

SPECIAL EDITION | METEC 2023

# METALS MAGAZINE

INNOVATION AND TECHNOLOGY FOR THE METALS INDUSTRY

## ORANGE IS THE NEW GREEN AT METEC 2023

WHAT DOES THE ARTIFICIAL INTELLIGENCE  
BOT CHATGPT KNOW ABOUT GREEN STEEL?

VISITING THE LINZ COMPANY LOCATION  
OF PRIMETALS TECHNOLOGIES





**METEC 2023 is the perfect opportunity to discover technologies designed for the greener world of tomorrow.**

# EDITOR'S COLUMN

## DEAR READER,

"Orange is the New Green" is the motto of Primetals Technologies at METEC 2023. So what does it mean? Actually, it is easily explained: Orange is our primary company color—which you will already be familiar with if you know our company logo. Green, on the other hand, stands for sustainable metals production, the circular economy, technology working in harmony with nature—in short, it stands for *green steel*. From this thought onward, you will likely need no further assistance in connecting the (colorful!) dots. At Primetals Technologies, we are on a mission to pioneer and deliver the solutions required for the green transition.

In fact, many of the innovations needed to realize low-carbon-emissions steel production already exist; with the advent of cheap renewable energy, they are bound to take off—and to fundamentally redefine the identity of the metals industry. Today, the transformation to green steel is in its exciting first stages, which makes METEC 2023 the perfect opportunity to discover the game-changers among the green production solutions designed for the world of tomorrow. And since this edition of Metals Magazine was specifically created to accompany you at the trade show, its goals are as straightforward as they are two-fold: to give you an idea of what to expect from Primetals Technologies at the event, and to provide you with further inspiration to take a fresh and comprehensive perspective on green steel. I look forward to seeing you at METEC 2023.

**Yours sincerely,**



**Dr. Tom Widter**  
Editor-in-Chief of Metals Magazine  
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**DR. TOM WIDTER**  
EDITOR-IN-CHIEF, METALS MAGAZINE



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METEC has always played a defining role for the metals industry as an indicator of trends and transformations. This year, green steel, sustainability, hydrogen-based production, and electric steelmaking take the stage.

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## METALS MAGAZINE ONLINE

Whether you're at work, at home, or traveling, you can always access Metals Magazine Online at [meta.is/magazine](https://meta.is/magazine)



# MESSAGE FROM THE CEO

## DEAR CUSTOMER,

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Every four years, there is excitement in the air when the METEC trade fair opens its doors in Düsseldorf, Germany. The event is an excellent opportunity to get up-to-date with the most recent developments in the steel industry, and to learn more about groundbreaking technological trends that are just around the corner.

However, what I look forward to the most is meeting you in person—and having an exchange of ideas. As previous METECs have shown, the trade fair enables everything from inspired “big picture” discussions about business strategy to detail-oriented conversations about next-level solutions that are going to change the face of the steel industry forever. I am proud of the fact that Primetals Technologies is at the forefront of innovation, and I am confident that our presence at METEC 2023 will showcase not only our impressive portfolio of solutions, but also our determination to pioneer the future of metals—for the greater good of the societies we live in.

The decarbonization of the steel industry is one of the most relevant topics at this year’s METEC, and while, at the moment, Europe is making the largest strides, it is safe to assume that other regions will also step up their efforts to build more sustainable economies. At Primetals Technologies, we believe that *green steel* is very much the future, as not only steel producers but also their customers—for instance, carmakers—are demanding steel products with a lower carbon footprint. As a result, we are seeing great demand in technologies that facilitate electrification, from our electric arc furnaces or the new Smelter in the upstream area to induction heaters used in the rolling and processing of high-end steel grades.

Now, what brings *you* to METEC 2023? Is it all of the above, or do you already have specific questions? Are you looking to get an important project off the ground? We will do everything in our power to support you in the best possible way—at METEC 2023, and beyond.

**Yours sincerely,**



**Satoru Iijima**

CEO of Primetals Technologies  
and Chairman of the Board



**“ METEC 2023 is an excellent opportunity to get up-to-date with the most recent developments, and to learn more about technological trends.”**

**Satoru Iijima**

CEO of Primetals Technologies and Chairman of the Board



## WITH PRIMETALS TECHNOLOGIES


Primetals Technologies supports steel producers everywhere in the world with innovative solutions. Find out how—in our project and company news.



- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. Washington, D.C., U.S.A.       | 8. Taranto, Italy                 |
| 2. Monroe, South Carolina, U.S.A. | 9. Zenica, Bosnia and Herzegovina |
| 3. Ouro Branco, Brazil            | 10. Hämeenlinna, Finland          |
| 4. Düsseldorf, Germany            | 11. Taiyuan, China                |
| 5. Duisburg, Germany              | 12. Tangshan, China               |
| 6. Gerlafingen, Switzerland       | 13. Kaohsiung, Taiwan             |
| 7. Ghent, Belgium                 |                                   |

Geographic locations of the project news topics discussed in this section





The new line will enable Nucor to produce AHSS and other automotive grades.

## NUCOR STEEL BERKELEY TO RECEIVE AUTOMOTIVE-GRADE CONTINUOUS GALVANIZING LINE

**1. U.S.A.:** Nucor Steel Berkeley has placed an order with Primetals Technologies for a new, automotive-grade continuous galvanizing line (CGL). The CGL will be implemented at Nucor's facility located in Huger, South Carolina, and will represent one of the most advanced CGLs in the Western Hemisphere. With an annual capacity of approximately 500,000 tons, the new line will increase the company's galvanized production capacity. It will also enable Nucor Steel Berkeley to produce advanced high-strength steels and other automotive grades. The new equipment supports Nucor's strategy of shifting its portfolio further toward higher-margin, value-added products. There were several factors that influenced Nucor's decision-making process. Primetals Technologies met all technical requirements and will, during the project execution phase, leverage the strengths of its global organization. Locally, skilled workers based at the Primetals Technologies service workshop in Huger will perform pre-assembly work on-site, and will support installation and modification procedures. Nucor Steel Berkeley expects to produce the first coil by mid-2025.

Nucor is the largest recycler of any material in the Americas (pictured: Nucor Steel Berkeley).



A heavy load for any vessel: this brand-new LD converter weighs no less than 560 tons.

## LD CONVERTER WEIGHING 560 TONS SHIPPED FROM EUROPE TO THE U.S.A. AS A SINGLE PIECE

**2. U.S.A.:** It was a great moment when, in the fall of 2022, the 138-meter-long cargo ship, Happy River, left the port of Rotterdam, Netherlands, and headed for the U.S. The ship was carrying an LD converter (BOF) from Primetals Technologies with a heat size of 330 tons. The converter will replace an older model that, over time, exhibited cracked walls. All critical weld seams were done in a certified workshop, ensuring top-class quality and durability. Since the new converter was assembled in Europe, the choice was made to deliver it to its overseas destination in the form of a single, 560-ton piece. To ship any equipment this large, meticulous preparation is required. Immense care was therefore taken to ensure that the converter would stay locked in place during the two-week-long trip—even in the event of the ship facing a storm. Thanks to this mode of transport, the new owner will be able to skip any on-site vessel assembly. They will also profit from shorter shutdown periods once the new converter is installed.



The team that led the implementation of advanced digital solutions for continuous casting at Gerdau's Ouro Branco, Brazil, plant



Gerdau's caster maintenance specialists are now using smart glasses to get support.

## STRATEGIC PARTNERSHIP TO ADVANCE DIGITALIZATION AT GERDAU DEEPENS WITH NEW INITIATIVES

**3. BRAZIL:** Brazilian steel producer Gerdau, who signed a strategic partnership with Primetals Technologies at METEC 2019 to promote digitalization in steel production, realized two important projects. The company implemented a comprehensive process optimization and quality control solution from Primetals Technologies at the continuous slab caster No. 3 at Gerdau's integrated steel plant in Ouro Branco, Brazil. The new systems are run on virtualized servers through a software subscription model that includes regular updates. The new solution features automated casting speed control, condition monitoring of the secondary cooling system, and early detection of breakouts. In addition to the upgrade of caster No. 3, Gerdau chose to execute a separate pilot project centered around the m.space services platform provided by Primetals Technologies. The pilot was also run at Gerdau's Ouro Branco plant and focused on Gerdau's slab caster. It gave the steel producer the opportunity to access technical information about the company's spare parts, and to submit service requests online via m.space.

**The new solution for Gerdau's slab caster No. 3 features automated casting speed control, condition monitoring of the secondary cooling system, and prevention of breakouts.**



The Messe Düsseldorf location will be hosting the METEC 2023 trade show from June 12 through 16.

## METEC 2023 TO FOCUS ON GREEN STEEL AND SUSTAINABILITY

**4. GERMANY:** Every four years, Düsseldorf becomes the Mecca for metals industry representatives worldwide. In 2019, visitors from 127 countries flocked to Germany's seventh-largest city to attend what is known as the METEC trade show. Since then, a lot has changed in metals production, and there are many reasons to be excited about METEC 2023—which will take place from June 12 through 16 at the Messe Düsseldorf location. Primetals Technologies will be using its presence at the event to cater to the diverse needs of the global steel industry, always considering the latest developments in terms of technology, strategy, and policy. Thematically, the main focus of Primetals Technologies will be on Green Steel. This means answering questions such as, "How can we optimize our production route for minimal carbon emissions?"—or, "What will it take to make the same steel grades we are currently producing if we add electric steelmaking to our setup?" Of course, Green Steel is not the only topic that Primetals Technologies will be bringing to METEC 2023. Automation and Digital Plants will look at all the ways a modern plant can use sophisticated digital solutions to rise to the next level, Asset Optimization will focus on maintenance and efficiency themes, and Strategic Development will provide valuable insights for mapping out business targets.

