining operations dotted around the provinces of Heilongjiang and Shandong. This also means that consistency in supply is a problem, because each mine will have material with varying chemical compositions. Typically, Heilongjiang produces mostly fines, while Shandong produces a higher proportion of coarse flake sizes.

Global imports of natural graphite by volume



Global imports of natural graphite by unit value



In recent years, well reported environmental crackdowns on illegal or polluting graphite operations in China have also added some uncertainty to the market, not to mention steadily increasing production and labour costs. In addition to this, China is exporting less and less 94pc small flake material, because most of it is used in the domestic refractory market or to produce high value-added products for the battery industry in South Korea and Japan.

As further evidence of this, China is now a major importer of high-grade natural graphite, accounting for 14pc of natural graphite imports in January-July 2018. China's recorded imports were 324,800t, worth \$346.5mn and with a unit value of \$1,070/t. The other major importing countries were Japan (14pc), the US (9pc) and Germany (9pc)

Natural graphite production outside China

After China, the next largest producers of flake graphite in 2017 were India, with mine production of 150,000t, and Brazil with 95,000t, followed by Canada with 30,000t. At present, no graphite produced in India or Brazil is used to produce anode material.

Mozambique entered the graphite market in 2017. The country went from having no graphite exports to around 23,000t with the start-up of Syrah Resources' Balama mine. Syrah is aiming to become the world's largest producer outside China. The company is targeting an increase in production at Balama to 350,000 t/yr.

After a slowdown in exploration activity in recent years, several junior mining companies continue to raise capital and progress new projects to feasibility study and beyond in Australia, Madagascar, Canada, Tanzania and Namibia, to name a few. As with so many other commodity markets, depressed prices in recent years have impacted the level of financing, and junior mining companies overall remain poorly funded.

How is natural graphite priced?

Mined graphite ore is first beneficiated into graphite concentrate (typically 90-95pc total graphitic carbon content) and then sized and screened into various mesh sizes. For commercial production, these sizes are: small/fine flake (-100 mesh); medium flake (-80 mesh); large flake (+80 mesh); and jumbo flake (+50 mesh).

Flake prices are then determined based on a range of factors such as graphite content, flake size and impurity levels. Typically, coarse large flakes (+80 mesh) and XL flake (+50 mesh) with a higher purity (94pc or higher carbon content) command a premium price.

Like other illiquid markets such as lithium, the market price for graphite remains opaque. While price references exist, these are mostly used just as a reference, and not yet in

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contracts. Another factor is that up until now most reference prices have been based on a wide range of graphite qualities and this has made tying contracts to a single index difficult to achieve. As a result, pricing is still negotiated bilaterally between buyers and sellers.

Natural graphite prices today

While the combination of tightening supply in China for high-purity grades in small sizes, and promising EV growth are supportive for graphite prices in the long term, average selling prices in the market remain muted. The reality is that high-growth markets such as li-ion batteries have not yet had a significant impact on demand and consumption.

Prices have edged up in recent months because buyers have been stockpiling graphite from China ahead of the winter, as many mines typically close for the season. Still, industry participants point out that this improvement comes off a low base.

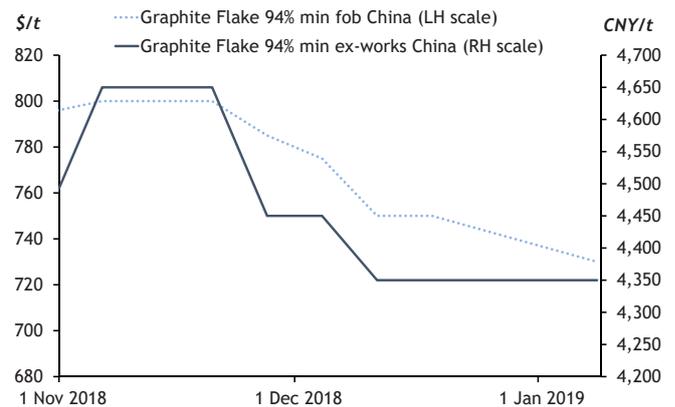
Prices for graphite flake 94pc fob China (\$/t, -100 mesh) were assessed by Argus at \$680-780/t on 8 January 2019. To put this in context, during the exploration boom days of 2011-12, reported prices for graphite fines reached over \$1,300/t with large flake selling for up to \$3,000/t in early 2012.

