# From gray to green

How to build a competitive green steel business.

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# Contents


03
Executive summary

05
**Rising** demand for green steel

09
**Reinventing** how data, AI, IT and OT are designed and deployed

11
**Transforming** ways of working

14
**Securing** a robust, cost-effective supply of scrap metal and renewable energy

17
**Renewable** energy

19
Green steel presents **a unique opportunity**

# Executive summary

## The steel industry is shifting from gray to green. With clients in the energy, construction, automotive industries and beyond committing to net zero, demand for green steel is rising fast.

In response, steel manufacturers are investing billions to replace their decades-old blast furnaces (also known as basic oxygen furnaces or "BOFs") with direct reduction of iron (DRI) using hydrogen and electric arc furnaces (EAFs). EAF steel production is already soaring, and it's expected to increase by a further 80-100% by 2050.[1] Regulations like the European Green Deal and the EU's Carbon Border Adjustment Mechanism (CBAM) could further accelerate this shift.

But there's a catch. EAF projects are currently concentrated in Europe and North America. For companies in these markets to compete against rivals in China and India, where BOF steelmaking remains prevalent, they need to start generating sufficient quantities of green steel at much lower costs.

That's easier said than done. EAFs do offer several operational advantages over BOFs, such as greater potential to plan and standardize maintenance. And they provide flexibility to ramp operations up or down depending on customer demand and market conditions.

**But the switch to EAFs also presents significant challenges, including:**

- Integrating the new batch-based EAFs with legacy downstream steel-making assets that follow continuous manufacturing processes
- Moving to scrap metal as a feedstock, and managing huge variance in quality, supply and cost
- Securing renewable electricity and green hydrogen in sufficient quantities and at competitive prices.

Addressing these challenges means navigating a difficult learning curve. Steel makers have no time to spare, because they must meet customer demands for certain properties of steel at the right price, while using entirely different production processes and feedstocks. It's an extremely tall order.

**Overcoming these challenges and designing for the future is mission-critical. Specifically, companies must:**

- Reinvent how data, AI, IT and OT are designed and deployed right across the organization. Unless steel manufacturers upgrade their broader technology in parallel with the EAF implementation, there's a risk that they'll invest billions in new furnaces, only to find that the plant is obsolete by the time it's up and running.

- Transform ways of working by reimagining their approaches to planning, logistics, quality management, maintenance, safety and more.

- Secure a robust, cost-effective supply of scrap metal and renewable energy—the two main components necessary for producing green steel. This includes managing variable quality, supply and price in the highly fragmented scrap metal market, and seeking greater engagement with the energy ecosystem.

The bottom line is that the shift to green steel is a game-changing opportunity for steel manufacturers to transform competitiveness. Right now, companies are focusing closely on which furnace to buy. However, since DRI and EAF are sourced from a handful of suppliers, the implementation of these technologies provides limited scope to gain competitive advantage. Instead, steel manufacturers must look at the bigger picture and contemplate how they will use technology more broadly to drive competitive differentiation in the next generation of the steel industry. That's the far more exciting—and challenging—prospect.

