UNLOCKING THE FIRST WAVE OF BREAKTHROUGH STEEL INVESTMENTS

in the United States

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Prepared by

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PREFACE

In the September 2022 publication *Making Net-Zero Steel Possible,*[1] the **Mission Possible Partnership** (MPP) found that approximately 70 "near-zero emissions" iron ore–based steel mills need to be operational by 2030 for the global steel industry to be on a 1.5˚C-aligned pathway.[i] As of 2022, the pipeline of projects falls well short of this target, and even among projects that have been announced, few have secured final investment decisions (FIDs) to proceed. Growing the project pipeline and accelerating commercial-scale proposals to FIDs is the critical task to decarbonize steel globally.

As a core partner of MPP, **RMI** has sought to build on *Making Net-Zero Steel Possible* by answering the question of what it will take to achieve FIDs for near-zero emissions steel projects in the next five years. With support from Breakthrough Energy, RMI and the Energy Transitions Commission are conducting a series of regionally focused forums to determine what is needed to make these steel projects investable under a given set of local conditions, beginning first in the United Kingdom and followed by the United States, Southern Europe, and Western Europe.

This insight report outlines the findings of the forums focused on the United States, covering the need for "breakthrough" near-zero emissions steelmaking in the United States,[ii] the financial, operational, and market gaps this type of steelmaking faces under prevailing conditions, and potential pathways to making it investable in the immediate future. Crucially, this report suggests a viable route to breakthrough steel in the United States if a few key conditions are created:

- Partnerships across the value chain that de-risk green infrastructure investment
- Syndication of public and private funding opportunities to diversify first-of-a-kind investment risks
- Optimization of current federal funding opportunities available through the Inflation Reduction Act and the Infrastructure Investment and Jobs Act
- Off-take agreements for low-emissions products from steel buyers

These collaborative steps across steel industry stakeholders are essential for establishing the US low-emissions steel investment case. The market conditions and government support available in the United States for breakthrough iron and steelmaking investment are aligned and awaiting the first market movers to kick-start the domestic flow of breakthrough, near-zero emissions steel supply.

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i Near-zero emissions represents breakthrough technology targeting net-zero-emissions steel, focusing on eliminating the dominant emissions sources from iron and steelmaking processes and recognizing that upstream emissions from iron ore mining, grid emissions intensity, and natural gas methane leakage would prevent realizing net-zero emissions.

ii "Breakthrough" refers to the first-of-a-kind project that introduces a new production route.

EXECUTIVE SUMMARY

Despite the United States having some of the lowest average carbon-intensity steel globally, its steel industry still makes up approximately 7% of the nation's industrial emissions each year.[2] Although the United States has shifted to produce approximately 70% of domestic steel though electric arc furnaces (EAFs),[3] iron ore–based steelmaking still largely depends on emissions-intensive fossil fuels — coke, coal, and natural gas. Iron ore-based steel demand persists in the United States to serve growing steel demand and customers with tight product specifications, such as the automotive industry. New technology and operational changes to reduce steel emissions will be required this decade to align US steel production with the 1.5°C emissions budget. The transition of domestic steel to breakthrough, near-zero emissions steel will take innovation and investment beyond that of traditional industry capital cycles.

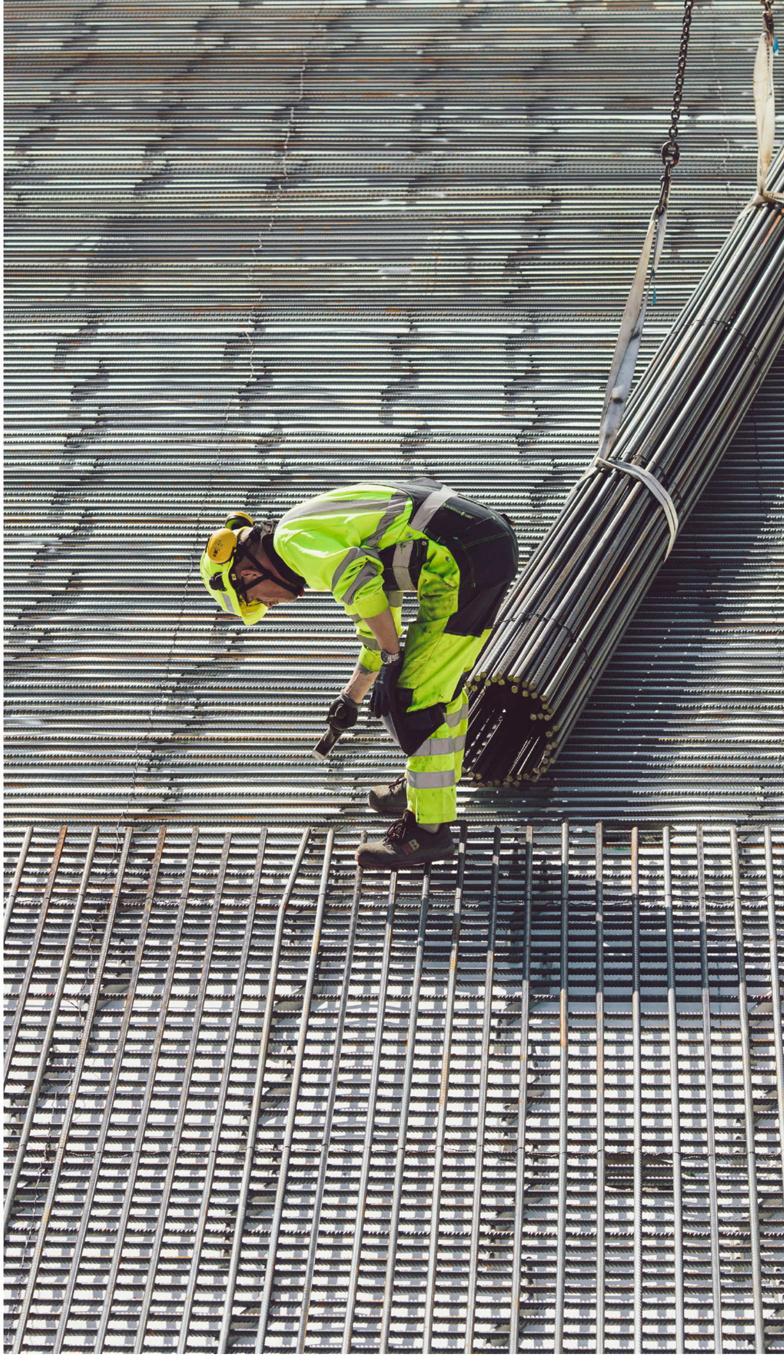
The recently passed Inflation Reduction Act (IRA) and the Infrastructure Investment and Jobs Act (IIJA)[iii] provide energy- and climate-related financial support, which will accelerate public and private investment in new, clean infrastructure throughout the United States. Similar government support is materializing globally as other nations seek to compete for clean energy and low-emissions commodity markets. The United States' current clean energy incentives have created pathways to some of the lowest cost clean energy in the world and mark a unique moment in time for US manufacturing to competitively lead in industrial decarbonization.

In the US forum series industry experts across the steel value chain — steelmakers, iron ore miners, energy providers, buyers, financiers, government, and other relevant experts — have

iii The IIJA is also known as the Bipartisan Infrastructure Law (BIL).

debated outstanding obstacles and brainstormed solutions on how to reach an investment decision for the first domestic breakthrough near-zero emissions steelmaking project over the next five years.

The analysis uncovered multiple financially viable routes to near-zero emissions steelmaking in the United States under the federal funding programs currently available for industry and energy industries. Several low-emissions steel archetypes that meet or exceed carbon intensity requirements of all current near-zero emission steel product-level guidance were evaluated, but the analysis focused primarily on a renewable hydrogen–direct reduced iron–electric arc furnace (H2-DRI-EAF) production route due to the technology's near-zero emissions profile and ability to be applied in both ore-based and scrap-based steelmaking. In the financial analysis, several configurations demonstrated project viability with the benefit of the recent hydrogen production tax credit (PTC) adding early project cash flows, improving project valuation, and decreasing project payback period. Multiple near-zero emissions brownfield and greenfield routes have emerged as positive investment opportunities. The combination of government subsidies, preferential financial terms for climate-focused investments, and market appetite to pay a premium for a low-emissions product have created an opportunity for near-zero emissions steel to be investable in the United States.



