U.S. DEPARTMENT of ENERGY

The Intrinsic Role of Coal in Achieving Steel Dominance

President Trump's Executive Order "*Reinvigorating America's Beautiful Clean Coal Industry and Amending Executive Order 14241*" tasked the Secretary of Energy to determine if coal used in steel production meets the definition of a critical material under the Energy Act of 2020.

A robust steel industry is fundamental to American manufacturing and to fueling growth in industries that ensure the national and energy security of the country. As a constituent of steel, metallurgical coal is necessary for steel production and is produced from numerous domestic sources by the reliable US coal industry. For any significant and sustained growth in domestic steel production, the supply of metallurgical coals including anthracite coal must similarly grow.

The U.S. steel industry faces multiple threats to achieve domestic manufacturing independence. On February 10, 2025, the President of the United States of America released a Proclamation 10896 entitled "Adjusting Imports of Steel into The United States." The Proclamation indicates the U.S. steel industry has been unable to meet the 80% U.S. steel production capacity utilization target set by the Secretary of Commerce in 2018. The U.S. was initially successful in meeting this goal due to imposition of 25 percent ad valorem tariffs, but factors including modifications to the tariffs resulted in increased steel imports which threatens to impair national security.

Reestablishing security of steel supply for the United States requires increasing both steel capacity and the production of metallurgical coal, a key component of steel making. Currently, the U.S. produces ~ 90, imports 28, and exports 9, million short tons (MMst) of steel, for 109 MMst of current consumption. Since fully utilizing the current U.S. steel fleet would result in only 100 MMst of production, new capacity would be required to grow U.S. steel production for the purpose of growing the manufacture of steel intensive goods, such as automobiles, ships, power plants, drilling wells, pipelines, transmission lines, etc.

Metallurgical coal is coal that has certain properties conducive to efficient production of coke, a required material for steel production involving the integrated basic oxygen furnace and blast furnace method (BOF/BF). This method produces just under 30% of current U.S. steel output. Metallurgical coal is described by the proportion of volatile matter inherent in the material, which is categorized as either low-, mid-, or high-vol. The met coal that is most prized for coke-making – mid-vol – is also in the shortest supply. Blends of certain low-vol and high-vol coals are therefore made to approximate mid-vol qualities. These coals are concentrated in the Appalachian region of the United States.

Also concentrated in Appalachia is anthracite, an input for steel production via Electric Arc Furnaces (EAF). EAF is the primary production method and accounts for the

balance (70%) of current U.S. steel production. The injection of carbon in the form of anthracite reduces the power consumption and process time in the EAF method. Increasing steel production via EAF entails increasing U.S. anthracite production to enable secure supplies.

The continued decline of the Appalachian coal industry, in which thermal coal (for power and steam), metallurgical coal, and anthracite share infrastructure and workforce, would render impossible achieving steel dominance.

Existing definitions under the Energy Policy Act of 2020 seem inadequate to the task of recognizing the critical need for metallurgical coal necessary to achieve dominance in steel and growth in steel-intensive manufacturing. Metallurgical coal should be considered a critical material for steel dominance, as a substantiative and sustained increase in U.S. steel production would necessitate increasing metallurgical coal and anthracite production to peak historical rates.

DOE's Critical Material Assessment Methodologies

Section 7002 of he Energy Act of 2020[1] includes defines critical materials as follows:

> "The term 'critical material' means—(A) any non-fuel mineral, element, substance, or material that the Secretary of Energy determines (i) has a high risk of a supply chain disruption and (ii) serves an essential function in 1 or more energy technologies, including technologies that produce, transmit, store, and conserve energy; or (B) a critical mineral."

For the portion of the definition that does not include a critical mineral, there are three key elements: (1) that the material be "non-fuel," (2) there be a high risk of supply chain disruption, and (3) the material serve an essential function in energy technology.

The first element of the definition excludes fuel. The term "fuel" generally refers to a substance that is burned to provide heat or power. Metallurgical coal, when used for steelmaking, serves a non-fuel function in the process by acting as a chemical reductant and alloying agent that enables the transformation of iron ore into steel at elevated temperatures. In this process, the carbon from coal becomes integrated into the final steel product, and heat that is generated is not intended for use outside the steel-making process but is necessary to allow reactions to proceed at elevated temperatures. Heat is produced but only as a necessary byproduct of the process. This distinguishes the non-fuel use of metallurgical coal to make steel from the fuel uses for thermal coal. Coal used in the steel-making process serves a non-fuel mineral purpose and therefore satisfies the first criteria of the Act.