# Rising demand for green steel

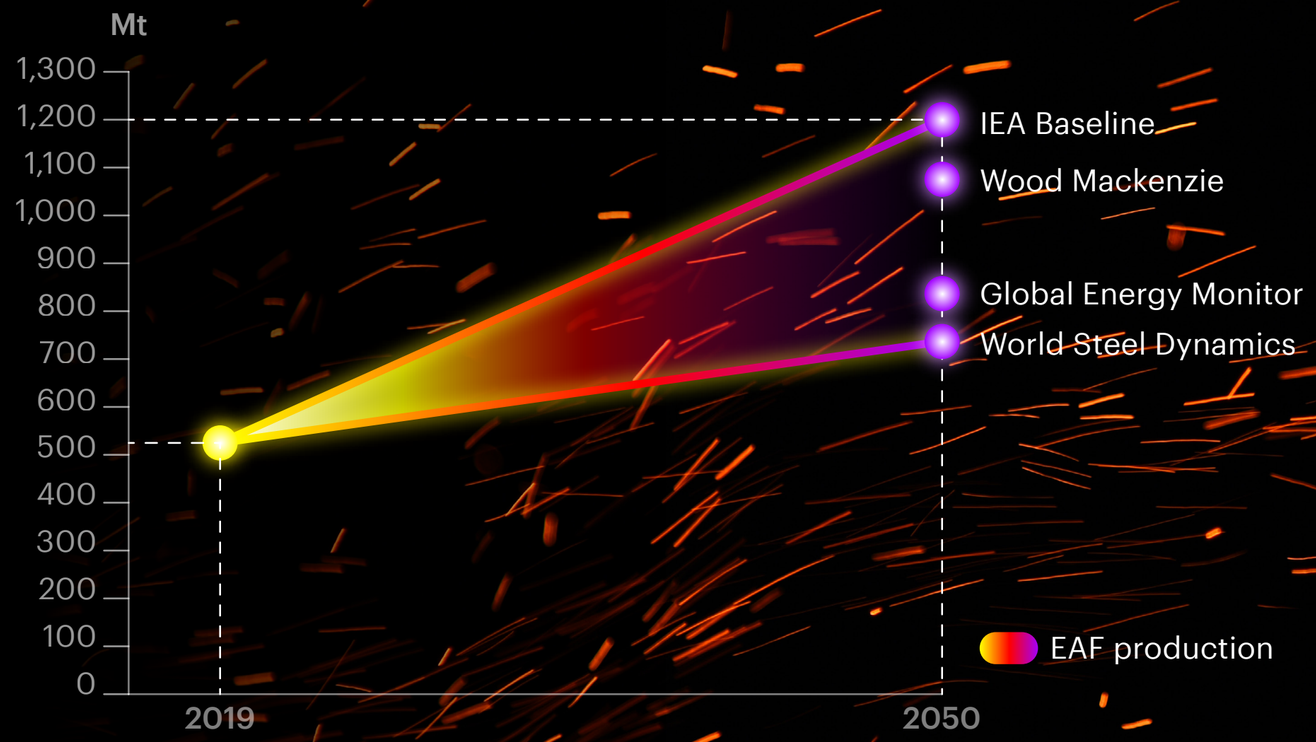
Most companies that purchase steel have committed to reaching net zero. But they'll only be able to achieve these targets if they can buy sufficient quantities of green steel at competitive prices.

## This has prompted the steel industry to transform—especially in the EU. Steel manufacturers are investing billions to move from BOFs to DRI using hydrogen and EAFs. This shift may accelerate further with regulations like the European Green Deal and CBAM.

Globally, 110 new EAF projects with a combined value of $95+ billion were announced between 2020 and 2022.[2] And EAF steel production is projected to rise higher still, increasing a further 80-100% by 2050 (see figure 1).

So far, most EAF projects are concentrated in Europe and North America. This poses a tough question for steel manufacturers in these markets: How can they compete against rivals in places like India and China, where BOF steelmaking remains prevalent?