The recommended next steps for producers looking to capture the US near-zero steel market share and buyers targeting near-zero emissions steel procurement include:

- **Build partnerships across the steel value chain** to mitigate carbon transition risks and secure green infrastructure access. Leveraging the full suite of partnership opportunities across the decarbonization economy (e.g., new hydrogen and industrial hubs) can mitigate risk exposure, realize scale, and secure early access to green infrastructure.
- **Optimize federal funding opportunities and incentives** by staying agile and informed. Securing FID before September 30, 2026, allows for the greatest potential to stack federal incentives from the IRA and IIJA given program timelines. Funding requirements and evaluation criteria are still being developed for these programs and incentives; companies are advised to stay current on funding opportunities and guidance, which are released in regular announcements through the federal eXCHANGE system and the Internal Revenue Service website.[4]
- **Seek out new funding routes through sustainability and innovation funds** for first-of-a-kind investments. Regulators and investors alike have prioritized the importance of sustainable investments, unlocking preferential lending rates and terms for decarbonization projects. Additionally, private (e.g., venture capital) and public (US Department of Energy [DOE] Loan Programs Office [LPO]) funding opportunities focused on climate investments provide access to capital for these first-of-a-kind, breakthrough steel projects.
- **Send firm, clear signals through low-emissions steel procurement.** Firm procurement signals are required to kick-start the domestic near-zero emissions steel supply. Coordinated aggregation of buyer procurement will likely be necessary to accumulate sufficient demand to support a breakthrough near-zero emissions production asset and secure investor confidence in the facility's revenues. Buyer coalitions can serve as a powerful platform to agglomerate demand across sectors.[5]

PART I

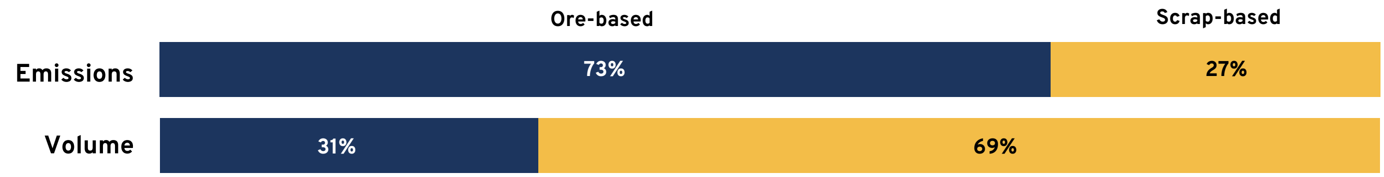
THE UNITED STATES' OPPORTUNITY TO LEAD THE GREEN STEEL MARKET IN THIS CRITICAL DECADE

Steel is a central commodity in the US economy, representing $110 billion gross domestic product in 2021.[6] The strong domestic steel market provides multiple national benefits, including domestic supply security by producing 86 million tons (Mt) in 2021 to meet approximately 90% of the domestic demand of 97 Mt in the same year.[7] The steel industry also provides benefits to the national labor market, representing 81,000 jobs and employing an additional 64,000 people in foundries.[8]

The US steel industry is at a critical point as six aging blast furnaces will likely face a critical investment decision of transition or reline capital in the next 10 years, in conjunction with the near-term deep industry emissions reductions necessary to meet the Biden administration's 2030 goals of achieving economy-wide emissions reductions of 50%–52% from 2005 levels.[9] Despite the strong domestic presence of scrap-based steel supply in the United States, demand for ore-based steel persists to meet growing steel demand under limited scrap-based supply lines and to serve customers with tight product specifications, such as the automotive industry. The decarbonization of ore-based steel supply — which as shown in Exhibit 1 represents the majority of US steel emissions — will require new technology and operational changes to reduce industry emissions this decade.

EXHIBIT 1

Scrap-based steelmaking dominates production volume in the United States, but ore-based steelmaking dominates emissions



Source: World Steel Association, *World Steel in Figures*, 2022; US Energy Information Administration, *Annual Energy Outlook*, 2022; RMI analysis.

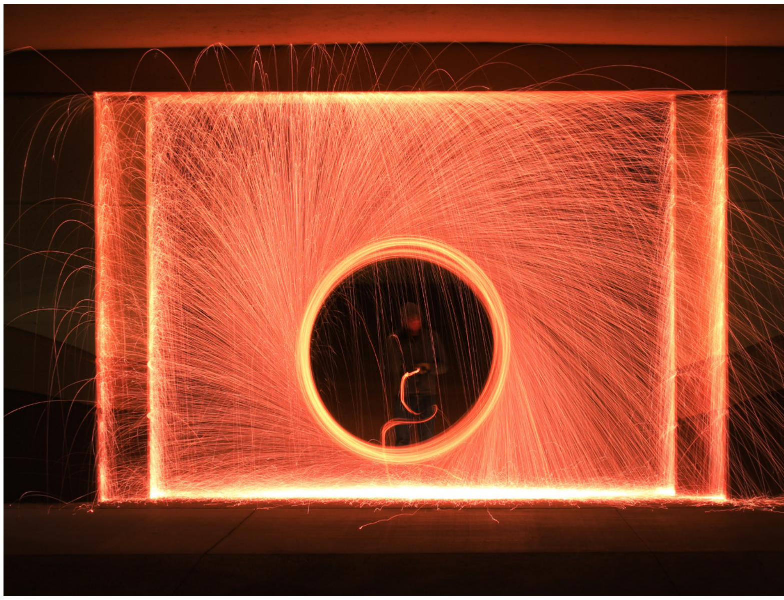
US steel production is expected to increase 12% by 2050 to support increased renewable energy integration and the shift to electric vehicles,[10] further punctuating the need to decarbonize steel production to support the emerging low-carbon economy. The US domestic low-emissions steel market is expected to grow to $30 billion by 2050 with additional export opportunities in neighboring Canada and Mexico representing an additional $20 billion in low-emissions steel demand.[11] The transportation industry has strategic buying power as the lead purchaser of ore-based steel in the United States and has demonstrated a commitment to the low-carbon transition with new electric vehicle product lines and lightweight, high-strength steel applications. Further, public and private commitments to emissions reductions in end-use sectors have stimulated zero- or low-emissions commodity demand as companies look to drive emissions out of the full procurement value chain and regularly report Scope 3 emissions to consumers.

The current market and political landscape in the United States have created an environment where domestic manufacturing has an opportunity to capture increased market share and strengthen domestic supply chains. In the aftermath of supply chain disruptions caused by COVID-19 and global tariff policy, 83% of North American manufacturers indicated they plan to re-shore supply chains, which could provide windfalls of $443 billion to the US economy.[12] Government incentives through the IRA and IIJA have clearly outlined the federal government's support to rejuvenate domestic industry and supply lines, supported through an array of tax credits, grants, and procurement mechanisms. A low-emissions pathway to a domestic steelmaking resurgence can support domestic demand, sustain the current labor market, and reduce emissions.

PART 2

THE ECONOMICS OF BREAKTHROUGH STEEL INVESTMENTS

Steelmaking is highly capital-intensive, requiring significant investment in assets with long life spans. A conventional blast furnace–basic oxygen furnace (BF-BOF) mill with a production capacity of 1 Mt costs approximately $1.2 billion to build and operates for decades, with major reinvestment, to the tune of several hundred million dollars, required every 20 years on average to "reline" (renovate).[xvii]



Like most projects with capital-intensive investments, the scale and complexity of steelmaking investments mean that proposed projects are subject to comprehensive techno-economic assessments, with crucial steps such as feasibility studies and front-end engineering design (FEED) studies. A final investment decision (FID) represents a critical point in the investment process, signalling a firm financial commitment upon which contractors can proceed with procurement, construction, design, and engineering plans. FID status, therefore, represents a vital milestone in the realization of a steel project.