**Primetals Technologies will be using its presence at METEC 2023 to cater to the diverse needs of the global steel industry.**



## HKM ORDERS NEW BOF RELIN- ING MACHINE

**5. GERMANY:** German steel producer Hüttenwerke Krupp Mannesmann (HKM) has ordered a new relining machine from Primetals Technologies for use with an LD converter (BOF). It will replace a 30-year-old and outdated machine at HKM's steel plant in Duisburg, Germany. Startup is scheduled for June 2024. HKM's decision to award the contract to Primetals Technologies was primarily based on the tailor-made design, which was optimized according to HKM's needs. Primetals Technologies had carried out a comprehensive study to find the best relining solution for HKM— one that would meet their needs in terms of state-of-the-art ergonomics, staff access via a separate elevator, and an automated working platform. Previous successful relining machine projects also contributed to the decision. Primetals Technologies will engineer, manufacture, and implement the relining machine and will provide advisory services for installation and startup.

## AFV BELTRAME STAHL UPGRADES WIRE ROD MILL IN GERLAFINGEN

**6. SWITZERLAND:** Metals producer AFV Beltrame Stahl Gerlafingen (AFV) has recently contracted Primetals Technologies to upgrade its wire rod mill in Gerlafingen, a city in the canton of Solothurn, located in the north-western part of Switzerland. The scope of supply includes an intelligent pinch roll and high-speed laying head. The new equipment will improve production performance by ensuring the uniform packaging of the coils. The wire rod mill produces 600,000 tons of coil per year, while the bar mill has an annual capacity of 80,000 tons. Both units are fed from the same roughing and intermediate mill train. The new upgrades will help to minimize vibration—and, as a consequence, reduce wear. AFV will also be in better control of the tail ends and front-end positioning. In terms of electrical equipment, new AC motors for the pinch roll and laying head will also be supplied. The motors will be controlled by high-performance, low-voltage, variable-frequency drives with an active front-end rectifier. The implementation of the system will be realized using a Simatic S7-1500 programmable logic controller. Startup of the new high speed pinch roll and laying head assemblies is expected in summer 2023.



## ARCELORMITTAL TO REPLACE BLAST FURNACE COPPER STAVES

**7. BELGIUM:** ArcelorMittal has ordered new copper staves from Primetals Technologies for its steel plants in Ghent, Belgium, and Bremen, Germany. The steel plant in Ghent had problems with its previous staves, as wear and bending had become pressing issues. The new copper staves for the Ghent plant feature Primetals Technologies' tried and tested anti-bending solution, which prevents stove-corner bending caused by thermal effects, and helps to avoid any cracking of welded pipe connections. Such cracks can lead to the loss of cooling water and have a negative effect on production. The new staves, which are implemented in the furnace stack, feature slide-in hexagonal inserts. These inserts capture and retain unreduced materials on the hot face of the copper staves, leading to significantly less wear and lower maintenance-related expenditures.

**The new copper staves represent a well-proven anti-bending solution developed by Primetals Technologies for the prevention of pipe cracks.**

## THIRD MEROS PLANT STARTED UP AT ACCIAIERIE D'ITALIA

**8. ITALY:** The third MEROS plant implemented at Acciaierie d'Italia's sinter plants in Taranto, Italy, has started up successfully. Acciaierie d'Italia had ordered a total of seven MEROS plants, four at the sinter plants and three at power plant No. 2. Construction work for the remaining four plants began in September of 2022. "We are very satisfied with the performance of the three already implemented MEROS plants. In terms of sustainability, MEROS is a key technology for us, and we look forward to completing the program with the additional four plants," says Alessandro Labile, Plant Director at Acciaierie d'Italia in Taranto. MEROS is off-gas cleaning technology that removes almost all potentially harmful substances found in waste gases from, for example, sinter plants or power plants. At the site in Taranto, the results speak for themselves: the three operational MEROS plants are reducing dust emissions from the two sinter plants to less than 3 milligrams per cubic meter—significantly below the legal limit of 10 milligrams. In addition, the dioxin levels are at less than 0.01 nanograms per cubic meter, far below the level of 0.15 nanograms required by Italian law. "Thanks to our highly efficient MEROS solution, air quality in Taranto has improved immensely. It is an important project that reflects both the profound positive impact this technology is having on the environment and our long-standing and strong partnership with Acciaierie d'Italia," says Dr. Alexander Fleischanderl, Head of Green Steel and Senior Vice President at Primetals Technologies.





## NEW LD CONVERTER BOOSTS PRODUCTIVITY AT ARCELORMITTAL ZENICA

**9. BOSNIA AND HERZEGOVINA:** Bosnian steel producer ArcelorMittal Zenica started up a new 125-ton LD converter (BOF) supplied by Primetals Technologies. The vessel shape is part of an optimized design, and the production line's overall capacity is now significantly higher. "This is a very successful project," says Adnan Topalovic, head of the CAPEX and Projects department at ArcelorMittal Zenica. "Thanks to the new solution, the converter reaction volume was increased, and this vessel has shorter tap-to-tap times. These are great benefits for us."

**The LD converter's vessel shape is part of an optimized design, and the production line's overall capacity is now significantly higher—much to the satisfaction of ArcelorMittal Zenica in Bosnia.**

## SSAB'S HÄMEENLINNA ISSUES FAC FOR COLD-MILL MODERNIZATION PROJECT

**10. FINLAND:** In February 2023, Primetals Technologies received the final acceptance certificate from Hämeenlinna steelworks, part of steel producer SSAB, for a comprehensive upgrade of the main drives for mill stand No. 1 at their 4-stand tandem cold rolling mill. The complete drive system was modernized, including the transformers, drive, and motor. The project involved the manufacture of a synchronous motor that uses a new stator, as well as a spare rotor and slip rings. The old oil transformers were replaced with new maintenance-free dry-type models.





TISCO's magnificent control center sets a high bar for state-of-the-art control room design.

## TISCO RECEIVES COMPREHENSIVE PROCESS-OPTIMIZATION UPGRADE FOR "ONE BUTTON STEELMAKING"

**11. CHINA:** It was the most extensive upgrade of a plant's process-optimization system thus far implemented by Primetals Technologies: Taiyuan Iron and Steel Group Co's (TISCO), based in Taiyuan, Shanxi Province, China, modernized its Level 2 automation systems at 14 steelmaking units across the entire meltshop and at seven continuous slab casters, as well as the central management system for raw-material logistics and evaluation. The comprehensive upgrade enables TISCO to orchestrate the steel-production process from a central control center. Thanks to the modernization effort, TISCO now enjoys full plant automation—"one button steelmaking"—as all systems are connected to the same unified network. TISCO can now establish process parameters even more accurately using modern metallurgical models, which will improve the quality, productivity, and flexibility of TISCO's production process. The software system features a significantly improved and more intuitive user interface for ease of navigation. The servers are virtualized, meaning that the new process-optimization solutions are run without dedicated hardware, which reduces IT-related maintenance costs.



## TANGSHAN QUANFENG SIGNS THREE-YEAR SERVICES CONTRACT

**12. CHINA:** Chinese steel producer Tangshan Quanfeng, which is owned by Dongshua Steel, a part of the larger Shuangying Group, has signed a maintenance services contract with Primetals Tangshan Technology Services (PTTS). Over the last three years, PTTS has provided Quanfeng with high-quality offline services for the complete thin-slab caster at Quanfeng's plant in Tangshan, Hebei province, China. The services provided included the continual refurbishment of caster segments and rolls. Thanks to the exceptional quality of the maintenance work, Quanfeng increased its productivity levels, developed additional steel grades, and was able to produce higher-quality steels. The new maintenance contract will cover the next three years, with PTTS' several hundred experienced workers and experts in metallurgy providing services for all aspects of the thin-slab caster. PTTS was established in 2017 and is a joint venture of Primetals Technologies and HBIS Tangsteel. It is headquartered in Tangshan and has operations in multiple locations in China. PTTS provides comprehensive services in the fields of off-line maintenance, refurbishment of equipment, condition monitoring, and operational support for slab casters.



**Quanfeng increased its productivity levels, developed additional steel grades, and was able to produce higher-quality steels.**



A work of art: the headquarter building of China Steel.

## CHINA STEEL TO INCREASE E-STEEL PRODUCTION

**13. TAIWAN:** China Steel Corporation (CSC) has ordered a pickling line and tandem cold mill upgrade from Primetals Technologies for its plant in Kaohsiung, Taiwan. The plant is currently designed as a 4-stand tandem cold mill. The upgrade will revamp stands 2, 3, and 4 using Hyper UCM technology, and will add an induction heater as well as an additional stand at the entry side of the mill. Primetals Technologies has recently executed similar revamps that were all geared toward the production of high-grade electrical steel, which was important to CSC. The new equipment will increase CSC's production capacity of electrical steel and is scheduled to commence operation in 2025.

# ORANGE IS THE NEW GREEN.

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## METEC 2023

THE INDUSTRY'S PREMIER TRADE SHOW  
RETURNS TO DÜSSELDORF, GERMANY.