**Figure 1: Projected growth of EAF steelmaking, 2019-2050**



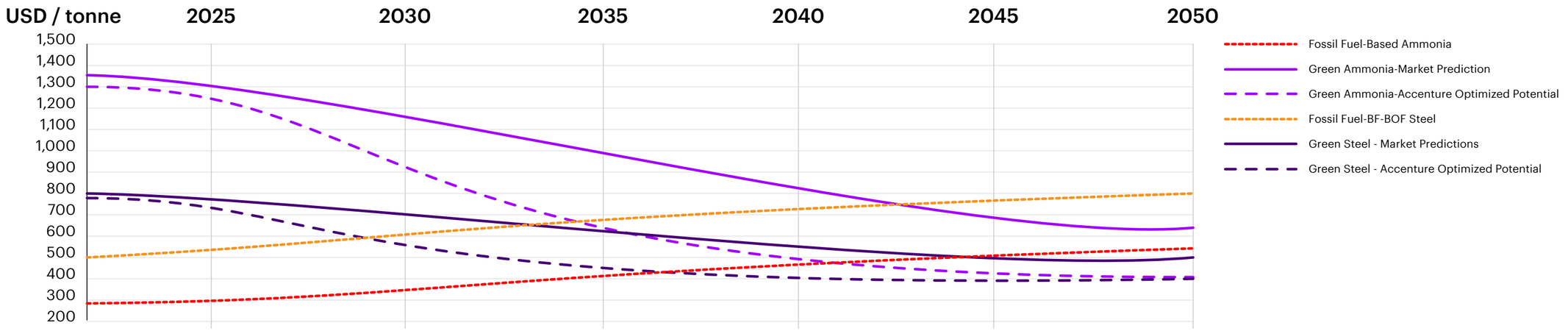

Sources: World Steel Dynamics "Strategic Insights from World Steel Dynamics" February 2021; Global Energy Monitor 2022" Pedal to the Metal" June 2022; Wood Mackenzie, Q3 2022; IEA Iron and Steel Analysis 2022

## EAF: Not as easy as ABC

**The transformation to EAFs brings a series of challenges, including:**

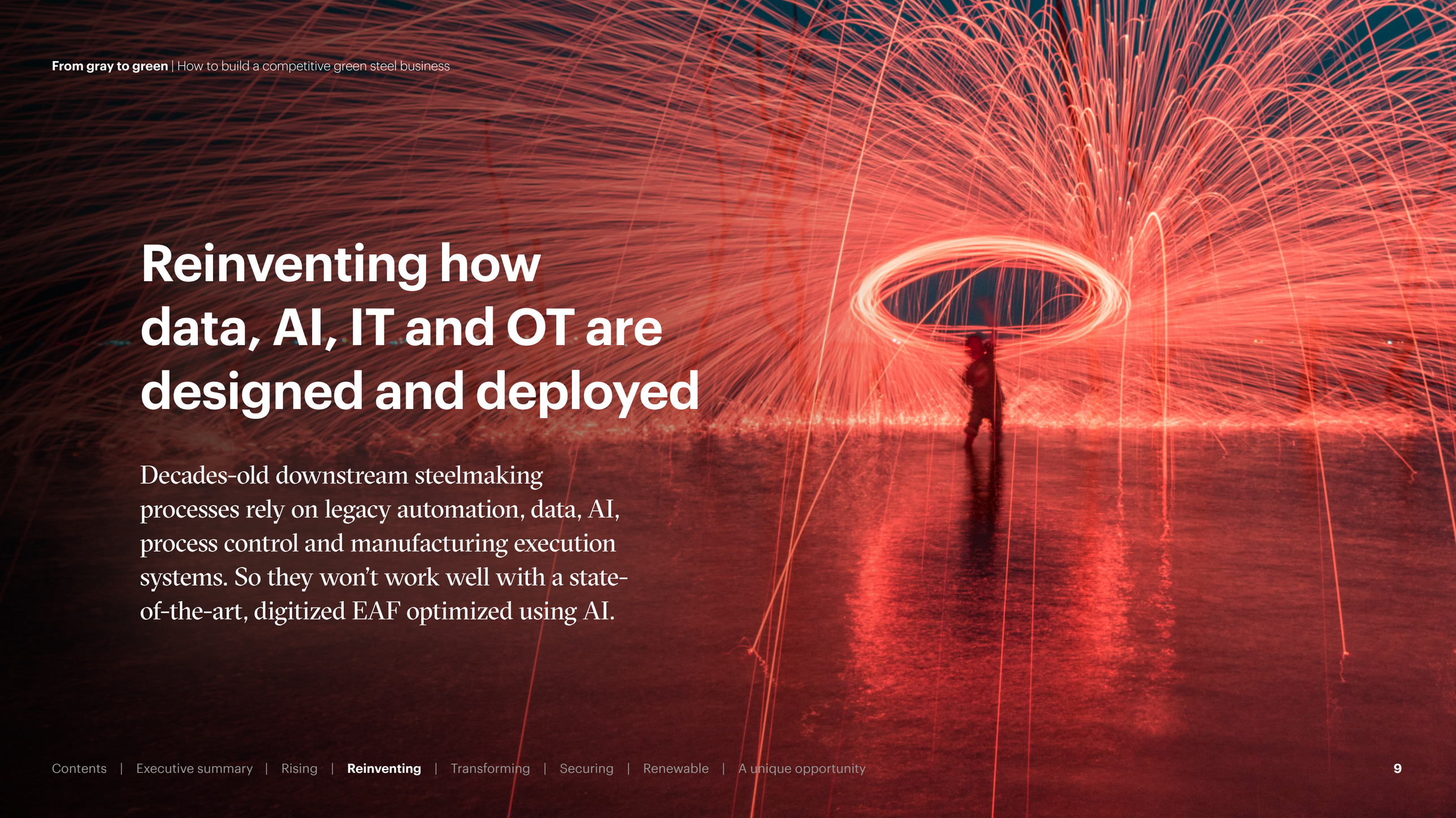
- Integrating the new batch-based EAFs with legacy downstream steel-making assets that follow continuous manufacturing processes.
- Moving to scrap metal as a feedstock, and managing huge variance in quality, supply and cost.
- Securing renewable electricity and green hydrogen in sufficient quantities and at competitive prices. Electricity already accounts for 15% to 20% of the total cost of steel production in an EAF.[3] This challenge is particularly acute in Europe, where the availability of affordable clean energy could rise or fall—either accelerating or blocking the shift to EAFs.
- Ramping up new assets and accelerating the learning curve so that mills can produce the same steel qualities using an entirely new feedstock and very different production processes.
- Transforming the cost structure to achieve a step change in global competitiveness. Decarbonization can be very expensive. But we've developed an action plan that shows how strong collaboration, a robust digital core and new ways of working can decarbonize heavy industry and achieve price parity for technologies like green steel, green hydrogen and renewable energy four to nine years earlier than current market estimates (see figure 2).