2.1 A Process to Progress Breakthrough Steel Investments

To identify and resolve what it will take to reach FID on the first wave of breakthrough commercial-scale, near-zero emissions steel production in the United States over the next five years, RMI launched a US-focused forum series in collaboration with the Energy Transitions Commission (ETC) and with support from Breakthrough Energy. Over the course of four forum discussions, RMI convened players across the steel value chain to discuss the viability of different breakthrough, near-zero emissions iron and steel project developments in the United States. Participants included steel producers, energy and feedstock suppliers, equipment providers, steel buyers, investors, and policymakers; and the conversation was underpinned by a project finance, archetype-based open-access tool that modeled the financial implications of low-emissions iron and steel projects in the United States, which was created by ETC and validated by industry experts.
To aid the forums, six breakthrough iron and steelmaking archetypes were evaluated for brownfield conversion and greenfield locations. The archetypes focused primarily on a renewable hydrogen–direct reduced iron–electric arc furnace (H2-DRI-EAF) technology route given the deep decarbonization potential of the archetype.

Brownfield conversion archetypes

1. **Convert BF to DRI-EAF:** retrofitting an existing BF-BOF site and switching production to DRI-EAF technology. The DRI-EAF is assumed to initially use natural gas for DRI production before switching to green hydrogen in 2030.

2. **Convert BF to DRI-melter:** retrofitting an existing BF-BOF site by switching the BF to a hydrogen-based DRI and melter, or submerged arc furnace, to feed low-emissions iron into the repurposed BOF.

3. **Greenfield DRI and Brownfield EAF:** building a new hydrogen-based DRI to supply an existing EAF facility with low-emissions, hot briquetted iron (HBI).

xvii Mission Possible Partnership, ***Making Net-Zero Steel Possible***, 2022, pp. 29, 59. The precise investment cycle length of a blast furnace depends on its "campaign" (operational) life and operational characteristics.

Greenfield archetypes

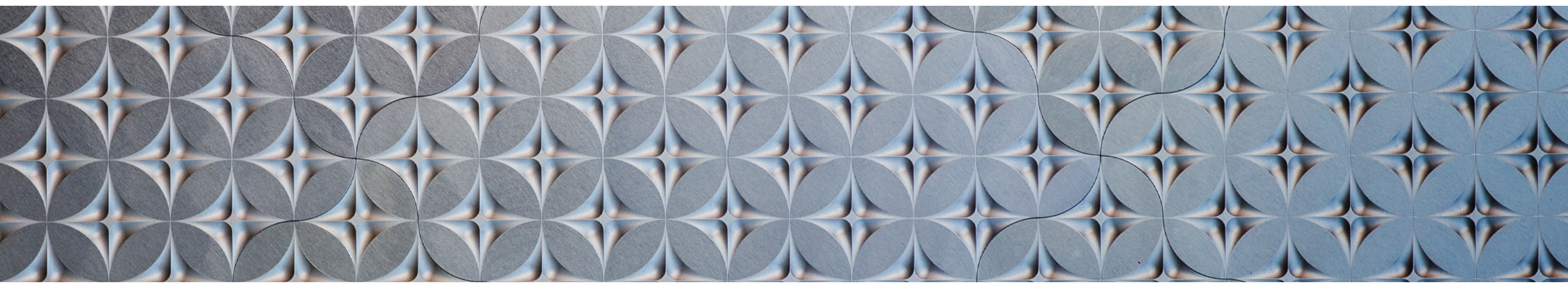
4. **Greenfield H2-DRI-EAF:** building a new integrated DRI-EAF mill, using green hydrogen at a new facility location. The DRI-EAF is assumed to use 100% hydrogen fuel for the DRI from the start of operations.

5. **Imported HBI and Greenfield EAF:** imported hydrogen-based HBI from outside the United States to supply a new US-based EAF that creates low-emissions, domestic steel.

6. **Greenfield Standalone DRI:** building a US-based hydrogen DRI facility, which then supplies merchant green HBI to the global market.

Hydrogen-based iron making was prioritized in this analysis because it is a commercially viable route to realizing the breakthrough near-zero emissions steel production required to change the emissions profile of steel. Although carbon capture on a natural gas DRI is an alternative route that can access government stimulus through the IRA 45Q mechanism, carbon capture technology has yet to be commercially proven at an upward bound (i.e., 90%+ capture rate) and has upstream methane leakage considerations that can erode the emissions profile of the steel product and the United States' progress toward reaching its commitments to the International Energy Agency (IEA) Global Methane Pledge.[xviii]

Accounting for the United States' availability of natural gas, ample existing infrastructure to supply blue hydrogen (natural gas–based hydrogen through steam methane reformation with carbon capture), and recent carbon capture incentives made available through 45Q, the analysis incorporated blue hydrogen as a route to H2-DRI in the model and forum discussion. Due to the direct relationship between blue hydrogen and natural gas commodity volatility, the current elevated global energy market contributes to higher near-term cost for blue hydrogen compared with green hydrogen, which is largely dependent on fixed capital cost assumptions that are projected to rapidly fall under a declining technology cost curve. Blue hydrogen production would rely on carbon capture technology which has yet to demonstrate high carbon capture rates at a commercial level and has fugitive methane emissions, which calls into question the viability of a blue hydrogen route as the most efficient pathway to near-zero steel production.



2.2 Investment under Current US Policy and Market Conditions

Addressing multiple brownfield and greenfield routes to enable breakthrough, near-zero emissions steel production, **the US forum series identified that several project designs were viable under baseline conditions,**[xix] **while strategic market levers can contribute additional project value, improve payback periods and increase project margins across several archetypes modeled**. Exhibits 2 and 3 provide the projected cash flow and earnings before interest, taxes, depreciation, and amortization (EBITDA) over the 20-year project life as well as the respective net present value (NPV) and levelized cost of production (LCOP) of these configurations under current US market conditions.

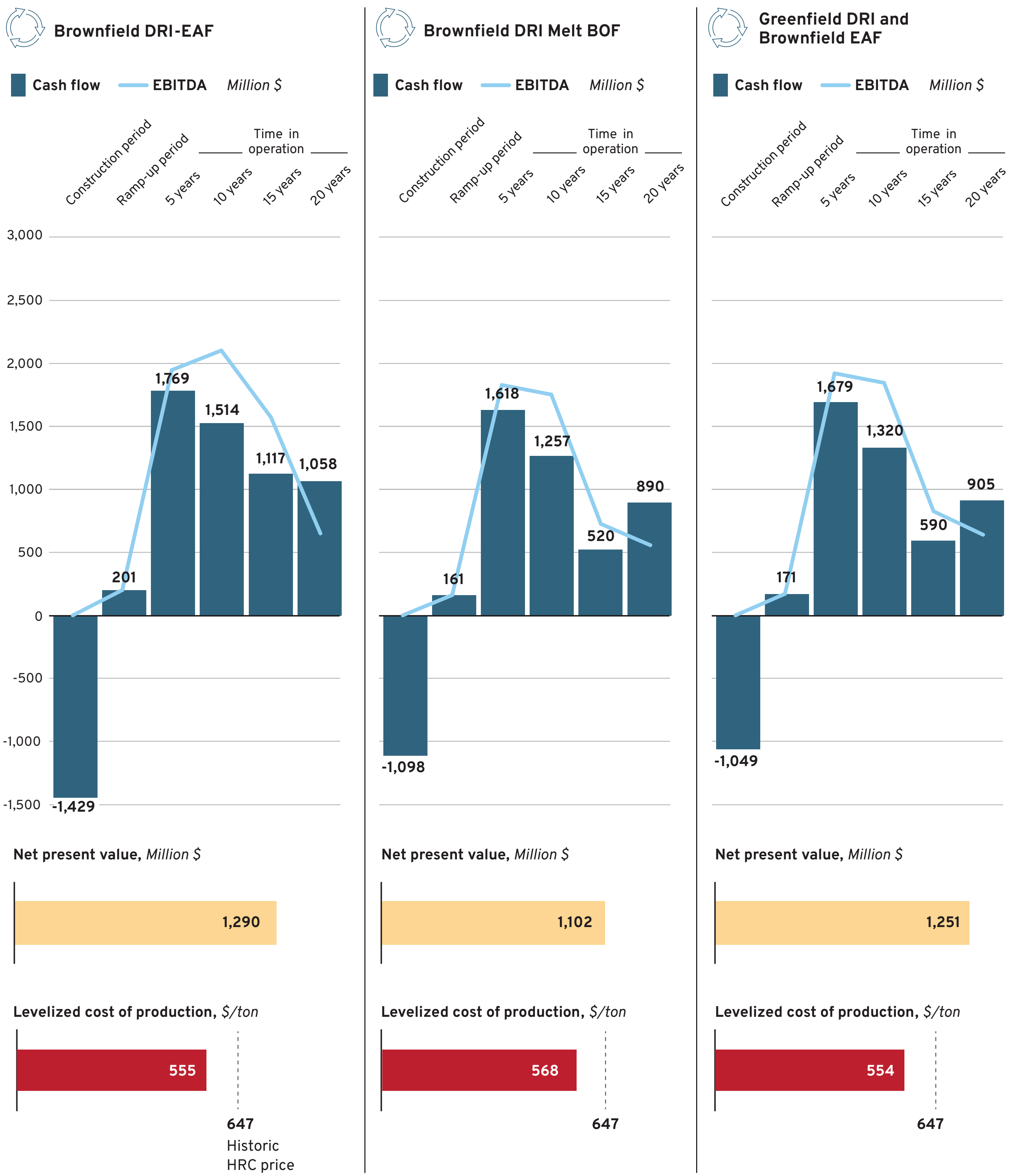
The baseline analysis demonstrates multiple viable routes to low-emissions steelmaking in the United States. As shown in Exhibit 2, all three brownfield archetypes are investable based solely on the current green hydrogen PTC ($3/kg-$H_2$) available under the 2022 US IRA. Archetypes that are more capital-intensive, such as the greenfield H2-DRI-EAF configuration, have a higher initial investment cost but can still realize a competitive project valuation. Beyond the baseline analysis, low-emissions steel projects in the US can improve their business case by leveraging strategic project adjustments, such as capital subsidies for industrial demonstration projects, locations with competitive renewable generation, and low-emissions market premiums.

