

Report Brief

Ceres

Smarter, Leaner, Cleaner

Direct Reduced Iron and the Future of American Steel

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Ceres Analysis

The American steel industry is headed into a major reinvestment cycle. A new generation of technology—based on direct reduced iron (DRI)—is the most attractive place to put that capital. It's more flexible, more competitive, and cleaner than the alternatives.

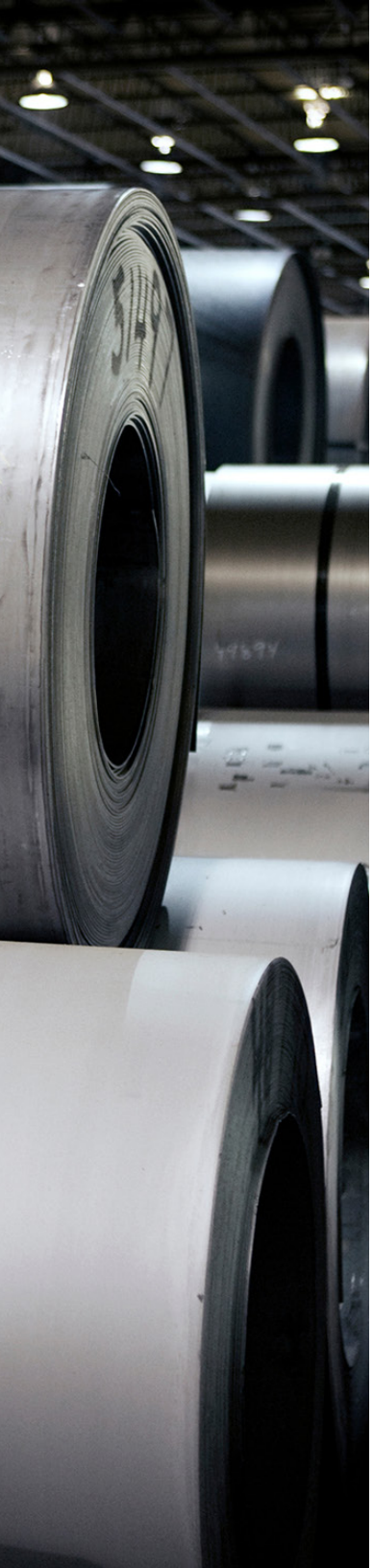
Across the U.S., the steel industry's aging ironmaking blast furnaces and the coke ovens that fuel them will soon reach the end of their lives and must be refurbished, replaced, or retired. Decisions about how to make these multi-billion-dollar investments will define the structure of the U.S. steel system for decades.

This analysis, produced for Ceres by independent steel industry analysts with the guidance of 44 expert advisors, evaluates the feasibility of different iron and steel making technologies in four regions that capture the diversity of American steelmaking—Minnesota's Iron Range, the Gulf Coast, Pennsylvania, and Northern Indiana.

Across all four regions, direct reduced iron outperforms on cost, flexibility, financial returns, and pollution.

- Our analysis examines the full economic and technical potential of direct reduced iron, an alternative to the traditional blast furnace for converting iron ore into iron. It shows that DRI-based steel mills are the lowest-cost, new-build option in every region we modeled.
- DRI facilities coupled with a smelter can produce pig iron at costs competitive with the $2 to $3 billion the U.S. spends on merchant pig iron imports each year. (Imported pig iron is used in electric arc furnaces (EAFs), which currently produce 70% of the steel made in the U.S.) DRI facilities coupled with EAFs can produce steel that is cost competitive. These results hold true even when modeled against lower steel prices and higher electricity costs than the current market, providing a major opportunity to onshore production and bolster supply chain security.
- Flex-fuel DRI mills deliver other advantages that ironmaking in blast furnaces cannot. Compared with the blast furnace, DRI facilities are more flexible to operate and more efficient at making iron that is transportable. That makes it possible to decouple the iron and steelmaking processes geographically, enabling the industry to produce iron and steel where it is more cost effective for a customer and based on need.
- These mills also emit 40% lower greenhouse gases, 80% lower local air pollution, and can switch between gas and hydrogen as fuels—providing a future hedge against energy and emissions costs.

For a capital asset built to run for 20 to 30 years, the combination adds up to a compelling case.



More details are available in the full analysis of Smarter, Leaner, Cleaner: Direct Reduced Iron and the Future of American Steel.