**Figure 2: Driving price parity for green products over time**




| | 2024 - 2026 | 2027 - 2035 | 2036 - 2045 | 2046 - 2050 |
|---|---|---|---|---|
| Outcomes | | Unlock initial innovations and economic momentum to trigger prices falling down the S-curve. | Realize rapid efficiency gains across investment cycles, with a diversity of technologies including renewables, nuclear and CCUS. | Fully scale at price parity and beyond; simultaneously deliver growth and decarbonization. |
| Actions | Ready the digital core and workforce.<br><br>Implement actions to lay foundation for achieving outcomes. | Scale green products and services.<br><br>Invest in first phase of power and heavy industry low-carbon infrastructure. | Undergo three to four major investment cycles, across low-carbon power and hydrogen, and low-carbon industrial infrastructure, with each cycle bigger than the last. | Scale to net zero with further efficiency gains passing through to the end consumer. |

Source: Accenture S-curve modeling, Powered for change.



# Reinventing how data, AI, IT and OT are designed and deployed

Decades-old downstream steelmaking processes rely on legacy automation, data, AI, process control and manufacturing execution systems. So they won't work well with a state-of-the-art, digitized EAF optimized using AI.

Obviously, running the value chain based on the limitations of the legacy downstream operations isn't an option. Producing the right steel qualities at competitive prices requires steel manufacturers to navigate a fast-learning curve by transforming operational technology (OT) to optimize for DRI and EAF and downstream steelmaking in an integrated way.

Unless companies seize the opportunity of an EAF implementation to upgrade their broader technology, there's a risk that steel manufacturers will invest billions in new furnaces, only to find that the plant is obsolete by the time it's up and running.

**The reinvention of technology should encompass:**

- **Connecting all data** and eliminating siloes by creating a cloud-based solution where data on EAFs, feedstocks, customer orders, manufacturing operations and more are contextualized to run predictive quality analysis, optimize throughput and dynamically manage bottlenecks. This enables data-driven optimization across the end-to-end plant.

- **Analytics and AI to power real-time decision-making** and quality management.

- **Instrumentation across information technology systems and operational technology systems (IT/OT integration)** to connect tasks like demand planning to operations.

