Inside the Graphite Electrode World: Manufacturing, Markets and the Oil Connection

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Graphite electrodes rarely get much attention outside the electric arc furnace (EAF) community, yet they are the mission-critical consumable without which an EAF cannot operate. Conducting the massive current that generates the arc at temperatures above 3,000°C, electrodes have no commercially available substitute. How they are made — and why their supply chain runs through global oil markets and into the battery industry — explains some of the most consequential dynamics shaping EAF steelmaking today.

The stakes are larger than they appear. In the U.S., EAF steelmaking already accounts for over 70% of steel production, and that share keeps climbing — no electrodes, no EAF steelmaking. The same logic extends globally: EAF steelmaking produces roughly 75% fewer CO_2 emissions than the blast furnace route, making electrodes a key enabler of the steel industry decarbonization worldwide.

How an Electrode Is Made

Electrode production begins not with graphite, but with oil. Petroleum needle coke, a crystalline form of carbon derived from oil, is the essential raw material — there is no viable alternative for ultrahigh-power electrode production. Needle coke is milled, mixed and formed with a pitch binder into a green electrode, then baked, impregnated with additional pitch and rebaked. It then passes through graphitizing — the most energy-intensive step, requiring temperatures near 3,000°C — before final machining and shipping. End to end, the process takes approximately 6 months. Once installed, that same electrode is consumed in a single 8- to 10-hour shift — a complex, months-long product that nonetheless represents less than 2% of an EAF's total cost of production.

Why the Industry Talks About Oil

Because needle coke comes directly from decant oil, producers are

Figure 1

Graphite electrode in use in the electric steelmaking process.

Figure 2

Electrode going through the graphitizing process.

Figure 3

Graphite electrodes.

exposed to crude markets in both directions. Lower oil prices reduce refinery throughput, tightening decant oil supply; higher oil prices push refiners toward higher-value fuels, again squeezing supply while raising cost. Pricing isn't a direct mirror of the Brent crude oil price — producers also reference indices like the High Sulfur Fuel Oil, with quality-based premiums and discounts — but the relationship is real: decant oil typically represents around a quarter of an integrated producer's total production cost.

The recent escalation in the Middle East has reinforced this exposure. Disruption to global oil production and maritime shipping has pushed input costs higher, with several needle coke producers globally sourcing oil from the affected region. The result has been upward pressure on needle coke costs, and consequently on graphite electrode costs. Additionally, this uncertainty on the supply chain is growing steelmaker interest in regional, vertically integrated supply over long-haul sourcing — a furnace outage from an electrode shortage costs far more than the electrode itself.

Competing With Batteries for the Same Feedstock

Needle coke's story doesn't end with electrodes. The same material is also the preferred feedstock for synthetic graphite used in lithium-ion battery anodes — for EVs, energy storage and defense applications. Battery makers favor synthetic over natural graphite for its superior charge rate, capacity and cycle life, and premium needle coke yields the highest-quality synthetic graphite available.

Outside China, this is a highly concentrated market: just five plants, with total nameplate capacity of approximately 750,000 MT against current electrode demand of 550,000–600,000 MT. Battery anode demand is now layering on top of that — and is expected to eclipse electrode demand within the next few years.

An Electrode Market Moving Toward Imbalance

On the electrode supply side, prolonged low prices have taken a toll. Between 2022 and 2025, the global top five electrode producers reduced capacity by approximately 100,000 metric tons outside China. An Indian producer added capacity in 2024–2025, but that expansion was more than offset by previously mentioned closures. On the demand side, the trend runs the other way: more than 230 million metric tons of newly announced EAF capacity is projected to come on-line in the next years, part of a broader shift toward EAF steelmaking. Ex-China electrode demand is projected to grow roughly 15% by 2030.

Despite this, electrode prices remain well below historical averages. History offers a precedent for what happens when that kind of imbalance persists too long: the 2017–18 surge, triggered by capacity rationalization meeting recovering demand, saw electrode prices move sharply within months. Recent geopolitical tensions have only reinforced the case for supply chain security over dependence on long-haul sourcing. Should electrode prices remain subdued, the industry may find the period ahead less settled than it currently appears. ✦