Findings

Steel produced from direct reduced iron is the future of American steel, not because it can undercut the price of steel from a blast furnace that has already been paid off, but because it is the best place to put the next dollar of new capital.

1. DRI can compete for billions of investment needed to modernize America's steel mills

As aging blast furnace mills reach reinvestment decisions over the coming decade, billions of dollars of new capital will be deployed. The costs are significant: A blast furnace must be relined with heat-resistant bricks every 15 to 20 years at a cost that can run into hundreds of millions of dollars. And rebuilding the ovens used to produce the coke used in blast furnaces can cost more than $1 billion per unit—just to keep a legacy asset running for another 15 to 20 years compared with the 20-to-30-year lifespan of a new gas-fired DRI-EAF plant. DRI can compete for that investment furnace by furnace.

2. Domestic DRI could replace $2 to 3 billion in merchant pig iron imported annually

To compete for a greater share of the automotive steel market, EAF steelmakers need more pure iron from ore. Since U.S. EAF producers do not own domestic iron ore mines, the country imports roughly 4 to 6 million metric tons of pig iron, historically from Russia, India, and Ukraine but now mostly from Brazil. This creates a strong incentive for EAF steel producers to build new

What is Direct Reduced Iron—and why is the market already moving toward it?

DRI is an alternative to the blast furnace for converting iron ore into iron, but in a solid form. That iron can then be fed into an electric arc furnace to make steel. Alternately hot DRI can be fed into a smelter to produce liquid pig iron which can be made into steel in existing basic oxygen furnace (BOF) facilities or solidified to produce merchant pig iron.

DRI's operational flexibility derives from its ability to convert iron ore into iron in a solid state, without melting, at relatively low temperatures. A blast furnace, by contrast, melts ore at very high temperatures using coke, a fuel made by baking coal, and produces liquid pig iron. Due to their lower operating temperatures and solid product, DRI-based mills can be turned on and off more easily than a blast furnace, which must run continuously. Flexible production runs of DRI facilities are easier to pair with electric arc furnaces that have similar operating flexibility. And because DRI mills produce solid metal, their product can be transported over long distances vs. blast furnaces, which produce hotter, liquid metal better suited to on-site use. Higher operating temperatures for blast furnaces mean they must run continuously and are most efficient only when they charge hot iron directly into an adjacent basic oxygen furnace.

Further, DRI mills can run on natural gas, hydrogen, or a blend of the two. If and when hydrogen prices fall over time, DRI mills' ability to switch between fuels will enable them to choose the more economical option at any given moment.

The market is already signaling its preference for DRI. Most American liquid pig iron is still made in eight blast furnaces along the Great Lakes. But two merchant DRI mills already serve the U.S. EAF market (Nucor's operations in Louisiana and Trinidad). Another aimed at U.S. customers is under construction in Monterrey, Mexico. In the past year, U.S. Steel and Hyundai announced plans to build new DRI –EAF mills in Arkansas and Louisiana, respectively. By contrast, no brand-new blast furnace has been built in the U.S. since 1980.



DRI facilities coupled with a smelter to produce pig iron. Domestic production would allow them to avoid the risk of import tariffs, capture the value-add of producing pig iron domestically, and reduce dependence on foreign supply.

Our analysis shows that a domestic gas-based DRI–smelter mill can produce pig iron that is cost competitive with those imports in every region, at roughly $414 to $503 per metric ton. In other words, domestic DRI-based pig iron could replace the supply of a strategic material currently sourced abroad. The savings on raw material costs could, in turn, enhance the economics of current and new EAF mills.

3. DRI is the lowest-cost new-build steelmaking option in the four key regions we examined

On a new-build basis, DRI-EAF steelmaking costs roughly $610 to $628 per metric ton of finished steel, compared to $634 to $639 for a new blast furnace complex. The most competitive configurations of ironmaking and steelmaking technologies pair natural gas-powered DRI facilities with an electric arc furnace or feed DRI-smelter produced liquid iron into an existing basic oxygen furnace. Regional cost differences are small. What drives the choice between configurations is less about cost than local factors such as access to ore, customer proximity, existing infrastructure, and alternatives supplied by competitors.

4. All four regions, including traditional steelmaking states, are attractive for investment

Our analysis shows that Pennsylvania has a slight cost edge due to ready access to natural gas, established iron supply lines, a skilled workforce, and proximity to customers. The Gulf Coast benefits from deepwater port access, low-cost natural gas, and an emerging cluster of co-located DRI and electric arc furnace operations. Minnesota's Iron Range leads on access to iron ore and renewable electricity, which could unlock DRI's lowest-carbon potential. Northern Indiana remains competitive because of its legacy of high-quality primary steelmaking, strong transportation links, skilled workforce, and proximity to automotive customers.