The stand at METEC 2023 is centered around the concept of "Orange is the new green."

# ORANGE IS THE NEW GREEN

What does it mean to redefine sustainable metals production? As the world has faced continuous challenges over the past four years, industries have focused more and more on "going green" and investing in "green" technologies. Even the term "green steel" has become akin with the ideologies of sustainability. However, beyond these implications Primetals Technologies sees it as part of our DNA to provide our customers with sustainable technologies that lessen their environmental impact while maintaining productivity and profitability.

We define ourselves by our passion for the metals industry and a drive that is equitable with the energy and power of liquid metal. The heart of our pioneering spirit glows like that of glowing steel—orange. Therefore, as part of our identity, orange represents our passion for innovation and pioneering spirit. With this we are forging ahead toward a sustainable metals industry, one defined by groundbreaking and cutting-edge technologies imbued with our passion.

Now, more than ever, transformative technologies are reshaping the metals industry. With our solutions and pioneering spirit, we are making orange the new green.



## THE WORLD OF GREEN STEEL

Green steel is at the heart of the metals industry and the core of our presence at METEC 2023.

METEC represents an opportunity to experience the forces and trends driving the steel industry. With the recent establishment of Green Steel at Primetals Technologies, we have reformulated our approach to the metals industry by identifying and further developing technologies that contribute to a sustainable metals industry.

At the core of our presence at METEC is the world of green steel. Central to our stand is a column symbolizing the foundation of our approach to sustainability and transforming the steel industry. However, this representation is only the first of the immersive aspects of our stand that point to the ongoing revolution in the industry.

The green steel elements of our stand coincide with a series of scenarios that we believe will define our customer's path toward a sustainable metals industry. With varying approaches based on individual factors the road to green steel is paved by technologies that offer flexibility regarding a sustainable transition and reduced risk in terms of investment.



## ORANGE LAB

The Orange Lab offers a hands-on experience with our solutions and technologies.

METEC creates a unique opportunity to experience groundbreaking technology firsthand. From within the Orange Lab visitors to METEC can experience some of the latest solutions from Primetals Technologies with a focus on automation and digitalization.

A clear highlight of the Orange Lab is the Central Operation Cockpit. Built to represent the final construction, the Central Operation Cockpit at METEC allows visitors to immerse themselves in the perspective of a single operator, who, thanks to interconnected automation and digital solutions, has a bird's-eye view of the entire production process and the ability to control any step. These features are a clear representation of the automation and digital plant philosophy that place the human operator at the center of our solutions and utilize various tools to streamline the operation and maintenance thereof.

Finally, the Orange Lab is populated with various simulation software that demonstrates how digital tools can facilitate transparency regarding operations, improving production and reducing downtime.



## GREEN LOUNGE

Exclusive live events at METEC 2023 featuring customers, experts, and technologists.

Welcome to the Green Lounge, a collaborative space for exclusive events at METEC 2023, creating a space for exchange and discussion essential to the future of the metals industry. Customers and top specialists from Primetals Technologies are given a unique opportunity to ask questions and engage directly with one another. Visitors to the Green Lounge can directly ask questions to technologists and customers about our solutions and their application.

Featured events at the Green Lounge provide an opportunity to hear directly from customers about their experience with Primetals Technologies and their plans for a sustainable metals industry. With variables impacting the metals industry worldwide, the Green Lounge is the perfect environment to gain an intimate understanding of the benefits of the latest technologies and how the steel industry can collectively transform for the benefit of society.

Experience the sustainable transformation of the steel industry amongst like-minded technologists and customers at the Green Lounge.



A 3D tour of our plants and technologies with experts

## 3D SHOWROOM

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A unique feature of METEC 2023 is the 3D showroom. Immerse yourself in our 3D models as our specialists take you on a guided tour of our plants. The ability to deep dive into our 3D models allows you to envision how our technologies integrate into existing plants or will lay the foundation for new sustainable plants. Explore in detail various features and immediately ask questions of the experts in the room, who are part of this experience every step of the way.

The 3D Showroom features technologies from direct reduction to rolling and processing, covering nearly every aspect of metals production. The 3D Showroom adds perspective and tactility to transformational technologies. In a closed setting, our plants come to life. With our technologists at the helm, visitors can experience our passion for cutting-edge transformative technology firsthand and tour our unique solutions.



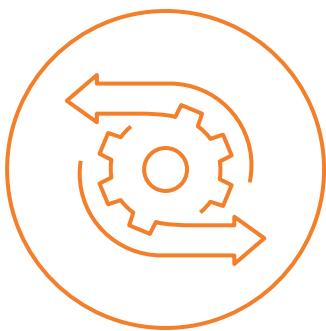
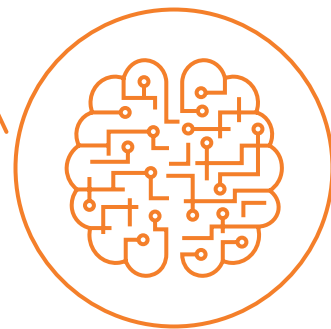


## GREEN STEEL

The global metals industry is undergoing a revolutionary transformation. The term green steel has emerged with an increased focus on decarbonization and a sustainable approach to metals production. Technologies and solutions benefiting the circular economy, hydrogen-based production, and an increased focus on direct reduction and electric steelmaking are more critical now than ever.

## AUTOMATION AND DIGITAL PLANTS

Automated, agile, adaptive, and constantly improving, this is an autonomous plant. The metals industry is pushing past all previous boundaries, allowing for production processes and operations that are exceptionally efficient, safe, and reliable. Automation and digital solutions are centered around supporting operators in eliminating unplanned and costly shutdowns with transparent operations, and clear interpretations of massive amounts of data.



## ASSET OPTIMIZATION

With steel demand on the rise, maintaining and increasing production capacities while improving energy efficiency, reducing waste, and lessening the industry's environmental impact is crucial. Advanced solutions that maximize existing assets, improve yield by reducing waste, optimize energy efficiency, and maintain productivity by offering efficient maintenance are how producers can reach their full potential and optimize their assets.

## STRATEGIC DEVELOPMENT

Where is the industry headed, and how do I get there? The metals industry is transforming rapidly, and a global revolution driving eco-friendly solutions is readily changing the landscape for heavy industry. Strategic development informs, assesses, and accompanies producers on their journey toward sustainability regarding the environment and profitability. The future of the industry will be defined by sustainability and pioneers.





Few artificial intelligence solutions have stood in the limelight quite like ChatGPT by developer OpenAI. Entire industries are fearing the disruption the technology may bring. Others look forward to a world in which many arduous, time-consuming processes will be automated or directed to the AI for execution. But how much does ChatGPT know about the metals business? Does it have the insight required to support steel producers in achieving long-term sustainability? We asked the AI to discuss the ten most important factors for producers wanting to become greener.



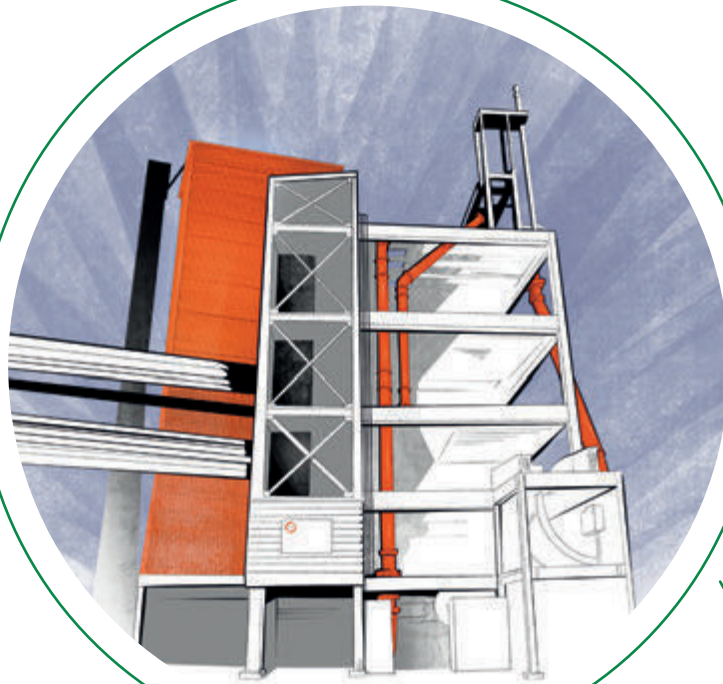
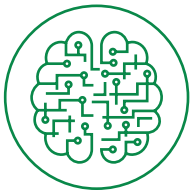
# I HAVE THE ANSWERS.

"What are the ten most important principles that steel producers need to consider in order to achieve long-term sustainability?"—This is the question we put to ChatGPT, arguably the most celebrated, feared, and admired AI tool of recent times. The answers are interesting for two reasons. First, the ideas brought forward by the chatbot do make sense. Readers of Metals Magazine will find that some of the ten points will seem more obvious than others. *Energy efficiency*, for instance, is an unquestionable success factor for producers to consider, while *human capital* may easily be overlooked in some of its dimensions. The way the AI discusses *decentralized production* is somewhat one-sided, as the strategy of distributing distinct production steps according to economic and political conditions in different regions is strikingly absent in ChatGPT's summary. But overall, the

AI does not include any topics that would appear outlandish or misplaced. Second, the answers provided by ChatGPT—which we have edited only slightly for clarity and brevity—allow readers to develop a perspective on the strengths and weaknesses of the current capabilities of the AI. At the time of this writing, ChatGPT exhibited a recognizable style—for example, we found that it often concluded its answers with a summary that was largely redundant (and therefore cut from in the AI's points found on the following pages). The lack of information on what sources the AI was using was another issue that soon became glaringly obvious (we did fact-check the bot's results). Still, our take-away is this: ChatGPT is remarkable technology and reads surprisingly knowledgeable about sustainable steel production. So now we ask *you*: do you share our view?