- **Automation** using sensors and other Internet of Things (IoT) technologies.

- **ERP**, because new technologies like AI can't run properly on outdated ERP systems. It would be like trying to run a state-of-the-art 5G smartphone on the telecoms infrastructure from 30 years ago. In addition, it's worth exploring the modules in SAP S/4HANA that can support the transition to EAFs, such as raw material management (for scrap metal) and energy management.

# Transforming ways of working

Most steel furnaces and rolling units are around 30-50 years old and companies have spent decades optimizing their operations. Investments in new DRI and EAF equipment create a once-in-a-lifetime opportunity to reinvent the ways of operating.

## This transformation is necessary, because:

- With an EAF, inbound logistics become much more complex, as companies require much larger volumes of scrap metal. Sourcing the right quantity and quality of scrap metal is one challenge. But it's even more important to predict the quality of scrap and adapt the furnace and downstream process settings to produce the right steel qualities. The operative steering of the steel process from scrap to finished product requires new ways of collaborating across units and functions, new capabilities and new roles.

- The planning process will become more dynamic. Combining batch-based DRI and EAF with continuous process steel-making requires more dynamic scheduling. In addition, companies gain flexibility to ramp operations up or down depending on customer demand and market conditions. So, a scheduling platform covering the full material flow from scrap to DRI/EAF to downstream steelmaking with dynamic bottleneck management and scenario planning is critical to mitigate the impact of unplanned downtime, and manage discontinuities between batch and continuous process steps.

- Quality management shifts from an established process honed over decades to a far more dynamic approach. Now, steel manufacturers must develop new techniques for testing and ensuring the quality of finished products. Furthermore, they must develop ways to predict the quality and alloys of each batch of scrap metal in real time, to determine which grades of steel it's best suited to producing.

- There's far greater potential to plan, pool and standardize maintenance on EAFs compared to BOFs. This can cut costs and prevent unplanned downtime.

- The shift to DRI requires new safety standards, as steel manufacturers will need to produce and handle hydrogen—an extremely explosive, volatile molecule. New plants will require a dedicated workstream to manage safety.

**New investment creates an opportunity to achieve a new performance frontier in cost competitiveness, by:**

- Reducing labor through mechanical automation, shifting tasks from the field into the control room, and enabling remote supervision and control of production.
- Standardizing work, tasks and job profiles.
- Setting up flexible pools of workers to manage peak workloads, by creating centers of expertise to bundle critical skills and generate economies of scale.

Transforming work, ways of working, roles and organizational structures is essential to implementing future-ready steel operations. The best approach is to start reimagining the plant from the ground up with a clean slate, rather than trying to copy-paste existing ways of operating and look for incremental improvements.

# Securing a robust, cost-effective supply of scrap metal and renewable energy

The switch to DRI and EAF drives a fundamental change in cost drivers—from coal and iron ore in BOFs to scrap metal and renewable energy. Investments in both of these areas are necessary to produce green steel at competitive prices, but they force steel manufacturers to make tough decisions about how best to allocate capital.

## Scrap metal

**EAF steel production requires roughly 6X greater quantities of scrap metal compared to the BOF method, and the quality is much more important.[4] This means that steel manufacturers moving to EAFs need a strong strategy to ensure they have the right volume of scrap at the right time and at the right price.**

But this is easier said than done, because the scrap metal industry is dominated by small, local suppliers. This market fragmentation has resulted in unreliable and opaque supply chains, unlike what steel makers and iron ore miners have achieved. Steel manufacturers using EAFs often source scrap metal from hundreds of small scrap yards.

Another challenge is significant regional variation in the availability of scrap metal. China, the largest scrap-generating country, does not export scrap, whereas the US, EU and Japan are net exporters of scrap. However, as scrap demand grows (fueled by increasing EAF steel production) and the pressure to reduce emissions intensifies, these countries may restrict exports to meet domestic needs.

Additionally, the quality of scrap metal varies significantly, whereas with iron ore and coal, it's relatively standardized. This is a key consideration, because the alloys present in each batch of scrap metal determine its suitability for particular use cases.