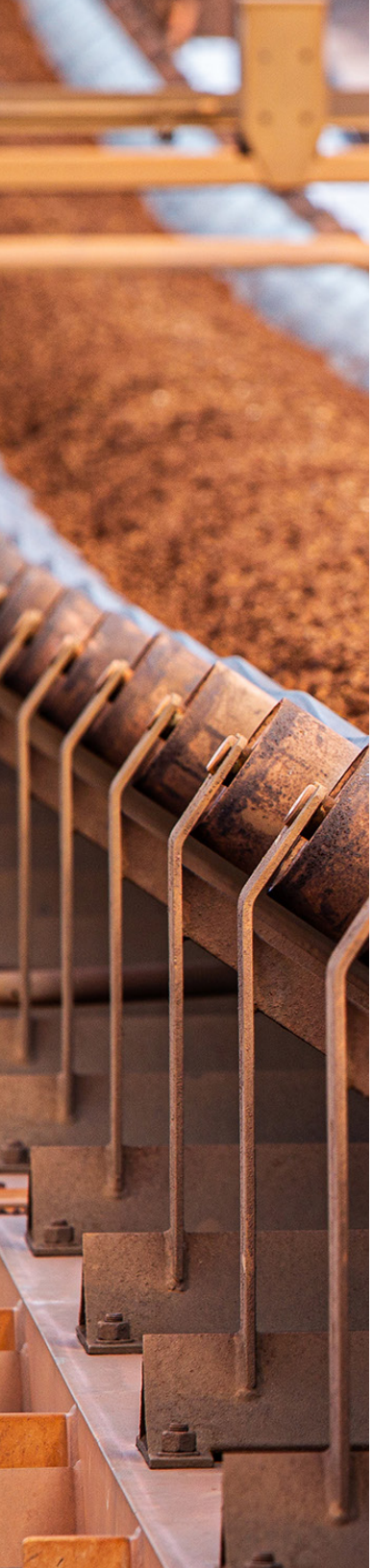
5. New DRI-based mills achieve the 15% rate of return required to make projects investable

New BF-BOF, natural gas DRI—EAF, and DRI-smelter-BOF mills meet the 15% rate of return typically expected by investors. In addition, our analysis found that DRI-based mills are an attractive investment even under adverse conditions: the investment still clears the 15% bar when we assume U.S. steel prices fall to their lowest level of the past fifteen years and against a 20% rise in industrial electricity prices. These findings assume continuity, with the U.S. operating a protected internal market for steel as it has continuously since 1969 under 11 different administrations.

6. DRI reduces exposure to energy risk

Flex-fuel DRI furnaces can run using natural gas or hydrogen as fuel. This lets producers switch or even blend fuels as prices, supply, and regulations change. While fuel switching is an important potential risk management tool, hydrogen prices need to fall for DRI operators to be able to take advantage of this capability in the future. Today, hydrogen-based DRI remains materially more expensive than natural gas, with a hydrogen premium on the order of $170 to $250 per metric ton. The gap closes only in locations where very low-cost electricity, on the order of $20 per megawatt-hour, can be paired with hydrogen storage, such as underground salt caverns.

Storage is key because it enables producers to manufacture hydrogen when electricity demand and prices are low, for instance, from wind farms operating at night. These conditions are not found everywhere, but they are achievable in specific regions that combine rich renewable resources with abundant storage capacity. Of the four



regions, Minnesota's Iron Range is the standout: its access to renewables, especially Great Plains wind, gives it a competitive advantage. In general, however, closing the hydrogen cost gap in the near term would require durable support policies.

7. DRI reduces pollution and regulatory risk

Compared with a coke-BF-BOF plant, and using average U.S. grid electricity, a natural-gas DRI–EAF plant is 80% less polluting when it comes to local air contaminants and emits 40% fewer greenhouse gas emissions. Those figures drop even further as green hydrogen becomes affordable. Beyond local health benefits, lower emissions reduce a plant's exposure to tightening environmental regulation, which might occur over its operating life.