The second element of the definition is satisfied because the United States has set a strategic policy goal to increase domestic steel production, which will require greater reliance on metallurgical coal in the near term. Metallurgical coal is currently exported in large volumes primarily due to limited current US steel production. As anticipated domestic and global steel output rises, those exports will necessarily decline, redirecting

[1] https://republicans-science.house.gov/_cache/files/f/3/f3916ab1-1d9b-428c-9f81-bbc33d9b5b55/6C087709B3DDEFFAAF8616C4BE34020CDD72E2790210DBDBF5A1334C235BBC0D.division-z---energy-act.pdf

demand toward internal use and straining existing supply. Metallurgical coal is sourced from geographically limited regions in Appalachia where production faces long-term declines and is not positioned to increase even if demand rises. The combination of concentrated supply, projected demand growth, and vulnerability to disruptions makes metallurgical coal critical to U.S. industrial resilience and national energy security.

The third element of the definition is satisfied because coal is essential to steel manufacturing and steel is an essential part of all energy systems in the US. Without coal used in steel-making there would be no power plants, electric transmission towers, pipelines, wells, or storage facilities. However, this is only a subset of the industries that should be considered when evaluating the criticality of steel and metallurgical coal. This broadens the first criteria's considerations of risks to supply chain disruption. Therefore, the definition of critical materials contained in the Act requires additional considerations to maintain consistency with the policy goal of steel dominance.

DOE established a methodology for assessing material criticality in 2010, which was applied to update DOE's understanding of critical material vulnerabilities in 2011, 2019, and 2023. The 2023 DOE Critical Materials Assessment was conducted pursuant to the Energy Act, where the methodology that determines importance to energy and supply risk in the context of future global energy demand is directly aligned with the statutory definition of critical materials. The 2023 DOE Critical Materials Assessment also informed the designation of the 2023 DOE Critical Materials List. The scope of energy technologies considered in the assessments has evolved over time. The 2023 DOE Critical Materials Assessment prioritized energy technologies for which future energy demand was expected to exert pressure on supply chains, building on 13 supply chain deep dive assessments for various energy technologies. DOE anticipates to release a Request for Information to solicit public comment on the scope of the next Critical Materials Assessment.

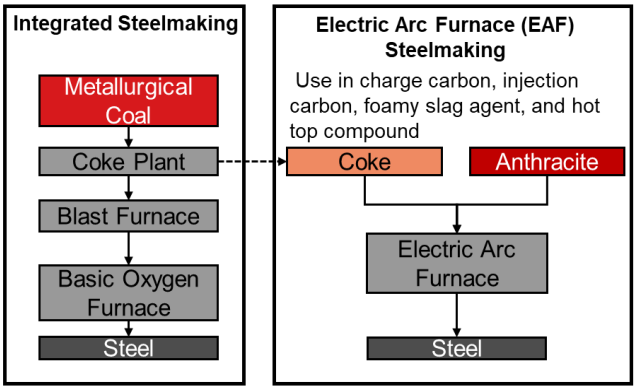
U.S. Steel and Coal Industries

To appreciate the pathway to U.S. steel dominance, it is beneficial to review the steel and coal industries.

Steel Industry

Steel Production Methods

The two primary methods of steel production in the United States are integrated steelmaking using a basic oxygen furnace/blast furnace (BOF/BF) and electric arc furnace (EAF). The BOF/BF method represents approximately 28% of U.S. steel production, with EAF production making up 72%.[2] In the BOF/BF method, metallurgical coal is used to produce coke, which in turn is used to remove oxygen from iron ore. This is a reaction that proceeds only at elevated temperatures and has the result of converting iron ore to pig iron that is further processed into steel. The EAF method relies on electricity to melt scrap steel (and other materials) to produce steel[3] and uses carbon additives including anthracite coal, petroleum coke, and metallurgical coke for charge carbon, injection carbon, foamy slag agent, and hot top compounds to enhance performance.[4] Coal's role in steel production is summarized in Figure 1.



Steelmaking Method	Integrated	EAF
U.S. Production (MMst)	25.1	64.5

Figure 1. Coal use in integrated steelmaking and electric arc furnace steelmaking processes. 2023 production data from USGS.