**HOW** ?

ChatGPT lists technological innovation first—when discussing the key drivers for a greener future for steel.

## 1. INNOVATIVE TECHNOLOGIES

“To remain relevant in a rapidly changing world, steel producers must embrace innovative technologies that allow them to produce high-quality steel products while minimizing their environmental impact. One innovative technology that has gained popularity in recent years is electric arc furnace (EAF) steelmaking. EAF steelmaking uses scrap metal as the primary raw material instead of iron ore, reducing the carbon footprint of the steel production process. Steel producers who invest in EAF technology are not only reducing their environmental impact but also gaining a competitive advantage over traditional blast furnace steelmakers. Another innovative technology that has the potential to transform the steel industry is hydrogen-based steel production. This technology uses hydrogen instead of coal or coke as a reducing agent, eliminating the carbon emissions associated with traditional steel production methods. The use of hydrogen also creates water as a by-product, which can be recycled in the production process. While hydrogen-based steel production is still in the early stages of development, several steel producers have already announced plans to invest in this technology in the coming years. Steel produc-

ers can also look to innovative technologies outside of the production process itself. For example, artificial intelligence (AI) and machine learning can be used to optimize production processes, reducing waste, and lowering energy consumption.

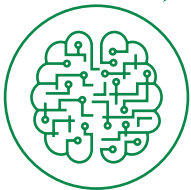
The benefits of embracing innovative technologies are numerous. First and foremost, investing in innovative technologies can help steel producers reduce their environmental impact and increase their sustainability. This is becoming increasingly important to customers, investors, and governments alike. Second, embracing innovative technologies can help steel producers stay ahead of the competition. By using new technologies to create products that are more environmentally friendly, more efficient, and of higher quality, steel producers can differentiate themselves from their competitors and attract new customers. Finally, embracing innovative technologies can also help steel producers reduce costs and increase profitability. And by producing steel products that are more environmentally friendly, steel producers can take advantage of government incentives and regulations that reward sustainable practices.”

## 2. ENERGY EFFICIENCY

“Improving energy efficiency is a critical factor in making steel production more environmentally compatible and sustainable. As the industry faces increasing pressure to reduce its carbon footprint, steel producers must prioritize energy efficiency to stay ahead of the curve and remain competitive in the long term. One way to improve energy efficiency is by upgrading equipment and technologies used in the production process. Traditional blast furnaces are highly energy-intensive, consuming large amounts of coke, coal, and other fossil fuels. Electric arc furnaces, on the other hand, use scrap metal as raw material and are more energy-efficient. By investing in advanced technologies such as electric arc furnaces and improving the energy efficiency of existing equipment, steel producers can significantly reduce energy consumption and greenhouse gas emissions. Another approach to improving energy efficiency is to optimize processes by reducing energy losses and improving process control. Advanced control systems can optimize process parameters and reduce energy consumption by adjusting the flow rate of materials, optimizing temperature levels, and controlling the use of

energy-intensive equipment. Regular maintenance and tuning of equipment and systems can also optimize energy use and improve energy efficiency.

Steel producers can also consider adopting renewable energy sources such as wind, solar, and hydro power to reduce their reliance on fossil fuels. By investing in on-site renewable energy production or sourcing renewable energy from external suppliers, producers can significantly reduce greenhouse gas emissions and improve the environmental performance of the steel industry. Moreover, energy-efficient operations can be achieved by optimizing the management of energy use. This includes conducting regular energy audits, setting energy performance targets, and implementing energy management systems. By continually monitoring and assessing energy performance, steel producers can identify opportunities for improvement and take appropriate measures to reduce energy consumption and greenhouse gas emissions. This can also help steel producers to reduce their energy costs and improve the economic competitiveness of the industry.”



**HOW**



Energy-recovery solutions and production routes that use less energy are another principle toward sustainability.

### 3. USE OF RENEWABLE ENERGY

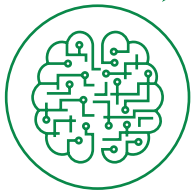
“The use of renewable energy is another critical factor in making steel production more environmentally compatible. Steel production is one of the most energy-intensive industries in the world, and reducing the industry’s reliance on fossil fuels is essential in mitigating its environmental impact. Steel producers can significantly reduce their greenhouse gas emissions by using renewable energy sources such as solar, wind, and hydroelectric power. To take advantage of the opportunities offered by renewable energy, steel producers must invest in the respective infrastructure and technology. This includes installing solar panels, wind turbines, and hydroelectric generators at their facilities, as well as partnering with renewable energy providers to purchase renewable energy credits or enter into power purchase agreements. By investing in renewable energy infrastructure and technology, steel producers can reduce their greenhouse gas emissions and improve their environmental performance.

Additionally, the use of renewable energy can offer economic benefits to steel producers, such

as reduced energy costs and increased energy security. As the cost of renewable energy continues to decrease, renewable energy can also provide a competitive advantage to steel producers, enabling them to differentiate themselves from their competitors and attract environmentally conscious customers.

An example of a company taking advantage of the opportunities offered by renewable energy is ArcelorMittal Europe. The company has set a target of reducing its carbon footprint by 30 percent by 2030 compared to 2018 levels, and expects to be carbon neutral by 2050. It has industrial-scale demonstration projects under construction for every part of its carbon-neutral roadmap, and it is building industrial-scale demonstration plants at its operations in Belgium and France.

In addition to investing in renewable energy infrastructure and technology, steel producers must also focus on improving the energy efficiency of their operations. This includes optimizing their production processes, reducing waste, and using energy-efficient equipment and technologies.”



Renewable energy may still be at an early stage, but the AI thinks it will play a major role in the coming decades.

HOW ?



Steel is the world's most recycled material, but there is still room for improvement—as per the AI's assessment.

## 4. RECYCLING

“Recycling has a significant role to play in reducing the environmental impact of steel production, as it reduces the need for virgin materials, decreases energy consumption and greenhouse gas emissions, and conserves natural resources. Steel is one of the most recyclable materials in the world, with a recycling rate of over 90 percent in many countries. However, there is still much room for improvement, and steel producers must take advantage of the opportunities offered by recycling to future-proof their business. One of the main opportunities presented by recycling is the potential to reduce the environmental impact of steel production. By using scrap instead of virgin materials, steel producers can significantly reduce their energy consumption and greenhouse gas emissions. Recycling one ton of steel saves approximately 1.4 tons of iron ore, 0.8 tons of coal, and 0.3 tons of limestone, as well as dramatically reducing energy consumption and greenhouse gas emissions. Steel producers can also benefit from the growing demand for sustainable materials. With consumers increasingly concerned about the environmental impact of the products they buy, there is a significant opportunity for steel

producers to differentiate themselves by offering sustainably produced steel products. By promoting the use of recycled steel and investing in sustainable production methods, steel producers can attract environmentally conscious customers and future-proof their business against changing market trends. In addition to the environmental benefits, recycling can also offer economic benefits to steel producers. By using scrap, steel producers can reduce their raw material costs and increase their profitability. Furthermore, by investing in recycling infrastructure and technology, steel producers can create new revenue streams and strengthen their position in the market.

To take advantage of the opportunities offered by recycling, steel producers must invest in recycling infrastructure and technology. This includes upgrading existing recycling facilities, investing in new recycling technologies, and partnering with other industries and stakeholders to develop sustainable supply chains. Steel producers should also focus on increasing the efficiency of their recycling processes, reducing waste, and improving the quality of their recycled steel products.”



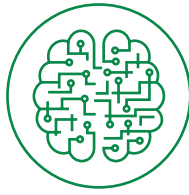
## 5. CIRCULAR ECONOMY

“The circular economy is a model that emphasizes the reduction, reuse, and recycling of materials and resources to minimize waste and promote sustainability. In recent years, the circular economy has gained increasing attention as a way to address the environmental challenges posed by our linear “take-make-dispose” economic model. Steel production is resource-intensive, with significant amounts of raw materials and energy required to produce steel products. However, the majority of these resources are lost during the manufacturing process, leading to significant waste and environmental impact. By adopting a circular economy model, steel producers can reduce waste, increase resource efficiency, and minimize their environmental impact. There are several ways in which steel producers can adopt a circular economy model. Firstly, steel producers can focus on using recycled steel in their production processes, thereby reducing their reliance on virgin materials and minimizing waste. Secondly, steel producers can develop closed-loop production processes that maximize resource efficiency and minimize waste. This can involve the reuse of waste materials, the imple-

mentation of energy-efficient production processes, and the use of renewable energy sources. Finally, steel producers can build partnerships with other companies and stakeholders to create a more integrated and sustainable value chain.

Steel producers that adopt a circular economy model can benefit from increased efficiency, reduced waste, and improved environmental performance. This can also lead to cost savings, as the reuse of materials and resources can reduce the need for virgin materials and lower production costs. In addition, the circular economy model can help steel producers differentiate themselves from their competitors and attract environmentally conscious customers. By focusing on circular economy principles, steel producers can demonstrate their commitment to sustainability and differentiate themselves from competitors who are still relying on linear production models. The strategy is also a means of appealing to consumers who are willing to pay a premium for sustainable products. This way, steel producers can generate new revenue streams and improve their financial performance.”





