Report Brief

Ceres

Smarter, Leaner, Cleaner

Direct Reduced Iron and the Future of American Steel

August 2026

Ceres Analysis

The American steel industry is headed into a major reinvestment cycle. A new generation of technology—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.

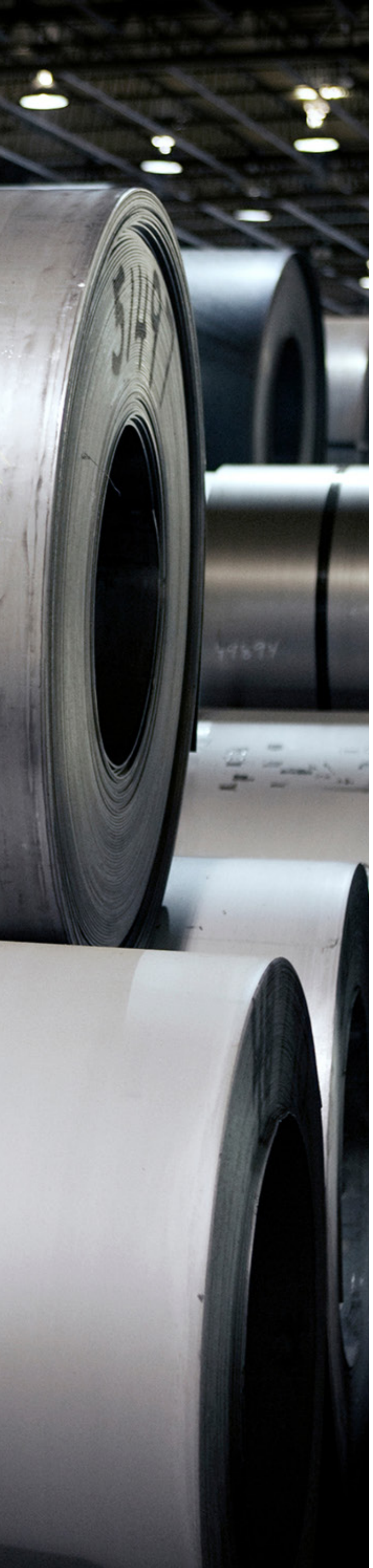
This analysis, produced for Ceres by independent steel industry analysts with the guidance of 44 expert advisors, evaluates the feasibility of different iron and steel making technologies in four regions that capture the diversity of American steelmaking—Minnesota's Iron Range, the Gulf Coast, Pennsylvania, 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 DRI. It shows that DRI mills are the lowest -cost, new-build option in every region we modeled.
- DRI facilities can produce iron at costs competitive with the $2 to $3 billion the U.S. spends on pig iron imports each year. 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 mills 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

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 furnaces 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 plant. DRI can compete for that investment furnace by furnace.

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

To compete for a greater share of the market for providing steel for automakers, electric arc furnace steelmakers need more pure iron from ore. Since some U.S. producers do not own domestic iron ore mines, the country imports roughly 4 to 6 million metric tons of pig iron, historically from Russia and Ukraine but now mostly from Brazil. This creates a strong incentive for electric arc furnace steel producers to build new DRI capacity. Domestic production would allow them to avoid import tariffs, capture the value-add of producing pig iron domestically, and reduce dependence on foreign supply.

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

DRI is an alternative to the more traditional blast furnace for converting iron ore into iron, which can then be fed into either a basic oxygen furnace or an electric arc furnace to make steel. A DRI mill has two features that create an advantage: 1/ its operational flexibility and 2/ its ability to run on two fuels.

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. Due to their lower operating temperatures, DRI mills can be turned on and off more easily than a blast furnace, which must run continuously. This makes DRI mills better suited to flexible production runs and easier to pair with electric arc furnaces that have similar operating flexibility. And because DRI mills produce products that are solids rather than hot metal, they are more efficient than blast furnaces, which produce hotter metal better suited to on-site use. Higher operating temperatures for blast furnaces mean they must run continuously and are most efficient when they charge hot iron directly into an adjacent basic oxygen furnace.