Steel Supply and Demand

China is the leading producer, consumer and exporter of steel. China produces over half of the global steel output of 2,100 MMst.[5] China's production is over ten times greater than the U.S., which produced 90 MMst of steel in 2023.[6] The largest exporters of steel are China (104 MMst), Japan, (35 MMst) and South Korea (30 MMst).[7] The U.S. is the world's largest steel importer and in 2023 consumed over 109 MMst.[8] The U.S. imported over 28 MMst of steel products predominantly from Canada, Mexico, Brazil, and South Korea and exported 9 MMst.[9] U.S. steel plant utilization averaged 75% in 2024, down from 79% in 2019.[10]

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[2] https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-iron-steel.pdf
[3] https://www.chartersteel.com/about/news/eaf-vs-bof-furnaces-in-steelmaking
[4] Rozelle, P L. "A review of the use of anthracite in electric arc furnace steelmaking.", Dec. 1994.
[5] https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-iron-steel.pdf
[6] https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-iron-steel.pdf
[7] https://worldsteel.org/wp-content/uploads/World-Steel-in-Figures-2024.pdf
[8] https://www.trade.gov/data-visualization/united-states-steel-imports-report#:~:text=The%20United%20States%20is%20the,countries%20and%20territories%20in%202024.
[9] https://www.trade.gov/data-visualization/united-states-steel-imports-report#:~:text=The%20United%20States%20is%20the,countries%20and%20territories%20in%202024.
[10] https://www.trade.gov/data-visualization/us-steel-executive-summary#:~:text=In%20December%202024%2C%20the%20capacity,from%2072.6%25%20in%20November%202024.&text=According%20to%20data%20from%20CRU,metric%20tons%20in%20November%202024.

Coal Industry

Coal Mining

Coal is segregated into four ranks, which are increasingly dense, dry, carbon-rich, and hard: lignite, subbituminous, bituminous and anthracite.[11] For steelmaking applications, bituminous and anthracite are the ranks of primary interest. Coal is further separated by application as thermal coal, a fuel in power generation, or metallurgical coal, a feedstock in steel production. Metallurgical coal may be used in thermal applications, but thermal coal is not interchangeable for metallurgical applications, resulting in a higher value of metallurgical coal, commonly referred to as met coal.[12,13] In the U.S., metallurgical coal mining occurs primarily in surface and underground mines in the Appalachian region. Met coal is segmented into grades designated by volatility and rank—high volatility anthracite (high-vol A), high volatility bituminous (high-vol B), low volatility (low-vol) and mid volatility (mid-vol). These comprise the coking coals that can soften and swell to form coke. EAF steelmaking requires coal properties distinctly different from coking coals. Anthracite is ideal for this purpose because of its high carbon content and low volatile content. Anthracite is obtained through underground and surface mining and recovery from coal refuse. The use of anthracite in EAFs reduces power consumption and minimizes process time.

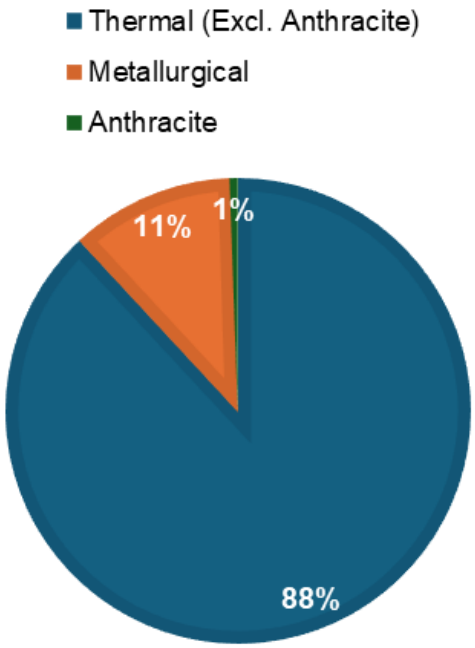

Figure 2. Thermal, metallurgical, and anthracite coal production as fraction of 2023 U.S. total.

To produce steel, the coal must have specific properties found in mid-vol coals, but mid-vol reserves are extremely scarce. As a result, steel plants often mix low-vol or high-vol coals to achieve ideal properties while minimizing cost. In the U.S., nearly 39% of metallurgical coal produced is high-vol A, 18% is high-vol B, 30% is low-vol, and 12% is mid-vol. The remaining metallurgical coal is pulverized coal injection (PCI) coal, a high carbon content, low impurity coal that improves BF productivity.[14] Production of coal primarily for steelmaking relative to total coal production is shown in Figure 2.[15]

[11] https://www.usgs.gov/faqs/what-are-types-coal
[12] https://www.eia.gov/coal/production/quarterly/archive/012123q4.pdf
[13] https://www.eia.gov/coal/annual/pdf/acr.pdf
[14] Larry Runner, CORE, May 1 2025.
[15] https://www.eia.gov/international/data/world/coal-and-coke/

Coal Supply and Demand for Steelmaking

The health of the metallurgical coal industry is a direct function of the health of the overall coal industry (Figure 3). The U.S. produced almost 67 MMst of metallurgical coal in 2023.[16] The U.S. is a net exporter of metallurgical coal, exporting approximately 51 MMst in 2023, over 70% of U.S. metallurgical coal production. In 2023, the U.S. exported its metallurgical coal to India (18%), Brazil (14%), China (10%), and Japan (10%). The only U.S. imports of metallurgical coal in 2023 came from Canada and totaled less than 1 MMst.