xviii The IEA Global Methane pledge is co-led by the United States and commits to reduce global anthropogenic methane emissions to at least 30% below 2020 levels by 2030.

xix Baseline conditions assume a 20-year project life for a 2 million-ton-per-year (Mtpa) facility at 90% utilization in the Midwest, with a 20% scrap intake, 10-years of $3/kilogram (kg) PTC for green hydrogen based on dedicated behind-the-meter renewable power, power purchase agreement electricity, and baseline cost assumptions for hot-rolled coil, scrap, natural gas, and DRI. Assuming FID in 2024, capital expenditures reflect a 20-year debt repayment with a one-year grace period, tax depreciation based on the Internal Revenue Service's general depreciation system for 200% declining balance and straight-line methods, and a 30% tax rate.

EXHIBIT 2

Brownfield operational configurations based on baseline case

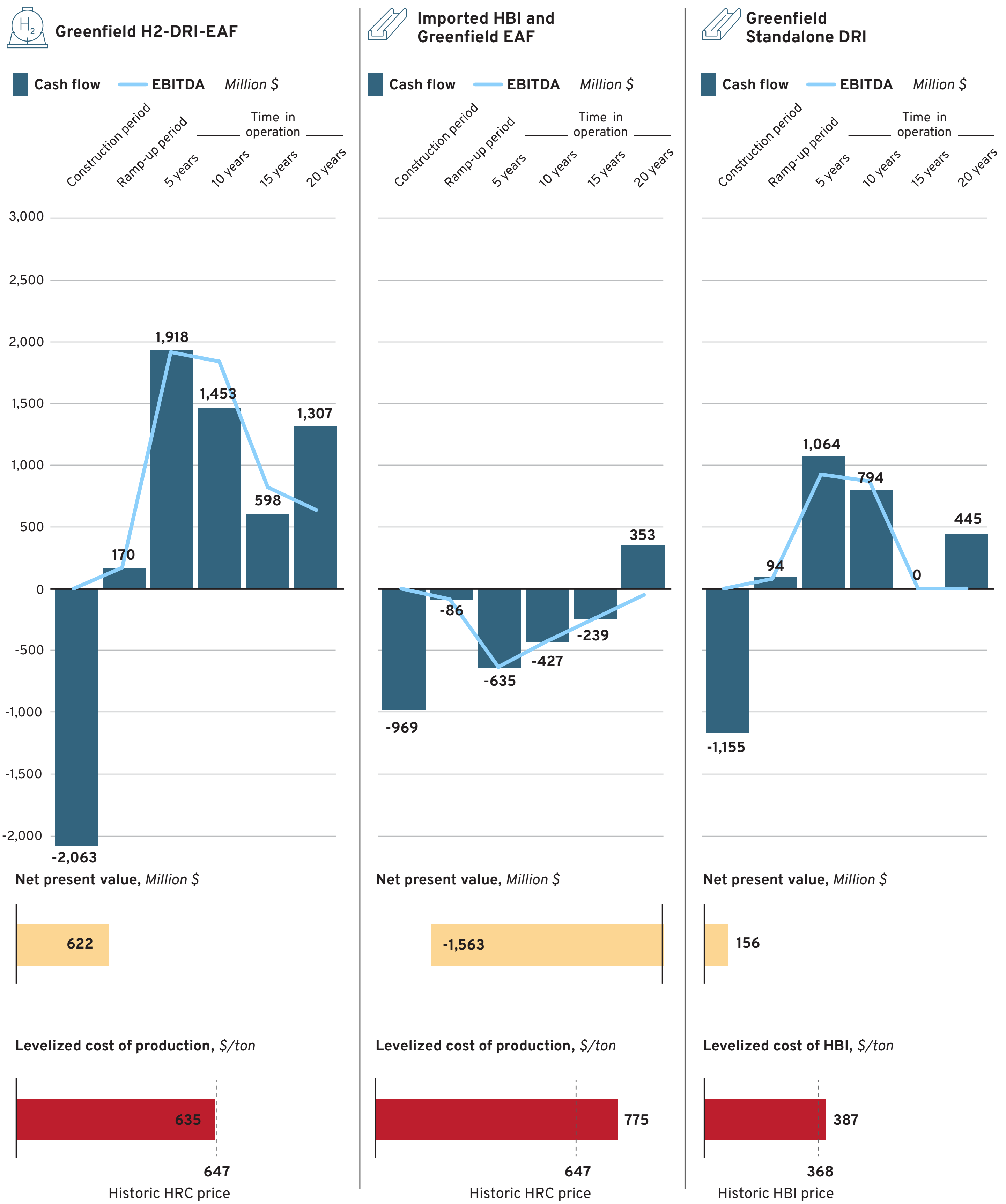


Note: Historic hot-rolled coil (HRC) price is based on the average of 2011–21 prices from UN COMTRADE and World Bank Commodity Price Data; the brownfield DRI-Melt-BOF operational configuration has limited reference points because this configuration has not been widely adopted to date. This baseline analysis has assumed $243 million for the melter capital cost of a 2 million-ton-per-year (Mtpa) facility.

Source: Energy Transitions Commission (in partnership with RMI), Breakthrough Steel Investments Regional Exercise Model.

EXHIBIT 3

Greenfield operational configurations based on baseline case



Note: Historic hot-rolled coil (HRC) price based on average of 2011–21 from UN COMTRADE and World Bank Commodity Price Data.

Source: Energy Transitions Commission (in partnership with RMI), Breakthrough Steel Investments Regional Exercise Model — US Analysis, 2022.