And although some clustering can be done in advance—for example, construction metal scrap is likely to have specific properties—most scrap metal is essentially a "black box" of unknown quality. Steel manufacturers that are able to predict and identify the properties of different batches of scrap metal in real time will be able to standardize and optimize the quality of the steel slabs they produce. And this is a powerful competitive differentiator because it dramatically cuts costs.

The bottom line is that scrap metal has become a strategic priority. Steel manufacturers have become accustomed to raw materials for production always being available. But as competition for scrap metal increases and geopolitical tensions simmer, that won't always be the case. If steel manufacturers wish to stay in control of their costs and production capacity and position themselves for future success in a net-zero world, they must treat scrap differently.

**Forward-thinking steel manufacturers are already exploring radical new approaches to ensure they have reliable access to scrap metal with defined quality and predictable volumes. This includes developing new ways of partnering with suppliers and clients, and using data integration and platforms to gain transparency of scrap metal quantities, qualities and origins. Some companies are:**

- Building partial backward integration by purchasing scrap metal yards and recycling companies to achieve stronger vertical integration, reduce dependency on third-party suppliers, shore up supply and create flexibility.

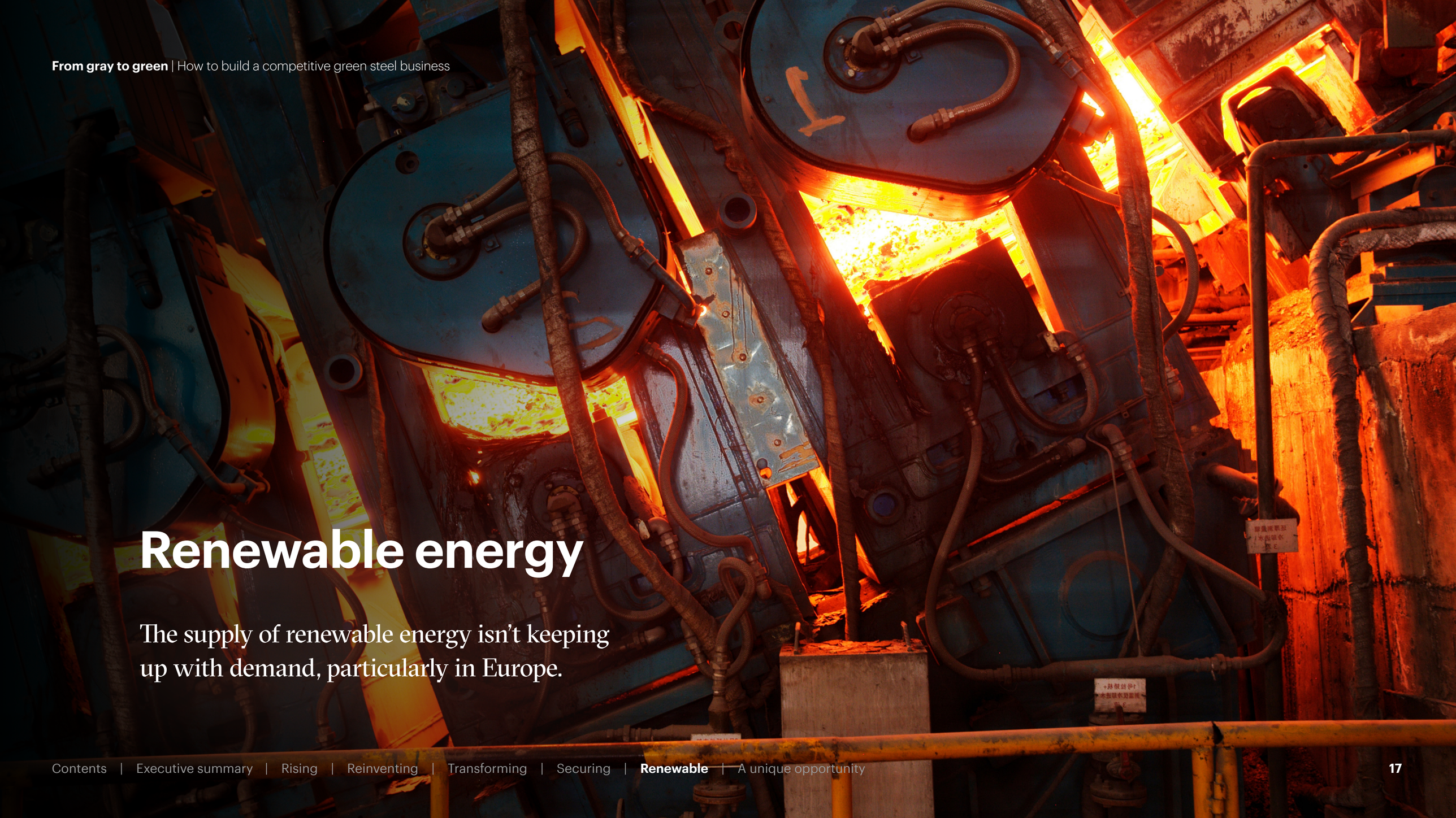
- Shifting from selling steel to leasing it, so the scrap metal is returned to the steel manufacturer at the end of the lifecycle.