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 iron is still made in eight blast furnaces along the Great Lakes. But two DRI mills already serve the U.S. market (including Nucor's operations in Louisiana and Trinidad) and another aimed at U.S. customers is under construction in Monterrey, Mexico. In the past year, U.S. Steel and Hyundai each announced plans to build new DRI mills, in Arkansas and Louisiana respectively. By contrast, no brand-new blast furnace has been built in the U.S. since 1980.

Our analysis shows that domestic gas-based DRI 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 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 new DRI mills.

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

On a new-build basis, DRI-electric arc furnace steelmaking costs roughly $610 to $628 per metric ton of finished steel, compared to $634 to $639 for a new blast furnace. The most competitive configurations of ironmaking and steelmaking technologies pair natural gas-powered DRI facilities with an electric arc furnace or feed DRI-produced 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 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.

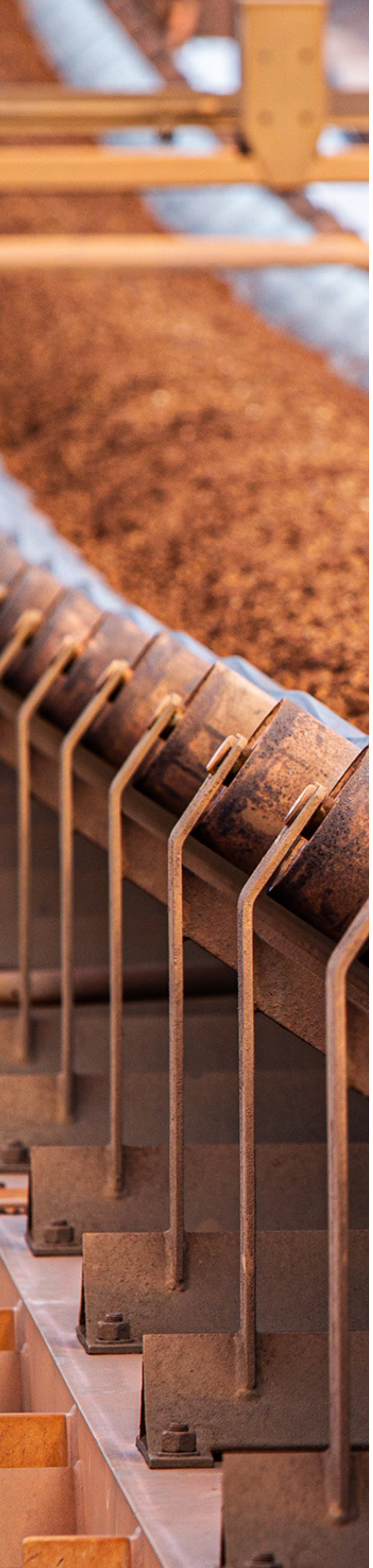
5. New DRI mills achieve the 15% rate of return required to make projects investable

Both new blast furnace steel and natural gas DRI meet the 15% rate of return typically expected by investors. In addition, our analysis found that DRI is an attractive investment even under adverse conditions: it 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 blast furnace, and using average U.S. grid electricity, a natural-gas DRI furnace 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

Because DRI efficiently produces different forms of iron, including pig iron, hot briquetted iron, and sponge iron, that are stable and transportable, downstream electric arc furnace steelmakers will have more options to source and move iron to meet customer needs. Shipping iron to a second site 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.

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. Blast furnace-blast oxygen furnace producers will have to consider whether a transition to gas-fired DRI that feeds existing basic oxygen furnaces will yield higher returns than costly refurbishment of existing blast furnaces and coke ovens. Electric arc furnace producers will have to consider DRI investments to source iron as they compete for a share of the automotive steel market. Both will have to look to their future competitiveness over the lifetimes of their investments.

For investors

The results point to near-term, new-build opportunities in 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 is 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 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 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.

Acknowledgments

This analysis was based on research authored by Dr. Chris Bataille and Dr. Francis Li for Ceres with the input of Ceres' Future of American Steel advisory group.

Project Managers
Daniel Seligman, Strategic Advisor, Heavy Industry, Ceres
Stephanie Hanford, Director, Heavy Industry, Ceres.