## 6. CARBON CAPTURE

“Carbon capture and storage (CCS) is a critical factor in making steel production more environmentally compatible and sustainable. As the industry faces increasing pressure to reduce its carbon footprint, producers must prioritize the adoption of CCS technology to avoid falling behind their competitors. One way steel producers can adopt CCS technology is by retrofitting existing plants with CCS equipment. Retrofitting existing plants can be challenging and expensive, but it allows producers to reduce their carbon emissions while continuing to use their existing production infrastructure. Another approach to adopting CCS technology is by building new plants that are designed with CCS technology in mind. New plants can be designed to integrate CCS technology from the outset, making the process more efficient and cost-effective. Mitsubishi Heavy Industries Group (MHI Group) is one of the companies that has been actively developing CCS technology for the steel industry. In 2020, MHI Group announced a partnership with world-leading steel company ArcelorMittal to explore the feasibility of using CCS technology at ArcelorMittal’s plants. MHI Group is also working on a project in Norway to capture CO<sub>2</sub> emissions from a waste-to-energy plant and transport the captured CO<sub>2</sub> to a nearby industrial site for storage. The project uses MHI Group’s proprietary KM CDR process, a post-combustion carbon capture technology. Steel producers are well-advised to consider the potential competitive advantage that comes with adopting CCS technology. Those who can offer low-carbon steel products may have a significant competitive advantage over those that cannot.”

## WHAT IS CHATGPT?



ChatGPT is an AI-powered conversational agent developed by OpenAI. It is based on the “generative pre-trained transformer” (GPT) architecture, which is a state-of-the-art natural language processing model. ChatGPT is designed to provide human-like responses to a wide range of queries and conversations. It has been trained on a massive amount of text data, enabling it to understand and generate natural language in a variety of contexts.

As a conversational agent, ChatGPT can be used for a variety of applications, including customer service, virtual assistants, and chatbots. It can answer questions, provide recommendations, generate text, and engage in conversations in a way that simulates human interaction.

The technology behind ChatGPT has many potential applications, including improving customer service, automating tasks, and providing personalized recommendations. However, there are also concerns about the ethical and social implications of AI-powered conversational agents, including issues related to bias, privacy, and control. Overall, ChatGPT represents an exciting development in the field of natural language processing and AI, with many potential benefits and challenges to consider.



### GET YOUR HANDS ON CHATGPT

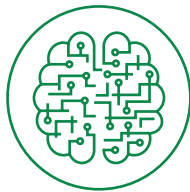
To get started with artificial intelligence, simply scan the QR code or enter the link provided below.

[chat.openai.com/chat](https://chat.openai.com/chat)

## HOW TO GET OPTIMAL RESULTS USING CHATGPT

To ensure that your interactions with ChatGPT are as effective as possible, it's important to keep a few key considerations in mind. Here are some tips to help you get the best results.

- Be specific in your questions: ChatGPT works best when given clear and specific questions or prompts. This will help it generate more accurate and helpful responses.
- Use correct spelling and grammar: ChatGPT relies on natural language processing, so it is important to use correct spelling and grammar when interacting with it. This will help ensure that it understands your queries and generates appropriate responses.
- Provide context when necessary: If you are asking a complex question or providing information that may be relevant to your query, be sure to provide context to help ChatGPT better understand your request.
- Be patient: ChatGPT is a sophisticated AI model, but it may take some time to generate a response, particularly for complex queries. Give it time to process your request.
- Use it as a tool, not a replacement for human interaction: While ChatGPT can be a helpful tool for answering questions and generating text, it is important to remember that it is not a replacement for human interaction.



## 7. POLICY AND REGULATIONS

“Governments around the world are increasingly concerned about the environmental impact of industries, including steel production, and are implementing policies and regulations to reduce emissions, protect natural resources, and promote sustainable practices. But steel producers can also leverage policy and regulatory changes to create new opportunities. For example, government incentives for renewable energy and energy efficiency can provide financial support for companies that invest in sustainable technologies. Producers can also engage with policymakers

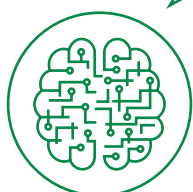
and regulators to help shape policies that are favorable to their business and promote sustainable practices. This can involve participating in public consultations, sharing best practices, and advocating for policies that promote sustainable production methods. In doing so, steel producers can demonstrate their commitment to sustainability and help shape policies that support their business objectives. By engaging with government officials and advocating for policies that align with their sustainability goals, producers can help create a more supportive regulatory environment.”

## 8. DECENTRALIZED PRODUCTION

“Decentralized production is a concept that has gained traction in the steel industry as an approach to improving resilience, sustainability, and efficiency. This strategy involves the distribution of production across multiple locations rather than relying on a central manufacturing facility. This way, steel producers can mitigate the impact of disruptions such as natural disasters, equipment failures, or labor strikes. Decentralization can also enhance sustainability by reducing transportation emissions and energy consumption. To achieve decentralized production, large steel producers can adopt several strategies. One approach is to establish satellite production facilities near major customers or markets. These facilities can enable tailored production and improved delivery times. Another option is to form partnerships or joint ventures with local manufacturers or suppliers, leveraging local expertise while maintaining global scale. Implementing decentralized production requires significant investment in technology and infrastructure that can facilitate communication, coordination, and quality control across multiple locations. Cloud-based software systems can enable real-time monitoring and data sharing, while analytics and arti-

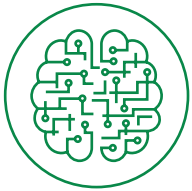
cial intelligence tools can optimize production and improve quality. Decentralized production presents a valuable opportunity for large steel producers to serve niche or specialized markets.

Steel producers that adopt a decentralized production strategy can differentiate themselves from their competitors, particularly in terms of responsiveness and sustainability. By decentralizing production, steel producers can achieve a more efficient and flexible production system, with reduced supply chain risks and enhanced sustainability. These factors can be particularly appealing to environmentally conscious customers who seek more sustainable products and solutions. There are also challenges associated with decentralized production, such as the need for significant upfront investment, the risk of quality control issues across multiple sites, and the potential for increased complexity in supply chain management. Steel producers need to carefully consider the trade-offs and potential risks when deciding to implement a decentralized production strategy. In spite of these challenges, the potential benefits may outweigh the risks for companies willing to make the investment.”



HOW ?

Decentralization is a relevant strategy used in many global industries, including the metals business, as the AI notes.



Maintaining a highly skilled, healthy, and safe workforce is a key factor in achieving sustainability, says the AI.

## 9. HUMAN CAPITAL

“The steel industry is highly dependent on its workforce. Thus, investing in human capital is essential for long-term sustainability in the industry. This involves creating a diverse and inclusive workplace that attracts and retains top talent, and providing continuous training and development opportunities to improve employee skills and knowledge. One of the challenges facing the steel industry is the aging workforce, with many employees nearing retirement age. This highlights the need for succession planning to ensure that the industry has the right people with the right skills to meet the challenges of the future. The steel industry has traditionally been male-dominated, but this is changing, with more women entering the industry in recent years. However, there is still much work to be done to increase the representation of women, as well as other underrepresented groups, in the industry.

Continuous training and development opportunities are critical for improving employee skills and knowledge, as well as enhancing job satisfaction and motivation. The steel industry is constantly evolving, with new technologies and processes

being developed to reduce the environmental impact of steel production. Thus, it is essential for employees to be trained on the latest technologies and processes to stay ahead of the curve. Training programs can also help employees develop new skills and move up the career ladder, which can improve retention rates and reduce turnover.

Investing in human capital also involves promoting a culture of safety and well-being in the workplace. Steel production is a high-risk industry, and safety must be a top priority. This involves providing employees with the necessary training and equipment to work safely, as well as creating a culture that values safety and encourages employees to report safety hazards and near-misses. Another important aspect of investing in human capital is promoting work-life balance. Steel production is often a demanding and stressful job, and promoting work-life balance can help employees manage their workload and avoid burnout. This can include flexible work arrangements, such as telecommuting, as well as providing resources for stress management and mental health support.”

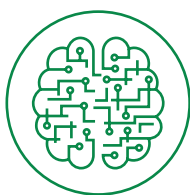
## 10. COLLABORATIVE EFFORTS

“By collaborating with stakeholders, including suppliers, customers, and local communities, steel producers can gain valuable insights into their operations and identify opportunities for improvement. One example of this kind of collaboration is the World Steel Association’s Climate Action program, which brings together industry stakeholders to address the steel sector’s environmental challenges. Through this program, steel producers can share best practices, develop new technologies, and work towards common goals. Collaborative efforts can also take the form of partnerships between steel producers and other industries or organizations. For example, steel companies can collaborate with renewable energy companies to develop sustainable energy sources for their operations. Additionally, collaborations with research institutions can lead to the development of new technologies for reducing emissions and improving efficiency. Steel producers should also consider opportunities to work even more closely with local communities. This can include initiatives to reduce air and water pollution, improve waste management, and minimize the environmental impact of operations. Benefits of collaborative

efforts for steel producers include improved environmental performance, increased efficiency, and reduced costs. By working together with stakeholders, steel producers can identify areas for improvement and develop more effective strategies for reducing emissions and improving sustainability. Collaborative efforts can also help steel companies stay ahead of regulations and consumer preferences, as well as enhance their reputation as responsible corporate citizens.