- Entering into buyback agreements whereby steel manufacturers purchase prompt scrap from their clients (also known as prime scrap or new scrap, prompt scrap is residual metal from large-scale industrial manufacturing that hasn't yet reached the marketplace).

- Creating new business models, such as a service model for handling prompt scrap.

- Forming partnerships with recyclers to build and operate shredding and sorting facilities that keep scrap in the vicinity of the EAF site and create arbitrage opportunities on both price and availability of different scrap grades.

- Preparing for the creation of a global scrap trading digital marketplace where suppliers, especially local scrap yards and scrap and waste managers, can sell scrap with transparency on volume, quality and price.



# Renewable energy

The supply of renewable energy isn't keeping up with demand, particularly in Europe.

By 2050, the energy requirement for the cement, steel, EV and chemical industry in Europe will reach 6,130 TWh. This is the equivalent of 836 nuclear plants, 0.07 million sq. km. of photovoltaic solar panels (the size of Ireland), or 0.5 million square kilometers of onshore windmills (the size of Spain).[5] It's an alarmingly wide gap between demand and supply.

Some industries are taking action by investing in their own energy sources—for example, the chemical industry has acquired significant equity shares in offshore wind parks. Steel manufacturers must also plan for a foreseeable shortage of renewable energy. If they don't, meeting short-term renewable energy needs may become so costly that EAF operators will need to sacrifice profit margins, or shut down operations temporarily until energy prices fall. Energy procurement and energy strategy will need to be a big factor for metals companies as they look to the future of EAF usage.