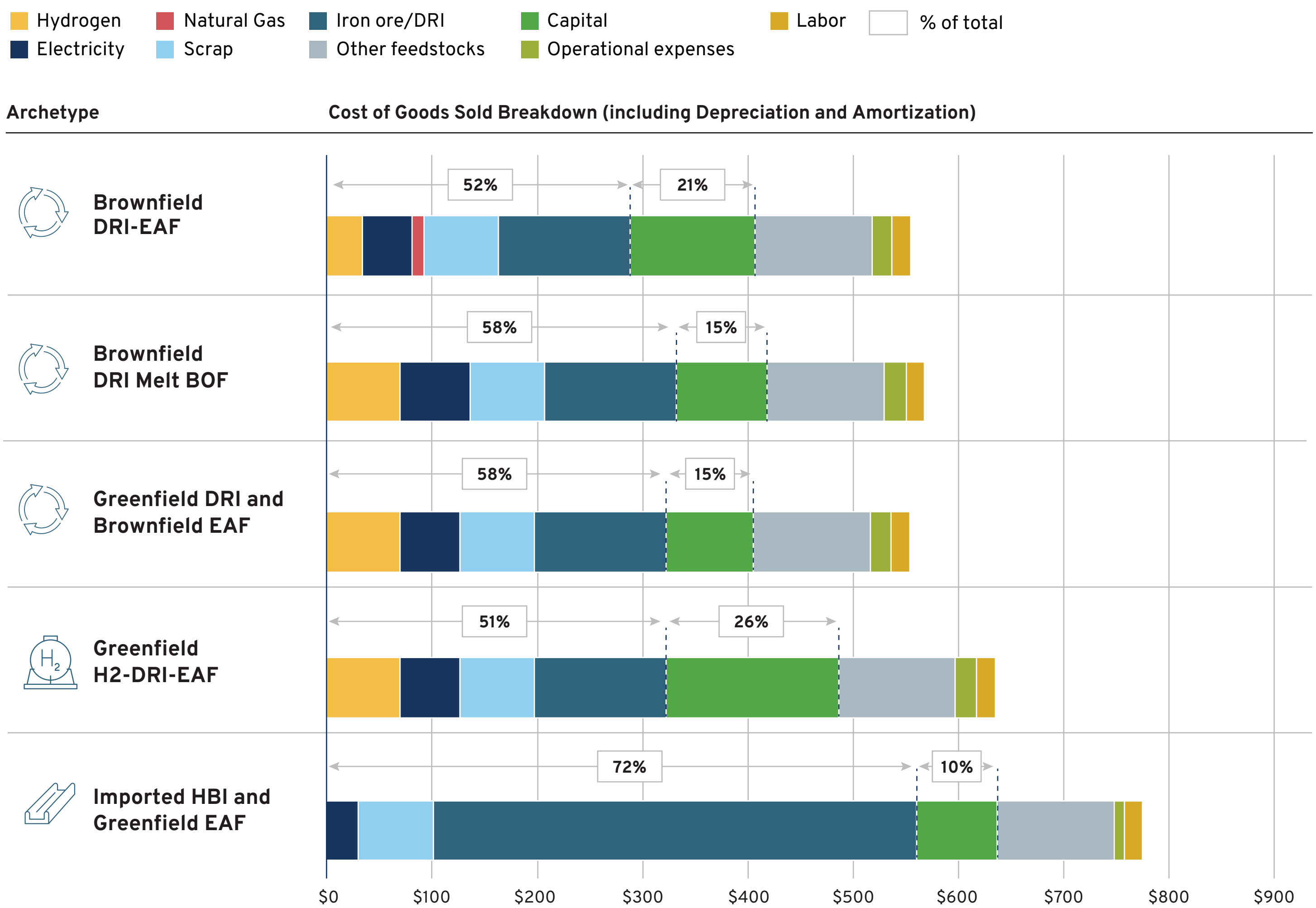
2.3 The Cost Drivers of Breakthrough Steelmaking

Energy, metallics, and capital make up most of the production cost (73%–82%) across all configurations evaluated. As demonstrated in Exhibit 4, these components are key drivers of the project's LCOP and present opportunities to reduce production cost and minimize the project's exposure to feedstock market fluctuations.

Project viability for steelmaking is largely influenced by market forecasts, which will naturally vary over time based on global trade and geopolitical dynamics. To accurately model the current US steel market environment, cost and operational assumptions were vetted with stakeholders across the steel value chain. Addressing the most cost-intensive categories is crucial to improving the business case of corresponding projects.

EXHIBIT 4

Financial breakdown of iron and steelmaking archetypes



Source: Energy Transitions Commission (in partnership with RMI), Breakthrough Steel Investments Regional Exercise Model.

2.4 Potential Levers to Improve the Breakthrough Steel Business Case

Current US policy and market appetite provide multiple opportunities for sustainably focused steel projects to close the financial gap through strategic project design, cost subsidies, and revenue security. A combination of several financial levers lends the potential to improve project returns, reduce project risks, and capture domestic low-emissions steel market share across several production routes. Exhibit 5 outlines several US funding and market tools that were identified in this forum series, including policy, finance, market, project design, and demand levers.

EXHIBIT 5

Financial levers that can impact project viability

POLICY	
LEVER	**DESCRIPTION**
Hydrogen PTC	A production tax credit (PTC) for hydrogen was included in the recently passed IRA. The PTC (45V) is broken down into different tiers based on both labor stipulations and the emissions intensity of the hydrogen produced. The maximum achievable credit is $3 per kilogram of hydrogen produced.
Renewable electricity subsidy	The IRA's 48E and 45Y production and investment tax credits for renewable power generation can provide up to 30% ITC or a $15/MWh PTC if prevailing wage and apprenticeship requirements are met. Additional bonuses of up to 40% can also be realized for meeting domestic manufacturing requirements or developing project locations focused on community equity requirements.
Capital subsidy	Industrial facilities targeting significant decarbonization through testing, demonstration, and deployment can access up to a 50% capital cost share through the US DOE Office of Clean Energy Demonstrations' grants, loans, or cooperative agreements made available through a $5.8 billion Advanced Industrial Facilities Deployment Program created under the IRA.[13] An additional $500 million has been made available for demonstration funding in the IIJA.

FINANCE	
Interest rate reduction	The baseline interest rate assumed in this analysis was 6%; however, a reduced lending rate could be secured through sustainably focused private financing or through the US DOE LPO, which supports innovative clean energy projects.

MARKET	
Hedging feedstock exposure	Securing long-term contracts and hedges for energy and metallics can mitigate exposure to volatile feedstock pricing and manage project cost risk.
Scrap ratio	The ratio of scrap used in steel production can have varying impacts on each archetype based on energy and scrap market pricing. The incorporation of scrap is dynamically managed in real time to optimize the operation's costs.

PROJECT DESIGN	
Timing of FID	Early FID can improve a project's valuation because the project is able to lock in limited, time-sensitive federal stimulus benefits and capture early market share of low-emissions steel revenue premiums.
Strategic location siting	For greenfield projects, selecting a facility location that is close to renewable energy resources can significantly impact the project's energy expenditures.

DEMAND	
Green premium rate	A premium rate for low-emissions steel products (e.g., green premium) will be determined by the market as low-emissions steel is procured and becomes commercially available. In this analysis, a green premium of 10% over historic market pricing for hot-rolled coil steel was added as a potential lever to increase the breakthrough steel project's valuation and profitability.
Green premium volume	The premium rate, along with the volume of the facility's potential product sold at a green premium, will determine the total revenue benefit from low-emissions steel sales.

Source: The United States Congress, H.R.3684 – Infrastructure Investment and Jobs Act, 2021; The United States Congress, H.R. 5376, the Inflation Reduction Act of 2022, 2022; Breakthrough Steel Investment Regional Forum Series – US, 2022.