In addition to these benefits, collaborative efforts can also have broader positive impacts on society and the environment. For example, partnerships between steel companies and renewable energy providers can contribute to the development of a more sustainable energy system overall.

Overall, collaborative efforts are an essential factor in making the steel industry more sustainable. By working together with stakeholders and engaging with local communities, steel producers can identify opportunities for improvement, develop new technologies, and implement more effective strategies for reducing emissions and becoming greener.” ●



### JOIN THE CONVERSATION!

Having read the AI’s ideas on the green future of metals production, what are your thoughts? Are you amazed with the level of knowledge on the steel industry that ChatGPT has already accumulated? Or do you feel that the AI’s answers were a bit on the shallow side? Join the conversation and let us know your opinion by sending an email to [metalsmagazine@primetals.com](mailto:metalsmagazine@primetals.com)

# CONNECTING THE WORLD FROM CENTRAL EUROPE



The main building of the Linz location houses several global departments.

## LINZ IS THE FEATURED COMPANY LOCATION IN THIS EDITION OF METALS MAGAZINE



As the beating industrial heart of Austria, Linz is home to one of the most famous steel producers in Europe—i.e., voestalpine. Nestled across from “LD Stahlwerk 3” one finds the main buildings of the Linz location of Primetals Technologies. The company’s largest location with nearly 1,600 employees, the Linz location plays a vital role as a main point of contact for all global locations and a crucial part in the activities of Primetals Technologies worldwide with its own workshop and specialized facilities. Lead Editor Adam Merki reports from Austria.

My first experience with Linz, Austria came in 2015. Reconnecting with a city my father had emigrated from nearly 70 years ago, I explored the city with my extended family and was fascinated by the contrast to many Austrian cities and the uniqueness of Linz. Driving to the top of the Pöstlingberg—a 539-meter-high hill across the Danube River on the northern side of the city—one is struck by the view and the massive industrial landscape that makes up a large portion of the city. “Everything over there belongs to ‘voest,’” my cousin remarked, as my eyes followed the Danube flowing through the city. Unbeknownst to me at the time, the area near “voest” would come to play an integral role in my future in Austria, namely a future at Primetals Technologies.

Fast forward several years later and Linz has become my home. The uniqueness of this beating industrial heart of Austria has made its way into my being. I am proud to live and work in Upper Austria and at Primetals Technologies. Moreover, the Linz location of Primetals Technologies is unique in its interconnectedness with all the company locations and customers worldwide, and brings an international perspective to the activities that take place in Austria. Working closely

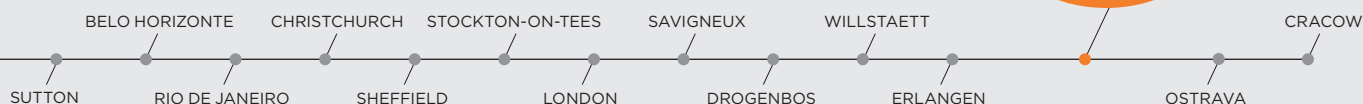
with colleagues active around the world and exploring the workshops and labs here in Austria, one truly realizes the global nature of Primetals Technologies and the role of the Linz location in bringing transformative technologies to customers across the globe.

### AT HOME IN LINZ

The company location of Primetals Technologies in Linz is located just across and amongst the buildings of one of our valued customers, namely voestalpine. A quick tram and bus ride from the main train station, the main building of the Linz location comes into view simultaneously with “LD Stahlwerk 3” of voestalpine. The geographic position of the Linz location almost implies how closely tied we are to our customers and the steel industry and reflects some of the long history of Primetals Technologies at voestalpine. Prior to becoming Primetals Technologies in 2015 and even prior to its history as Siemens VAI, Primetals Technologies was a part of voestalpine and still to this day one finds echoes of our close collaboration on new projects revolutionizing the steel industry, including the development of a pilot plant for hydrogen-based fine ore reduction combined with the Smelter (For more on the Smelter and HYFOR read more on pages 66-71). »

### LINZ

Linz is the capital of Upper Austria and the third largest city in Austria with around 200,000 inhabitants.



With the country flags of Japan and Austria flying outside, the main building in Linz welcomes visitors from around the world. Heading inside the main lobby, I am met by my colleague Manuela Niederhuber, head of regional communication activities in Austria. We then set off through the star shaped “Betriebsgebäude 47” or BG 47 to uncover many of the reasons why Primetals Technologies Austria is uniquely positioned in central Europe to provide technologies, services, and support to our customers and colleagues worldwide.

### A GLOBAL COMMUNITY

As we head upstairs, we are met by global CTO and regional CEO, Dr. Etsuro Hirai. Dr. Hirai shares with us his experience arriving in Linz and meeting his colleagues in Austria for the first time. “I was welcomed here in Linz and inspired by how dedicated and committed our team is to the advancement of iron and steel production.” He further discusses his background from Mitsubishi Heavy Industries, elaborating that Primetals Technologies is a key player in society around the world. Noting the crucial role that the steel industry plays worldwide, he states, “We advance our technologies in line with the demands of our society.” “We are all part of a global team,” he continues, elaborating that the global business units at the Linz location,

including upstream activities covering technologies from raw material to liquid steel and metallurgical services, are essential to our business worldwide, and build on each location’s expertise and personnel.

Dr. Hirai goes on to tell us more about the establishment of “green steel” in Austria and the importance of the role of these global activities. “The steel industry will decarbonize, and hydrogen is the key.” His remark reflects some of the latest industry trends, but he points out that the societal shift toward eco-friendly production was anticipated years ago and is now happening more rapidly. “Green steel,” he continues, “is a term that summarizes our technologies.” He explains that all our technologies are designed to increase energy efficiency, reduce waste, improve yield, improve recycling, and eliminate harmful off-gas, including CO<sub>2</sub> emissions. In Linz, converter steelmaking improvements and direct reduction are some of the significant means of transforming the industry utilizing our technologies and couples with expertise in environmental solutions to improve the impact of iron and steelmaking. As we take our leave from Dr. Hirai’s office, he wishes us all the best touring the rest of the Linz location. We head downstairs to meet Dr. Alexander Fleischer, head of Green Steel.

## TOURING THE WORKSHOP AT LINZ LOCATION



In the heart of the mechatronics workshop, Simon Pfeil works closely with the LiquiRob robot teaching new functionalities for future applications.



Pfeil spends a great deal of time programming new functions on the computer and testing new sensors to further improve LiquiRob’s performance.



Klaus Rosenblattl closely examines the HTC test stand to ensure everything is in working order for upcoming tests on slab samples.



## FROM CENTRAL EUROPE TO THE WORLD

Dr. Alexander Fleischanderl has just returned to Linz from a speaking engagement abroad. “It is always nice to be home for a few days,” he remarks. Being from Upper Austria, he is proud to be a part of such an international company and work at the company location where he calls home. Amidst the global transformation of the steel industry toward eco-friendly production and with topics like decarbonization leading to revolutionary changes, Dr. Fleischanderl reiterates how crucial it is that our company is well-connected to the entire world. With a great deal of work to be done worldwide, he notes how important it is that we also demonstrate our presence by engaging in discussions about the future and green steel. Driving these discussions are crucial upstream technologies for sustainable steel, such as electric steelmaking and direct reduction.

Walking through the halls we pass the “Remote Commissioning Center.” Colleagues from cold rolling invite us inside and elaborate on the formation of the Remote Commissioning Center. The center was originally started to compensate for travel restrictions in previous years, but now serves as a new opportunity to provide services without costly travel expenditures and the ability for our specialists to interact with plants

immediately all around the world. While watching a steel plant in action on the screen, it is astounding to see a plant halfway around the world operating in real-time. They elaborate further and explain that this has brought immense benefit to several customers and has improved their ability to further develop existing solutions because they are provided with immediate access to valuable data.

Taking our leave, we stroll through the multiple floors of metallurgical services. From spare parts to hands-on training, they are continuously in contact with colleagues around the world and provide customers immediate support no matter where the plant is located. I am struck by the size of the services team, whose photos line many of the walls. Each one tells another story of how they were able to pull through for a customer, solve an issue, and bring a plant back up to its full potential and how the services team is always interested in customer satisfaction first and foremost. From there, we head out of BG 47 and across the street to the second largest building BG 48.

## AN INNOVATION HUB

In the lobby of BG 48, Niederhuber and I are met by Dr. Peter Juza from the Electrics and Automation »



With various sensors on all of the test stands throughout the workshop, Rosenblattl ensures that all components are in working order.



Applying the finishing touches to the ShapeMon, Ralf Ulbrich works directly with each component going into the copper housing.



Wired by hand and tested thoroughly, Daniel Ott works in an enclosed area alongside Ulbrich, testing the cameras and lasers of the ShapeMon.

department. As we walk through the halls and meet with several colleagues, Dr. Juza reveals that Primetals Technologies is one of the largest software developers in Upper Austria and that our focus is on bringing more digital services to our customers. From subscription models to web-based platforms, he explains that each one of these initiatives ensures that customers are receiving the most up-to-date software from Primetals Technologies that will bring their plants up to their full potential and eliminate costly downtime.