Given that China is by far the world’s largest producer, the Chinese domestic market naturally influences international prices. This also means that inland logistics costs and value-added tax (VAT) – of 16pc – are reflected in export prices. Argus assessed graphite flake 94pc graphite prices ex-works China at 4,100-4,600 yuan/t on 8 January 2019. To better facilitate a comparison with the international market, Argus also publishes an ex-works ex-VAT price.

What’s next for graphite prices?

In the longer term, the continuing push toward EVs bodes well for natural graphite demand. While we are still waiting for the trend for EVs to really get going, there is a need for more transparency around graphite prices. This is especially the case with large-scale industrial buyers of batteries, particularly automotive original equipment manufacturers (OEMs), who require more supply-chain and price transparency not only to manage risk, but also as they come under more scrutiny and compliance from regulators and their own shareholders. Opaque market prices for critical raw materials make it virtually impossible to mitigate such risk, and volatile prices are a major concern.

Graphite flake prices



Argus’ graphite prices

Against this backdrop, Argus has been working with the graphite industry to develop a relevant market reference for indexation purposes and to bring more transparency to the market in this new complex automotive environment. Argus has identified 94pc as the most tradeable form of graphite. Exact details of our new graphite assessments are as follows:

fob China, \$/t

Grade: Carbon 94pc minimum (permissible range 94-97pc)
 Mesh size: -100
 Minimum lot size: 40t (two containers)

ex-works China, yuan/t

Grade: Carbon 94pc minimum (permissible range 94-97pc)
 Mesh size: -100
 Minimum lot size: 40t (two containers)

ex-works China, ex-VAT (\$/t)

Grade: Carbon 94pc minimum (permissible range 94-97pc)
 Mesh size: -100
 Minimum lot size: 40t (two containers)

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How Argus prices graphite

Argus uses a market-appropriate methodology to assess prices in each of the markets that it covers. Because all markets are unique, Argus designs a methodology specific to the commodity, geography and timing under consideration.

Argus methodologies reflect the way markets trade and are determined by industry conventions. We have ensured that our methodology for graphite meets the needs of the market and is in line with industry practice through direct collaboration with industry participants.

Argus price assessments are reliable indicators of commodity spot market values, free from distortion. Argus makes a distinction between open market, arm's-length trade and internal transfer pricing or long-term contracts, which are not taken into account in assessing graphite prices.

Argus has decades of experience and a proven track record in assessing prices in illiquid markets. We take a structured approach to assessing such markets. In the first instance, we seek price information relating to verified spot transactions through a survey-based approach that taps into a wide network of industry contacts across the supply chain.

Every day, our price reporters canvas market participants to identify any movement in price. Our graphite price assessments are published biweekly, every Tuesday and Thursday, in *Argus Metals International*, which also publishes commentary relating to any price movement.

Our price reporters make every effort to verify information they receive with the wider marketplace through bilateral meetings with key market participants, through email, and by telephone. All data captured by our market reporters are stored electronically, and regularly audited.

All our price assessments use best practice guidelines designed to comply with the principles set out by the International Organization of Securities Commission (IOSCO) in 2012, and we engage PWC to review those policies and processes. To view a copy of our full methodology, please [click here](#).

Why Argus?

Argus Media is a specialist global commodity price reporting agency that has been covering markets for over 40 years. The company's early origins were in analysing oil and refined products markets, but coverage now extends to a wide range of energy commodities.

Argus assessments are used as the reference price in physical supply and derivative contracts. They are accepted as accurate and reliable indicators of the real value of commodities across many different markets including — crude, petroleum products, natural gas and LNG, petrochemicals, electricity, biomass, biofuels, fertilizers, metals and coal.

Our data is used by companies and governments around the world to index physical trade, and as benchmarks in financial markets. With such extensive experience in energy markets, and largely illiquid markets, Argus Media is uniquely placed to provide the effective framework for establishing prices for graphite and other future energy materials.

For more information:

 metals@argusmedia.com

 www.argusmedia.com/en/metals

Argus also offers graphite (and other metals) consulting services and industry leading conferences.

For more information please visit:
www.argusmedia.com/en/industry-events?page=1

Our Metals coverage

Ferrous



- Iron Ore
- Coking coal
- Metallurgical coal
- PCI coal
- Ferrous scrap
- Finished steel
- Stainless steel
- Freight

Non-Ferrous



- Battery materials
(Lithium, graphite, nickel, cobalt)
- Scrap and secondary alloys
- Minor and speciality metals
- Ferro-Alloys
- Rare Earths
- Base metals