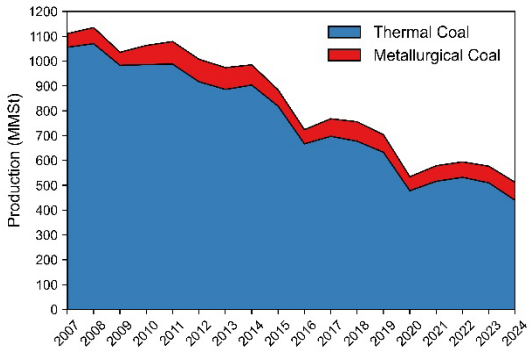

Figure 3Total U.S. coal production (thermal and metallurgical) from 2007-2024. Data source: OPIS U.S. Coal Outlook.

Most metallurgical coal is converted into coke to be used in steel manufacturing, and approximately 16 MMst of metallurgical coal was used in 2023 to make coke. U.S. coke making capacity is about 12 MMst.[17] With 2023 coke production near 11 MMst, the U.S. was using approximately 90% of its coke production capacity, which signifies minimal available capacity if additional coke production was needed. The nation is a net exporter of coke; approximately 1.5 MMst were exported in 2023, predominantly to Canada (66%) and Brazil (16%).[18] Approximately 0.2 MMst of coke were imported in the same timeframe. Note that to produce a ton of steel via BOF/BF requires approximately 0.86 tons of metallurgical coal.[19,20] Active U.S. coke plants and integrated BOF/BF steel mills are shown in Figure 4.

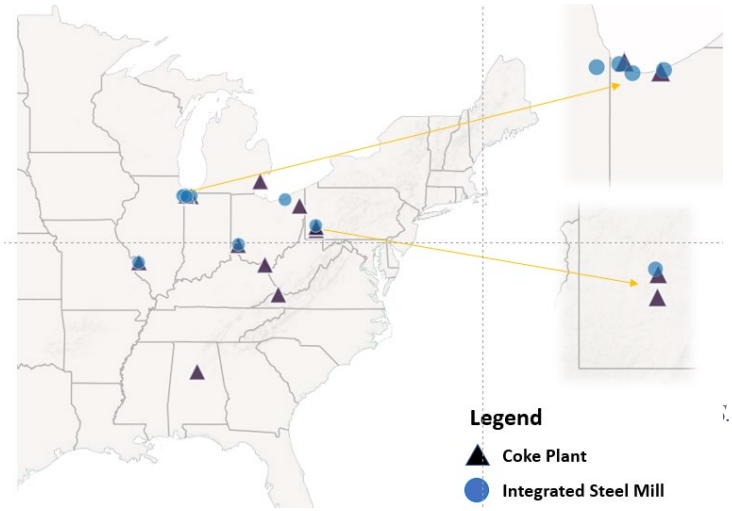

Figure 4 Active Coke plants and BOF/BF steel mills.

Anthracite production for EAF steelmaking is currently limited to Pennsylvania, which produced 4.3 MMst of anthracite from new mines and 4 MMst from refuse in 2023.[21] The U.S imported an additional 0.5 MMst of anthracite, and exported 0.8 MMst of anthracite, for net exports of 0.3 MMst.[22]

[16] www.eia.gov/international
[17] https://www.epa.gov/system/files/documents/2024-05/coke-ovens-rtr-eia-final-2024-05.pdf
[18] https://www.eia.gov/coal/production/quarterly/archive/012123q4.pdf
[19] https://www.epa.gov/system/files/documents/2024-05/coke-ovens-rtr-eia-final-2024-05.pdf
[20] Heattreat technologies
[21] 2023AnthraciteStatewideProductionSummary.pdf
[22] https://www.eia.gov/international/data/world/coal-and-coke/

Actualities of Steel Dominance

An industrial renaissance in the United States would trigger significant growth in both steel consumption and production. Several key challenges must be considered to expand domestic steel production including capacity, trade dynamics, critical infrastructure, workforce limitations, and regulatory concerns. The following provides an overview of initial capacity challenges. Additional analyses could use market data to project potential future U.S. steel consumption and exports. Such a projection would involve exploration of industries that may expand in the U.S. over the next several years, including transportation (auto manufacturing, shipbuilding, and rail), defense, energy (power plants, transmission lines, and pipelines), and general manufacturing (home appliances and factories) in combination with import needs of U.S. allies.