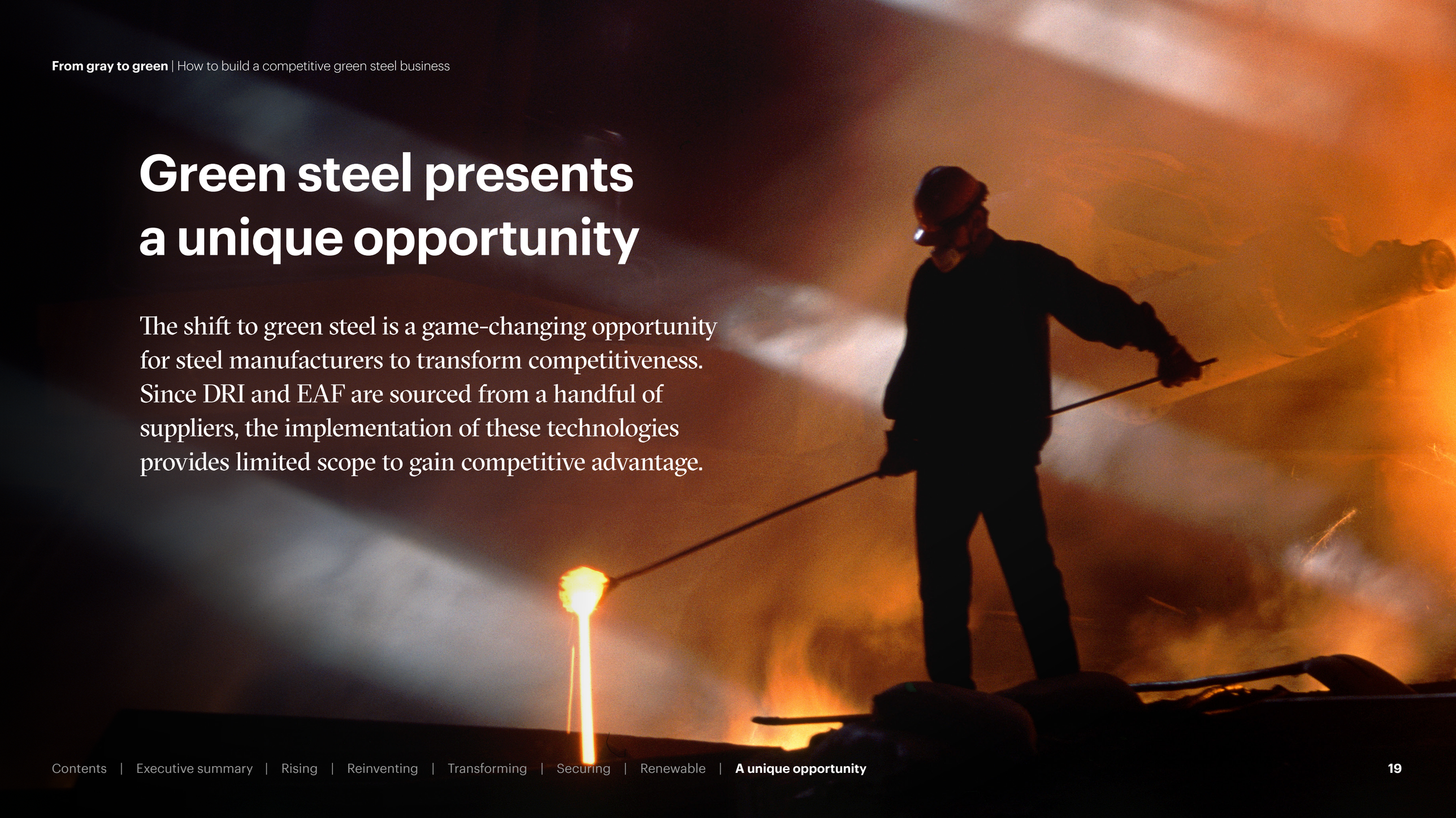
One solution is for steel manufacturers to engage more with the ecosystem around energy management. This includes forming agreements with grid operators and governments to ensure they have the power they need, and backward integration by investing in equity shares of offshore wind production. Compromise may be necessary—for example, some clients have negotiated greater access to nuclear power during periods when weather conditions don't allow for generation of solar or wind power. But in exchange, they need to slow down production temporarily, to ensure sufficient power remains available for other grid users.

Demand for energy is so high that companies are also exploring the option of collaborating with utilities and organizations that generate energy, such as small modular reactors (SMRs).

Whichever course of action they take, now is the time for steel manufacturers to negotiate for reliable energy supply at a good price.

# Green steel presents a unique opportunity

The shift to green steel is a game-changing opportunity for steel manufacturers to transform competitiveness. Since DRI and EAF are sourced from a handful of suppliers, the implementation of these technologies provides limited scope to gain competitive advantage.



## Instead, differentiation will come from mills' success in:

- Designing for the future by extracting the full value from data, AI, GenAI and automation.
- Transforming ways of working to optimize for EAF and DRI .
- Sourcing a reliable, cost-effective supply of scrap metal and renewable electricity.

In other words, steel manufacturers need to look beyond the decision of which furnace to buy, and instead contemplate how they will use technology more broadly to drive competitive differentiation in this exciting new chapter for the steel industry.

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5. Source: Accenture analysis, ABB, EIA, IRENA, European Nuclear Society, average values for different scenarios

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