PART 3

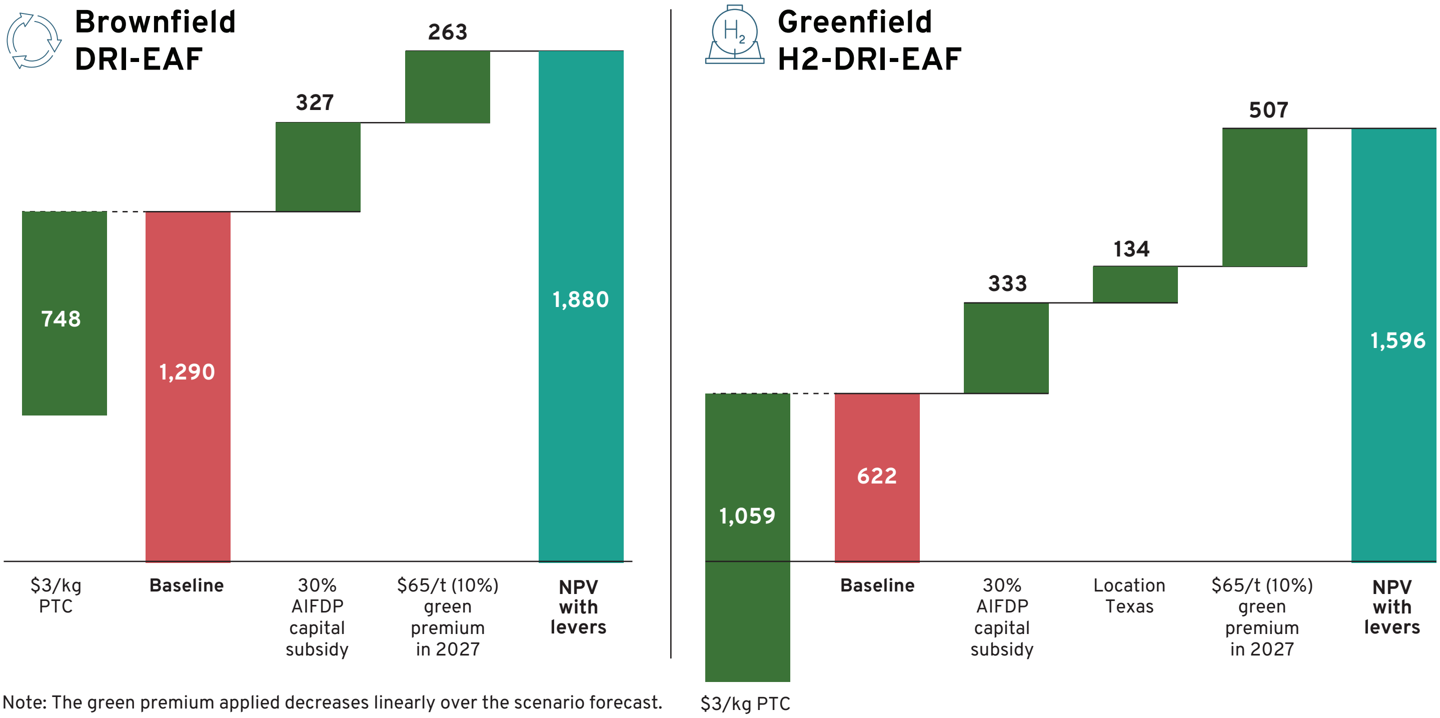
A WAY FORWARD

3.1 Routes to Improve the Near-Zero Emissions Steel Business Case

The $3/kg PTC for green hydrogen included in the Inflation Reduction Act is the most impactful project lever to unlock hydrogen-based iron and steel production pathways in the US. **Combining additional, attainable levers can further improve the valuation and project viability of low-emissions steel configurations in the current US market environment.** Exhibit 6 demonstrates how a combination of a small subset of available cost and revenue levers can improve the project valuation for even the most capital-intensive projects evaluated (e.g., greenfield DRI-EAF). On the cost side, a combination of a $3/kg PTC for green hydrogen, a 30% capital subsidy through the federal Advanced Industrial Facilities Deployment Program (AIFDP) and a strategic location for the greenfield facility were stacked to improve the project's operating cost. The two fully integrated H2-DRI-EAF projects then were assumed to realize a 10% market premium (e.g., green premium), or $65 per ton, for the intial domestic supply of low-emissions hot-rolled coil (HRC).

EXHIBIT 6

US low-emissions steelmaking is competitive under current market conditions, though some archetypes will need more support than others



Note: The green premium applied decreases linearly over the scenario forecast.

Source: Energy Transitions Commission (in partnership with RMI), Breakthrough Steel Investments Regional Exercise Model.

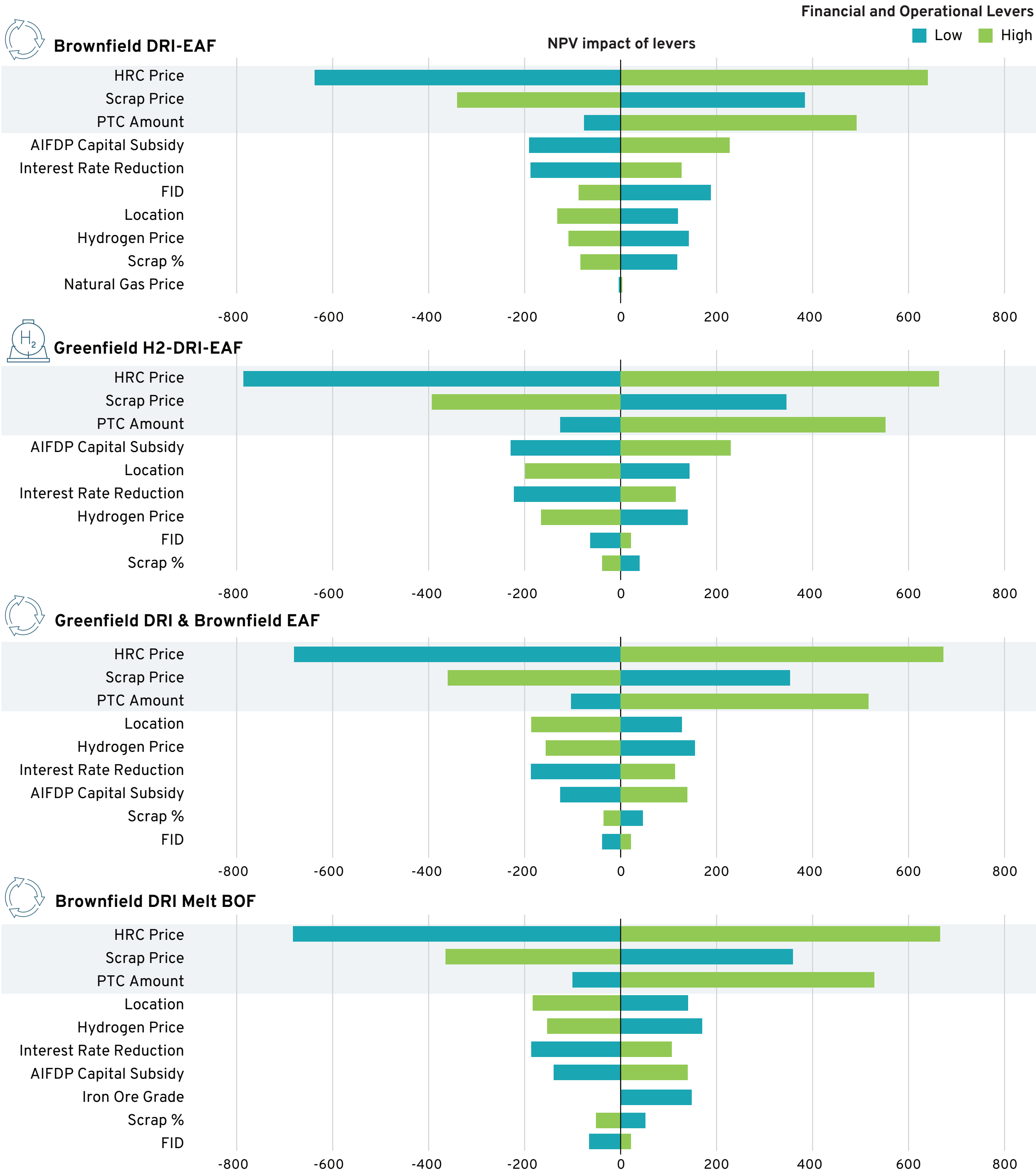
Market pricing can have a material impact on a steel assets' profitability, as demonstrated in Exhibit 7. Several key inputs have the potential to dramatically impact the business case of these breakthrough steel configurations. For example, the HRC price, scrap price, and realization of the hydrogen PTC ($/kg-$H_2$) have the potential to provide material impacts across multiple low-emissions steel archetypes.

Steel producers can take several key steps to minimize their exposure to these market dynamics and de-risk project profitability by securing stable term rates and optimizing available energy subsidies, such as:

- **Metallics pricing.** This sensitivity exercise shown in Exhibit 7 highlights the importance of hedging products and term contracts to manage commodity cost volatility. Securing a clean scrap supply at a competitive rate in line with the facility's design parameters is critical to controlling exposure to scrap prices.
- **Contracted sales.** Accumulating secure revenue and contracted off-take agreements as part of the project planning and de-risking process can have a material impact on the project's ability to secure FID and demonstrate tangible product demand.
- **Hydrogen PTC.** Capturing the highest tax credit tier of the 2022 IRA hydrogen PTC by deploying a 100% green hydrogen DRI facility would provide an early project subsidy that delivers a material benefit to the project's financial viability. Additionally, the use of green hydrogen can allow for a secondary competitive advantage through reducing market exposure and proactively securing hydrogen supply at a stable fixed price due to the capital cost structure of renewable-based hydrogen. This analysis incorporates a behind-the-meter system cost for green hydrogen, integrating capital and operating cost for renewable generation, regional capacity factors, as well as electrolyzer production and storage.