Touring through the halls, Dr. Juza explains that today's modern steel plants simply cannot do without electric and automation solutions. What was previously optional has now become essential. From driving the plant to helping maintain its functioning, automation and digitalization are about making the lives of operators and producers easier in terms of in-house knowledge and identifying problems and errors before they

happen, ensuring unplanned downtime becomes a thing of the past. Moreover, the solutions developed play a crucial role for the safety of workers, who, thanks to sensors and robotics, are now much further away from molten steel.

Dr. Juza also goes on to tell us how the company's passion for problem solving is engrained in the DNA of Primetals Technologies. He reveals that all the components delivered from Linz are meticulously tested and if anything does not function properly, our engineers become obsessed with ensuring the problem is solved for the customer. Being solution-oriented and understanding the big picture is essential. He elaborates that our approach to customers also involves consideration of IT architectures to ensure that the networked structure of the plant is up-to-date and upgradeable. "Upgradeable and backwards compatible, what's most important is that our solutions meet the needs of our



## WHAT CONNECTS LINZ TO THE WORLD ...

**Employees of Primetals Technologies share many passions, such as pioneering new solutions for their customers. But every location also has unique qualities. In this section, we catch a glimpse of what makes Linz so special.**



“When you go through our buildings, you hear different languages, from German to Spanish, English and Japanese. You truly understand how global our activities are.”

**Martina Gruber**  
Head of Controlling



“In Linz, you are always in contact with our colleagues worldwide. You truly feel that we are all part of a company offering solutions that have a positive impact on our environment.”

**Christian M'Baku**  
Sales Manager

customers so that their plants operate to their full potential,” Dr. Juza concludes.

One aspect that is unique to the company location in Linz is the close relationship between technical departments and the sharing of expertise. What occurs regularly digitally with colleagues around the world, can often take place analog in Linz. This benefits the development of the latest automation and digital tools, simply because collaboration and exchanges can occur by heading to a nearby department. The impact of this exchange is perhaps most visible in the close collaboration between automation and mechatronics, who develop digital and mechanical solutions that work in perfect harmony.

### THE MECHATRONICS WORKSHOP

After exploring the two largest buildings of Primetals Technologies Austria, we head off in the direction of

voestalpine’s “Stahlwelt”—a museum dedicated to steelmaking. Just past a set of buildings belonging to voestalpine, we are met by Nicole Oberschmidleitner, waiting outside BG 88. With the names of companies, such as K1-MET on the outside, the building is a testament to the collaboration that takes place in Linz to develop new technologies. Oberschmidleitner also explains that BG 88 is home to the mechatronics workshop and the LiquiRob robot, one of the most unique products from the Linz location.

Heading inside we are immediately struck by the atmosphere. Like a scene from a sci-fi film, electronic and robotic components of varying shapes and sizes are organized throughout the immediate area. Each component is a part of a different order, designed to fulfill a specific task, tested for quality assurance, and ready to be shipped. From dedicated sensors and mechanical components to testing stations for »



“Linz can be defined as a world steel capital on the Danube, with one of the most cosmopolitan and dynamic communities of steel professionals.”

**Dr. Carlo Piemonte**  
Technical Sales Director



“A great connection between Linz and the rest of the world is the Ars Electronica Festival, attracting artists and visitors from around the world.”

**Anna Mayrhofer**  
Product Manager



“Global IT is in close contact with the IT departments worldwide and cross-border cooperation is underpinned by regular meetings that connect Linz to the world.”

**Joachim “Joe” Berger**  
Head of Digital Workplace Solutions



## ADVANCING ENDLESS STRIP PRODUCTION

Dr. Kerstin Baumgartner works as a process technologist at the Linz location. She is proud to be apart of the team working on ESP.

### What, in your view, are the biggest challenges facing the metals industry?

**Dr. Kerstin Baumgartner:** What's most clear is decarbonization and the integration of advanced digital technologies, such as artificial intelligence into production processes and operations. From strictly metallurgist perspective, I find it an exciting opportunity to see how the industry will develop new steelmaking solutions for certain products for an increasing scrap rate in the coming years.

### What technologies might help the industry overcome pressing challenges?

**Dr. Baumgartner:** Perhaps unsurprisingly, I find that Arvedi ESP is energy saving and a key contributor to decarbonization. The technology itself is fascinating—i.e., being able to connect a caster directly to a rolling mill, was a metallurgist's dream that has now become a reality. Furthermore, direct reduction and fluidized bed reactors will be a major asset in the implantation of hydrogen-based processes. I am excited to see my colleagues progress and advance new process designs and solutions for iron ore reduction.

### What makes the Linz location of Primetals Technologies unique?

**Dr. Baumgartner:** The density of specialists in one place is amazing. With a tremendous amount of expertise in-house, we benefit immediately from our colleagues working in various departments to advance our developments further.

various solutions, the workshop looks like an inventor's dreamscape. Straight ahead of us is the LiquiRob robot.

Oberschmidleitner elaborates that the mechatronic workshop is a point of pride for the Linz location. "Each solution, from the LiquiRob robot to sensors and expert systems are assembled and thoroughly tested here in Linz before leaving for the customer," she explains. Oberschmidleitner elaborates that these steps are essential to guarantee that each solution will function upon its arrival and can go directly into operation on-site. "The principle of our solutions is that they are easily implementable for our customers and if integration into a plant is essential, we have our engineering specialists directly here in Linz to assist," she adds. From nozzle and heat transfer tests to various simulations and models, the workshop is fully equipped to ensure the optimal product is delivered, including rigorous quality control and photo documentation with each product.

## TECHNOLOGY-ORIENTED, CUSTOMER-ORIENTED

Oberschmidleitner accompanies us back to BG 47 and tells us that there is one more building that is essential to all Primetals Technologies activities. Behind BG 47 is a small building—BG 74. Home to our IT department, BG 74 is at the center of our remote technologies connecting Linz to the rest of the world. From maintaining the security of our company's data to ensuring the connection for the remote commissioning center or live augmented-reality-assisted services activities, the IT center in Linz is a core element to our technologies.

In BG 47, we are met once more by Dr. Hirai, who shares with us some final impressions of how he feels Primetals Technologies is meeting customer needs around the world. "One key principle is that we are a crucial supplier of infrastructure to society," he remarks, with an in-depth discussion of why our focus rests on continuously innovating. He reveals that our technologies are designed with our customers and society in mind and providing breakthrough technologies to benefit our customers is the driving force that inspires us. "Society and our customers are at the heart of everything we do, it is why we are pioneers."

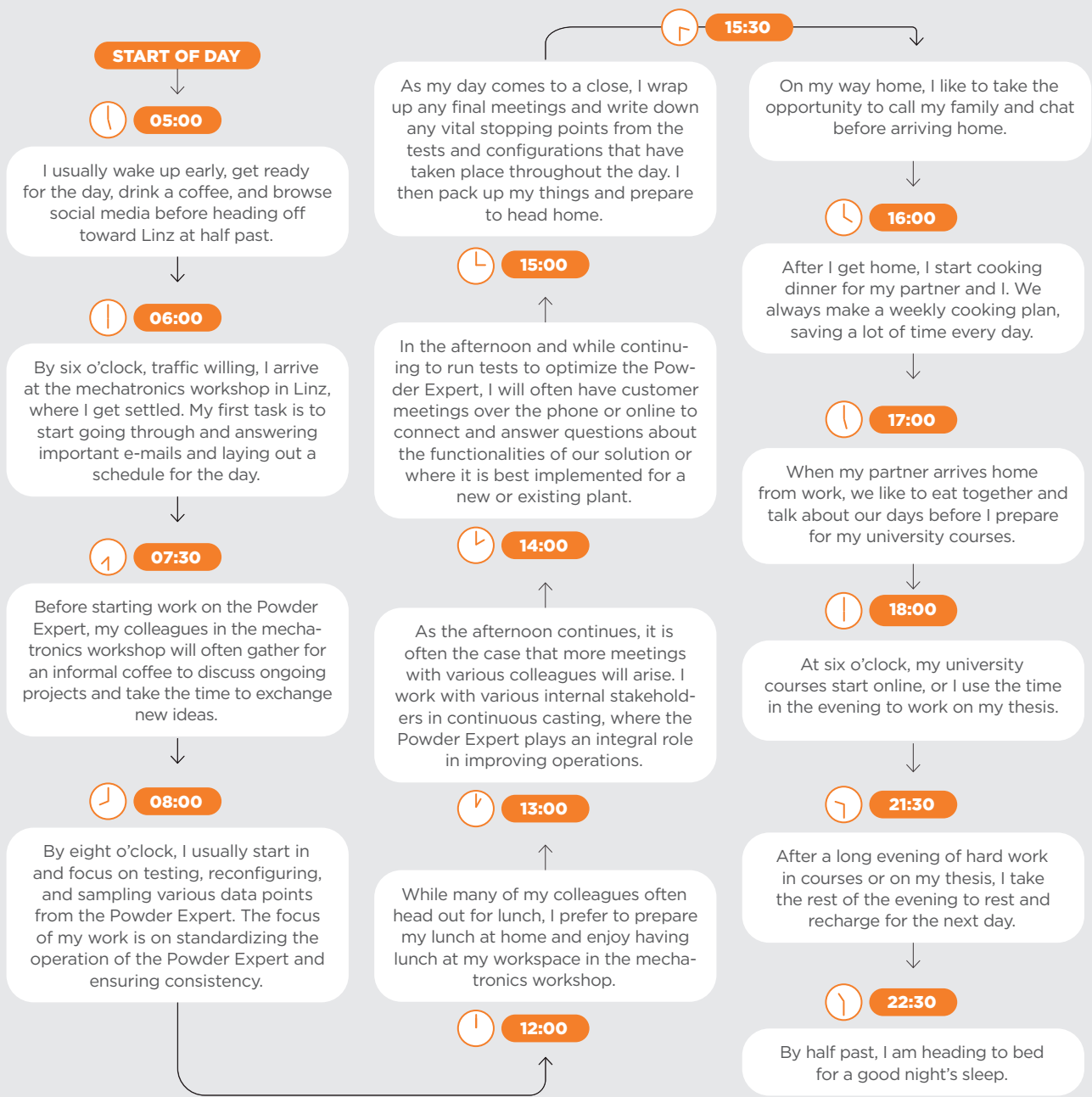
I bid Dr. Hirai farewell and Niederhuber and I return to our offices. Writing from Linz, the home of global marketing and communications and Metals Magazine, I reflect on what makes our location in Upper Austria so unique. The passion and drive of my colleagues and their approach to problem-solving makes me proud to be a part of a truly international company and at such an internationally-oriented location. Our global activities reach and impact customers and stakeholders worldwide and the Linz location of Primetals Technologies is truly connected to the world from the heart of central Europe.