8. The growing domestic American iron trade will accelerate a shift to DRI

DRI-based mills efficiently produce different forms of iron, including solid and liquid pig iron, hot briquetted iron, and sponge iron, that are stable and transportable. As a result, they can easily ship their products to EAF steelmakers located elsewhere or to meet a BOF customer's needs. Shipping solid iron to a site further away does require reheating, which adds some cost and emissions that using hot metal on site avoids. But that penalty is outweighed by the improved flexibility gained by both individual steelmaking sites and the U.S. steel industry as a whole. By contrast, more than 95% of the iron produced by U.S. blast furnaces is transported in molten form to a steelmaking furnace at the same site, so very little of it is cast into solid pig iron that can be shipped elsewhere.

Ceres' Recommendations

For steelmakers

Our analysis is a starting point, not a site-specific blueprint. We encourage companies to use it as a baseline as they evaluate DRI projects at particular sites. Companies should continue to consult widely, inside and beyond the Ceres advisory group, as they conduct analysis and weigh options. BF-BOF producers will have to decide whether or not a transition to gas-fired DRI-smelter that feeds existing basic oxygen furnaces will yield higher returns than costly refurbishment of existing blast furnaces and coke ovens. EAF producers will have to consider DRI investments to source clean iron, without contaminants such as copper and nickel, as they compete for a share of the automotive steel market. A single DRI–smelter unit producing merchant pig iron can meet the needs of several EAFs and replace nearly 35% of imported merchant pig iron.

For investors

The results point to near-term, new-build opportunities in a variety of configurations of flex-fuel DRI projects across all four regions. Siting decisions will be driven mainly by infrastructure, feedstock access, and downstream demand rather than by regional cost gaps.

For policymakers

Given that flex-fuel DRI configurations are cost-competitive in each region, state and local policymakers should engage steelmakers directly about the potential for DRI development projects in their own state. The performance advantages and flexibility of DRI show that additional plants are likely to be built. The major question is: where? Fortunately, state, and local governments have a number of tools available to support industrial development, from development-forward permitting to tax incentives.



For steel industry service and technology providers

DRI will become an increasingly important component of U.S. iron supply, enabling a variety of new system configurations as outlined in this report. We recommend offering DRI site visits as a way to familiarize stakeholders with DRI 's potential to onshore merchant pig iron production, modernize both steelmaking sites and the national steel production system, to onshore production of a critical material, to manage a variety of business risks, and to spur local economic development.

Methodology

This study is designed to provide a baseline understanding of DRI's technical and economic potential among steelmakers, technology providers, project financiers, and policy makers.

Ceres commissioned Dr. Chris Bataille, and Dr. Francis Li, industrial modernization analysts, to conduct a technical-economic analysis of the potential for DRI, between February and June 2026, with the support and advice of an expert stakeholder group. Assembled by Ceres, this panel of more than 40 experts represented the range of industries essential to steel's modernization, ranging from C-Suite officers and independent experts, to engineers, commercial lenders, and institutional investors, to metallurgists and procurement specialists from major automakers.

The study explores the feasibility of different iron- and steel making technologies under different sets of economic conditions in four regions that capture the diversity of American ironmaking: Minnesota's Iron Range, the Gulf Coast, Pennsylvania, and Northern Indiana. For each, the analysts weighed the factors that actually determine what gets financed and built: the cost of raw materials, energy, and equipment; transport; and how each pathway compares with the alternatives available in that region. Because input prices such as natural gas, electricity, and iron ore are volatile, they did not rely on single best-guess figures. They ran the economics across a range of plausible prices, so the findings reflect how each option performs under both favorable and unfavorable conditions rather than at one convenient snapshot.

More details are available in the full analysis from Dr. Bataille and Dr. Li, see Smarter, Leaner, Cleaner: Direct Reduced Iron and the Future of American Steel.

Limitations

This analysis compares production pathways under a common set of commercial assumptions, focusing on relative cost and capital intensity. It is built to show how pathways perform under shared conditions rather than to assess project-specific feasibility, detailed engineering design, or how markets might evolve over time. The results therefore indicate relative positioning for new-build DRI across pathways and regions under stated conditions, rather than predicting realized project outcomes.



About Ceres

Ceres is a nonprofit advocacy organization working to accelerate the transition to a cleaner, more just, and resilient economy. With data-driven research and expert analysis, we inspire investors and companies to act on the world's sustainability challenges and advocate for market and policy solutions. Together, our efforts transform industries, unlock new business opportunities, and foster innovation and job growth—proving that sustainability is the bottom line. For more information, visit ceres.org.

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