EXHIBIT 7

Consistent high-value levers emerge across archetypes, outlining lever priorities in improving project valuations



Note: The zero-value x-axis scenario represents the cost of a baseline 2 Mtpa integrated steel facility with the following operational and financial parameters; PPA electricity, 20-year lifetime, 1.5 debt-to-equity ratio, 8% internal rate of return, 6% interest rate. This baseline facility represented on the x-axis assumes the following financial levers have been applied; 2% interest rate reduction, 30% AIFDP capital subsidy, 2026 FID, Midwest location, \$1/kg-H_2 PTC amount, 40% scrap, and baseline pricing of HRC, scrap, natural gas, hydrogen, and HBI.

Source: Energy Transitions Commission (in partnership with RMI), Breakthrough Steel Investments Regional Exercise Model.

3.2 Additional Considerations for Achieving FID Status

Several themes and considerations were raised as part of this US forum series that can accelerate or hinder low-emissions steel production progress in the United States. Issues raised and discussed on these key themes and considerations are summarized below.

3.2.1 Public Funding Timelines and Requirements

With the recent influx of new federal funding programs, the opportunities, requirements, and timelines to capture these funds can seem challenging to navigate and prioritize. To assist with assessing the federal opportunities at hand, Exhibit 8 outlines the current US funding programs available for breakthrough steel investment and their respective timelines. For example, the hydrogen PTC sunsets after 10 years, in 2033.

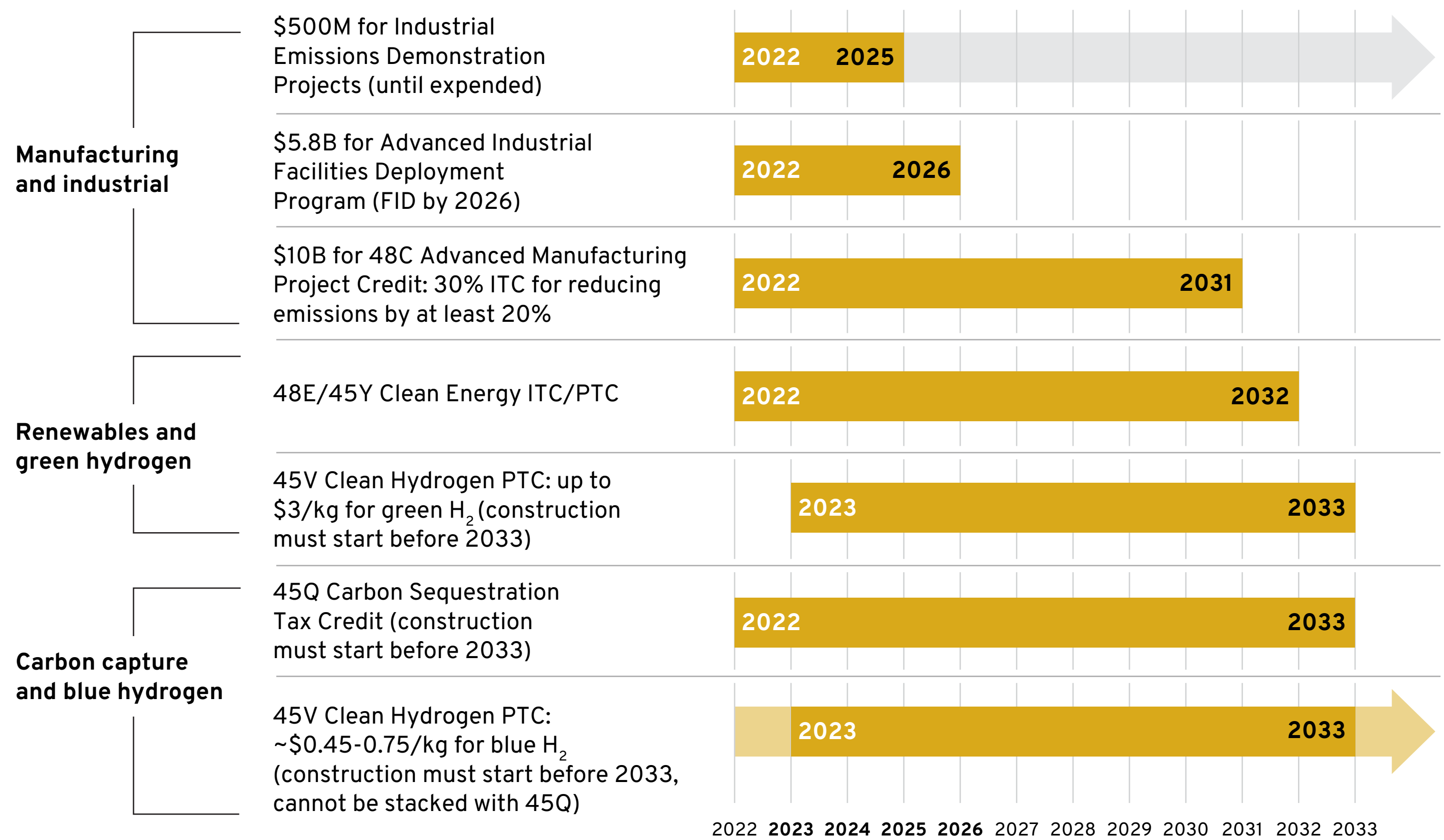
The period between 2023 and 2026 has the greatest potential for securing federal funding support and stacking federal incentives. Most of the current government funding opportunities are tier based, meaning different volumes of funding are made available depending on the project's near-term decarbonization potential, incorporation of specified labor stipulations, and contributions toward advancing energy and environmental justice. Stacking incentives and organizing projects so they can achieve the maximum funding tiers are essential tactics for project developers to realize the most advantageous funding support available for a first-of-a-kind decarbonized iron and steel facility. Projects that delay development will risk leaving valuable subsidies on the table.

3.2.2 First-of-a-Kind De-Risking and Project Structure

Risk mitigation for project investors is a critical aspect in realizing FID for nascent technologies and markets. Distributing project risk can take various forms and occur at different junctions within the value chain. Strategies to

EXHIBIT 8

Federal funding can be maximized by acting swiftly



Note: The funding deadlines portrayed pertain to FID and not project completion.

Source: The United States Congress, H.R.3684 - Infrastructure Investment and Jobs Act, 2021. The United States Congress, H.R. 5376, the Inflation Reduction Act of 2022, 2022.

de-risk breakthrough steel investment and accelerate FIDs include:

- **Funding source diversity.** Investment borrowing risk can be shared among multiple lenders to manage risk exposure in a new technology application or early-stage market — through a syndicated loan product or combination of public and private financing.
- **Market hedging instruments.** Managing cost and revenue exposure to short-term market rates using hedging products and term contracts can also provide a method to reduce project risk.
- **Secure revenue contracts.** Development of stable revenue stream(s) through contracted, or term, off-take agreements for the project's low-emissions steel product can also serve as a measure to de-risk the project's financial performance.

These three de-risking tactics have the potential to accelerate FID. The capital intensity and global market exposure of the steel industry make project de-risking a critical aspect in securing funding for a breakthrough steel project.

3.2.3 Securing Green Upstream Feedstock

Scaling green hydrogen will require multiple components across the value chain, including electrolyzer installations, gigawatts (GWs) of renewable capacity, energy storage, and enabling infrastructure such as pipelines and transmission. Permitting and construction timelines for renewable energy generation, hydrogen production assets (electrolyzers), and transmission infrastructure can be challenging to navigate and will need to be an area of focus for project developers.