We wish to thank the business and academic professionals who generously shared their insights, time, and experience to shape this study. Their expert contribution was advisory only and does not constitute or imply endorsement of the study, its methodology, or its conclusions. These are the sole responsibility of Ceres, Dr. Bataille, and Dr. Li.

Thanks also to the colleagues at Ceres who provided invaluable editorial review and design support with this project, including Heather Green and Maura Conron.

Cover photo: Courtesy of Nucor Corporation

Advisors

Jamie Beck Alexander, Director External Affairs, National Resources Research Institute (NRRI), University of Minnesota

Blair Bateson, Senior Vice President, Net Zero Strategy, Bank of America

Sean Boyle, Vice President, Commercial, Midrex Technologies, Inc.

Erika Chan, Head of Sustainability, United States Steel Corporation

Vincent Chevrier, Technical Sales and Marketing, Midrex Technologies, Inc.

Steven Clarke, Program Director, Climate & Energy, Ceres

Chad Donovan, Vice President, Central Sales and Marketing, SMS Group Inc.

Tom Dower, Vice President, Government Relations, ArcelorMittal

Peter Ellsworth, Senior Director, Investor Network, Ceres

Rich Fruehauf, Chief Venture Officer and General Counsel, Carnegie Foundry, LLC.

Aya Hamid, Research Engineer, Ford Motor Company

Naomi Hoffman, Senior Analyst, Responsible Investing, Nuveen

Arne Jahn, Managing Director, Head of Metals & Mining, PNC

Marty Johnson, Environmental Manager, Nucor Corporation

Amari Jones Scriven, Manager of Corporate Sustainability, Nucor Corporation

Valerie Karplus, Professor, Carnegie Mellon University

Sean Keenan, Vice President, Americas Supply Chain, SSAB Americas

Suleyman Kilci, Vice President, Sustainable Solutions Group, ING Americas

George Luckey, Manager, Advanced Metal Technology, Ford Motor Company

Stefano Maggiolino, President and CEO, Tenova HYL

Catherine Mazza, Director Relationship Management, Schroders

Jesse McCormick, Energy and Climate Finance, J.P. Morgan

Rachna Mehta, General Manager Market Intelligence, Midrex Technologies, Inc.

Francesco Memoli, President and CEO, Tenova Inc.

Lindsay Moreau, Director, Responsible Investing Stakeholder Relationships, Nuveen

Carol Moreno, CFA, Director, Investor Network, Ceres

Chris Mracna, Materials Engineering Supervisor, Ford Motor Company

Hyo Joon Park, Team Lead, HYUNDAI-POSCO, Louisiana Steel, LLC

Kevin Persad, Technical Manager, Nucor Steel Louisiana, LLC

Madhu Ranade, General Manager Raw Materials Strategy and Supply, Flat Roll Group, Steel Dynamics Inc.

Ram Reddi, Manager of Decarbonizing Engineering, Steel Dynamics Inc.

Christopher Richardson, Shareholder Advocacy Manager, Mercy Investments

Marina Severinovsky, Head of Sustainability Americas, Schroders

Sumeet Singal, Managing Director Corporate and Investment Banking, Citi

Brett Spigarelli, Endowed Taconite Chair, Senior Research Science, National Resources Research Institute (NRRI), University of Minnesota

Jessica Starr, Corporate Governance Officer, New York State Comptroller

Jamie Statter, Special Advisor Climate (Asset Management), New York City Comptroller

Lily Tardif, Assistant Vice President, Net Zero Strategy, Bank of America

Dakshesh Thacker, former Manager, Heavy Industry, Ceres (Consultant, Industrial Decarbonization, International Finance Corporation)

Aneil Tripathy, Director, Company Network, Financial Services, Ceres

Robert Valin, Senior Global Sourcing Manager, General Motors Company

Erik Van Doezum, Head of Metals, Mining & Fertilizers, Germany, Global Steel Lead, ING

Annabel Von Weise, Senior Associate, Company Network, Ceres

Sarah Wilson, Managing Director, Head of Climate Center of Excellence, Nuveen