Capacity Considerations

Satisfying Current U.S. Steel Consumption

Given the country's position as a net steel importer, aiming to meet existing U.S. demand with domestic production is a scenario to explore on the path toward steel dominance. If the U.S. were to satisfy 100% of current domestic steel demand and keep steel exports at 2023 levels, this would require an additional 28 MMst of domestic steel production, bringing total steel production to approximately 118 MMst, an output not seen since 1981. If this 28 MMst were to be produced solely via BOF/BF, there would be a need for about 18 MMst of metallurgical coal, which is more than half of present surge capacity in met coal mining. In this scenario, additional capacity would be required in several areas including metallurgical coal mines, coke plants, and steel making facilities.

Steel Increases by Production Method

Ramping up steel, coke, and metallurgical coal production to achieve steel dominance would require increased capacity, infrastructure, and labor. U.S. steel production in 2024 was at approximately 75% capacity utilization. Another scenario to cogitate is achieving optimal capacity (85%) while holding production ratios between BOF/BF and EAF constant. A capacity of 85% mitigates cost and maintenance of higher capacities and allows flexibility in production which facilitates proper market functions.[23] This would result in annual production of approximately 100 MMst of steel, including 28 MMst produced from the BOF/BF fleet and 73 MMst using EAF. This scenario requires approximately 18 MMst of coke per year, implying 25 MMst of metallurgical coal, for the increased BOF/BF production. The EAF steelmaking in this scenario would yield approximately 9 MMst of additional steel annually while consuming an additional 0.1 MMst of anthracite. [24] Increasing steel production beyond these levels would require additional steel and coal production capacity. Additional analyses could investigate workforce limitations associated with increased steelmaking operations.

A nuanced area of risk to future economical production of U.S. steel requires consideration of natural gas price dynamics. EAFs rely on inexpensive electricity. If natural gas prices increase, the price of electricity will rise. Additional analysis could explore natural gas prices and conditions under which BOF/BF becomes the preferred steel production method due to less favorable economics of EAF. For example,

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[23] https://www.crugroup.com/en/communities/thought-leadership/sustainability/the-myth-of-excess-steel-capacity/

[24] Echterhof, Thomas. "Review on the use of alternative carbon sources in EAF steelmaking." Metals 11.2 (2021): 222.

dramatically increased liquefied natural gas (LNG) exports could result in higher natural gas prices, increasing electricity prices, thus incenting BOF/BF.

Metallurgical Coal Considerations

The U.S. has overall coal reserves that exceed 470,000 MMst.[25] However, U.S. metallurgical coal reserves are only a portion of this figure and are primarily located in Appalachia.[26] Discussion with industry experts suggests approximately 100 MMst may be the maximum amount of U.S. metallurgical coal production, an amount that has not been seen since 2011. For instance, the Central Appalachia region has numerous small room and pillar metallurgical coal mines as opposed to longwalls, which would increase labor requirements. Alpha Natural Resources indicated in 2016 it had approximately 247 MMst of metallurgical coal reserves in West Virginia.[27] Additionally, Ramaco indicates it has 60 MMst of metallurgical coal reserves across Appalachia.[28] Coal industry experts indicate the U.S. mines may have the most difficulty ramping up low-vol and mid-vol production. Additional analyses could assess emergent threats to metallurgical coal reserves from a resurgence of domestic steel-intensive manufacturing and consider likely years of sustained production.

Criticality of Metallurgical Coal for Steel Dominance

Review of the current U.S. steel market and its reliance on metallurgical coal (including anthracite) reveals a production scenario on track for significant import reliance. Meeting the policy goal of US Steel dominance will require dramatic increases in domestic metallurgical coal production and use. E.O. 14261 tasked the Department of Energy with a review of the criticality of coal for steelmaking based on the Energy Act of 2020. This analysis supports the determination that metallurgical coal used for steelmaking is a US DOE critical material.

[25] https://www.eia.gov/international/
[26] https://www.eia.gov/todayinenergy/detail.php?id=61924
[27] https://pubs.usgs.gov/of/2020/1113/ofr20201113.pdf
[28] https://ramacoresources.com/met-coal-operations/#:~:text=We%20have%20a%20long%2Dlived,priority%20at%20every%20Ramaco%20facility.