Green hydrogen is central to the archetypes evaluated in this analysis and a 2 Mtpa breakthrough steel facility would require approximately 0.1 million tons of green hydrogen a year. Currently, green hydrogen production is limited to very small volumes in the United States (< 0.1 million tons), but this volume is expected to grow significantly this decade. Industry experts project the United States has the market potential to reach up to 6.2 Mt of annual green hydrogen production by 2031.[14] With hydrogen production set to scale rapidly in the United States, it is essential that steel production represents a significant portion of off-take. The emissions abatement potential for hydrogen in the steel industry is greater than many other use cases, and directing this valuable, low-emissions resource to the most effective decarbonization pathways is necessary for the United States to reach its climate goals.

3.2.4 Aggregation of Near-Zero Emissions Steel Demand

Coalescing offtake agreements and aggregating demand for near-zero emissions steel in the United States can act as a mechanism to align market specifications and kick-start sustainable steel production. Present commitments for near-zero emissions steel have been driven by consumer demand, as corporations are leading the way in the private sector by committing to Scope 3 supply chain emissions goals. In the public sector, “buy clean” legislation is bolstering demand for low-emissions building materials and government vehicles, but so far government initiatives have been slow to provide details and timelines on procurement strategies.

For steel suppliers, correlating these vague commitments to tangible production volumes, specifications, and timelines is a critical component to justify asset-level investment and near-zero emissions steel production. Demand aggregation with clear emissions guidance and timelines though consortiums like the First Movers Coalition (FMC) can provide tangible guidelines and expectations for steel providers. Increased participation in coalitions like FMC and coordinated off-take agreements between steel suppliers and buyers will help de-risk the investment for new breakthrough steelmaking facilities while also providing transparency on timelines and costs of securing low-emissions steel.

3.2.5 Common Definition of Low-Emissions Steel Products

A consistent issue across the steel value chain is in how to define low-emissions steel. In 2019, ResponsibleSteel launched its facility-level guidance and then in 2022 launched product-level guidance defining different levels of low-emissions steel.[15] The FMC definition of near-zero carbon steel aligns with ResponsibleSteel’s approach where emissions intensity requirements decline as the scrap ratio increases.[16] Yet, newer coalitions such as the Global Steel Climate Council are pushing back against this approach,[17] advocating that a flat emissions intensity guidance across scrap volume is more appropriate. Other organizations such as the American Iron and Steel Institute and the US Buy Clean Task Force also have begun to weigh in on product-level steel guidance.[18] Resolution to conform to a common global definition of low-emissions steel can provide consistent market guidance on emissions intensity guidelines to inform product and asset development, streamline buyer procurement, and accelerate the low-emissions steel market. The analysis provided in this report modeled low-emissions steel that meets or exceeds carbon intensity requirements of all product-level guidance referenced above.

PART 4

CONCLUSIONS AND RECOMMENDATIONS

Analysis of the United States' federal funding opportunities and market appetite for green steel supply demonstrates the potential to unlock FIDs across several brownfield and greenfield configurations for low-emissions steel production in the United States. Multiple brownfield and greenfield production routes were modeled to reach a positive project valuation with the support of the current green hydrogen PTC. The use of additional financial levers, such as a 30% capital subsidy through current Office of Clean Energy Demonstration funding opportunities and a green premium can unlock additional project value and margin for the first near-zero emissions steel projects in the United States across several archetype designs. As demonstrated in Exhibit 9, a green premium of 10% above historical HRC market prices can provide added project revenue that increases the project's overall cash flows and provides between $250 million and $650 million in project present value, depending on the steel archetype.

Realization of FID for breakthrough near-zero emissions steel production in the United States extends beyond financial metrics alone and will require continued collaboration across the value chain to secure infrastructure, offtake agreements, and project timelines that capture the available federal stimulus for low-emissions industrial production. This forum series has identified four key prerequisites for low-emissions steel producers and buyers as the US region embarks on the initial facilities to decarbonize US steel production.

EXHIBIT 9

Steel archetypes are positioned to reach FID in the US, with additional market and policy support to accelerate the transition to near-zero emissions production

	BROWNFIELD CONFIGURATIONS			GREENFIELD CONFIGURATIONS	
	Brownfield DRI-EAF	**Greenfield DRI and Brownfield EAF**	**Brownfield DRI Melt BOF**	**Greenfield H2-DRI-EAF**	**Greenfield Standalone DRI**
Baseline NPV, million $	1,290	1,251	1,102	622	156
Payback period, years	6	5	7	10	10
LEVERS TO IMPROVE BUSINESS CASE					
Capital subsidy (30% capital from AIFDP)	✓	✓	✓	✓	✓
Optimized for renewable resources (Texas)				✓	✓
Market green premium ($65/ton in 2027: 10% premium from historical HRC price)	✓	✓	✓	✓	✓
Improved NPV, million $	1,880	1,903	1,762	1,596	1,000
Payback period, years	5	4	6	8	7
Difference between baseline NPV and improved NPV	+590	+652	+659	+974	+844

Note: The green premium applied decreases linearly over the scenario forecast. For the Greenfield Standalone DRI which produces green HBI, this $65/ton premium in 2027 translates to a 17% premium on historical DRI price.

Source: Energy Transitions Commission (in partnership with RMI), Breakthrough Steel Investments Regional Exercise Model — US Analysis, 2022.

1. **Build partnerships across the steel value chain to mitigate carbon transition risks and secure green infrastructure access.** The transition to low-emissions steel requires a shift across the entire value chain. New infrastructure must be developed to provide low-emissions energy (e.g., renewable power and hydrogen), new steel assets will need to be funded and constructed, and buyers will have to reimagine procurement practices to prioritize product sustainability. The inclusion of multiple parties in these breakthrough steel projects holds an opportunity to diversify risk among the various partners that have a vested interest in realizing the transition to low-emissions steel. Economy-wide decarbonization and risk sharing is materializing across emerging hydrogen and industrial hubs throughout the United States, where diverse consortiums provide opportunities to scale new, green infrastructure across multiple industries and benefit from complementary demand patterns. As renewable hydrogen capacity ramps up, steel producers and upstream material providers (i.e., iron ore and energy partners) can help facilitate and direct green hydrogen production and infrastructure by becoming involved in industrial hubs early and committing to incremental hydrogen off-take volumes over time.

2. **Optimize federal funding opportunities.** Recent federal legislation provides a unique and significant funding opportunity for breakthrough steel investment, but there is a limited window of time to optimize the funding available as some of the funds sunset as early as 2026. Because new information is continuously released on programmatic requirements and timelines of these new government funding programs, industrial projects looking to capture these funds will need to stay engaged, agile, and informed to move quickly and capitalize on these unique and fast-paced funding opportunities.

3. **Seek out public and private sustainable-focused funding routes.** Tapping into funding sources that are focused on sustainable investment can be a resource for breakthrough

near-zero emissions steel production to access capital as well as capture lower interest rates and better lending terms. In addition to environment, social, and governance–focused investment funds, climate private equity and dedicated innovation funds continue to emerge across the funding landscape to provide preferential access and terms on sustainably focused investments. Government-backed loans can also serve as an access point to competitive financing through the US DOE LPO. In addition, recent steel-sector efforts such as the Sustainable Steel Principles and Climate Bonds Initiative[19] — which aim to align lending to low-emissions production — demonstrate the financial industry's shift in lending risk analysis which will shift capital flows toward near-zero emissions steel investments.

4. **Send firm, clear market signals through low-emissions steel procurement.** Despite ample memorandums of understanding and public low-emissions procurement goals, the market's grasp of tangible demand volumes, material specifications, green premiums, and timelines are still unclear. Firm procurement signals (e.g., aggregated requests for proposals that detail these requirements) from steel buyers are required to kick-start the domestic near-zero emissions steel market and support the construction of the United States' inaugural low-emissions steel mill. Coordinated aggregation of buyer procurement will most likely be necessary to accumulate sufficient demand to support a low-emissions steel product facility. Buyer coalitions can serve as a powerful platform to aggregate demand across sectors.

The US near-zero emissions steel market is at the precipice of breakthrough steel investment to quench buyers' mounting demand. Every player in the value chain has a role in realizing FID for breakthrough steel investment that will kick-start the United States' near-zero emissions steel market, and the time to start is now.

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RMI is an independent nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all.

Energy Transitions Commission

The Energy Transitions Commission is a global coalition of leaders from across the energy landscape committed to achieving net-zero emissions by mid-century.