# A DAY IN THE LIFE OF MARLENE OBERPEILSTEINER



**MARLENE OBERPEILSTEINER**  
Powder Expert Specialist

As part of the series “Visiting the Company Locations of Primetals Technologies,” we sit down with one employee of the respective location—with the aim of illustrating what a regular workday is like for them.



# EXPERIENCING THE LOCATION AND LINZ AREA



## DANUBE RIVER

The second largest river in Europe, beginning in Germany ending in Romania, is a key aspect of the Austrian city. Near the city center, citizens of Linz can be seen along the river throughout the year walking along the “Donaulände”—a park stretching the length of the river between the Niebelungenbrücke and the new Railway Bridge, home to the outdoor sculpture gallery “forum metall” (see page 94) to everyone.

## ARS ELECTRONICA CENTER

Dubbed the “Museum of the Future,” the Ars Electronic Center is an interactive museum oriented toward a progressive future, where art, science, and technology meet in harmony. Exhibitors are from all around the world and often participate in the annual Ars Electronica Festival in late summer.



## PÖSTLINGBERG

Linz’s “mountain” is a 539-meter hill on the northern side of the city. The basilica, located at the highest point of the mountain, is immediately recognizable, featuring two spires. The Pöstlingberg is also home to the Grottenbahn, “the home of the dwarves,” a popular attraction capturing the enchantment of fairytales in the mountainside. Finally, the journey to the top is also unique, in a ride in the Pöstlingbergbahn, the steepest adhesion railway in Europe.

## NEW RAILWAY BRIDGE

Linz is currently home to four bridges accessible by car, the newest of which is the “Eisenbahnbrücke.” Opening in 2021, the structure welcomes cars, buses, cyclists, and pedestrians to cross the 400-meter-long bridge equipped with a total of 1650 tons of reinforced steel. The bridge also breathes new life into the banks of either side of the river, offering up additional space for recreation on the river’s edge.



## HOLY TRINITY COLUMN

Located in main square of the city center, the Holy Trinity Column is a 20-meter-high column completed in 1723 and dedicated to the Holy Trinity for protection against fire, war, and plague. The “Hauptplatz” is one of the largest enclosed squares in Austria and was an integral part to the economy of the Austrian city. With a gilded top, the white marble column is a unique characteristic of Linz’s city center.

## PROMOTING INNOVATION IN LINZ AND AROUND THE WORLD

Dr. Etsuro Hirai is the CEO of Primetals Technologies Austria and the CTO of Primetals Technologies around the globe. Dr. Hirai began at Primetals Technologies in 2015 and worked as CTO of Primetals Technologies in London from 2015–2017. From London to Hiroshima, he has worked as the CEO at Primetals Technologies Japan with a focus on downstream technologies. Transferring to Linz in 2020, Dr. Hirai brings his background from Mitsubishi Heavy Industries to his role. Living and working in Upper Austria, he admires and promotes the innovative spirit of the Austria location and values the passion for green steel that the Linz location spreads worldwide.



### What was your experience, arriving at the Linz location of Primetals Technologies?

**Dr. Etsuro Hirai:** My arrival at Linz was not what you would expect. Due to travel restrictions in 2020, I was unable to travel to Upper Austria. Thus, my first day at the Linz location of Primetals Technologies began in Tokyo, Japan. However, after I arrived, I felt welcomed at the Linz location and enjoyed getting to know an entirely different aspect of Primetals Technologies.

### What makes the Linz location of Primetals Technologies so different?

**Dr. Hirai:** In 2020, I was arriving at the Linz location from Japan, which really can represent two sides to metals production. In Hiroshima, the competencies are centered around downstream technologies. In Linz, it is exactly the opposite—i.e., upstream technologies—and this is built into the unique atmosphere here.

### By atmosphere, do you mean the culture in Upper Austria?

**Dr. Hirai:** Certainly, you could call it culture. You see when you arrive at Primetals Technologies you notice immediately our neighbors—voestalpine. Between our geographic location and the long history in the iron and steel industry, the location is passionately focused

on this aspect of the metals industry. It is a type of mindset that exists because of our close connection to industry partners. In Linz, you are embedded in a history, a culture, of upstream engineering and innovation.

### With upstream competencies centered in Linz, what is the impact of industry trends, such as green steel and digitalization?

**Dr. Hirai:** Green steel has become a great term for our technologies. When I began working at Primetals Technologies in 2015, I anticipated the future of the industry to be in ecological processes. In 2015, “ecological” was the term that was utilized for “green” technologies, but what’s important is that the industry has truly begun a transformation toward environmentally friendly production routes. This is a key factor for upstream processes, such as the blast furnace. Replacing the blast furnace is essential to a sustainable society and sustainable infrastructure and solutions, such as hydrogen-based direct reduction, are the path forward.

### Is hydrogen-based production the future of iron and steel production?

**Dr. Hirai:** The idea of the reduction of iron with hydrogen has been around for some time, but the availability of hydrogen and motivation to produce large amounts



“Reflecting on my experiences, I encourage my colleagues in management to think of the future and what the world will look like moving forward.”

**Dr. Etsuro Hirai**

CEO of Primetals Technologies Austria  
& CTO of Primetals Technologies, Ltd.

of hydrogen were missing. Today, society recognizes that hydrogen is an ideal element to be used in heavy industry, but the availability of hydrogen is the biggest challenge, and this is combined with the challenge of the energy transition. Hydrogen-based production and a push toward green steel are rapidly reshaping the industry.

**As the iron and steel industry progresses, will transformations in the energy sector be enough to keep up with the demand for hydrogen?**

**Dr. Hirai:** This defines one key factor of our business—i.e., long-term perspectives for society and innovation. I brought my philosophies from Mitsubishi Heavy Industries with me to Linz and one of them is defining our role as a supplier of societal infrastructures. Primetals Technologies provides the foundation for the iron and steel industry. MHI's core is in the energy sector, and I see great potential for synergy between our activities. This is what it means to supply infrastructures to society, that is, thinking off all sectors working together to benefit society through technology.

**You mentioned your philosophies, how would you describe your values as a leader?**

**Dr. Hirai:** I often reflect on my arrival in Austria, and I remember explaining to my colleagues that in Japanese there is no word for leadership. We say leadership in Japanese because there is no direct translation, but we do have a concept of what it means to be a leader. For me, it means providing direction and setting the right tone. In the first case, I look to my experiences in the industry and encourage my colleagues in management to think of the future and what the world will look like moving forward. I believe this is part of creating direction for my colleagues. Secondly, I have talked quite a bit about atmosphere, and this is key when you are a leader. You could also say setting the right tone, but the idea is about creating a team and for that I refer to two words: honesty and transparency. This has helped me break down barriers and create a teamwork atmosphere. I follow these same principles, which I believe sets the tone when meeting with managers and employees.

**As technology advances, how does this impact our role as a supplier?**

**Dr. Hirai:** Our development runs parallel with societies development and our technologies for production are dependent upon the demands of society. Events such as the pandemic have introduced more remote work into our business, and we are expanding our digital portfolio and infrastructure to better meet the needs of our customers. We will continue to innovate in this way and transform our business as a supplier to meet the future demands of our customers.

**What recent technological developments do you feel will reshape society?**

**Dr. Hirai:** There are two technologies that I feel will reshape society in the next 10 to 20 years. The first of these technologies is artificial intelligence. Artificial intelligence has become a rather trendy topic recently, but it has demonstrated the potential to develop rapidly. This makes it an extremely exciting technology with almost unlimited potential. The second is quantum computing. Although the broader availability of quantum computing remains ambivalent, I feel that this technology, combined with artificial intelligence, will fundamentally change society. These technologies would allow for computers to advance beyond human capacities, predicting phenomena, transforming encryption and processing. It would even make driverless cars possible. When these two technologies come together, it will be fascinating.

**What questions remain open for society in the future?**

**Dr. Hirai:** We have discussed the importance of hydrogen moving forward for heavy industry and society and with that energy. However, personally, I think that hydrogen is not necessarily the final development for our future. Various unknown technologies and processes based on biological, chemical, quantum, and nuclear discoveries will emerge and lead us. We need to watch carefully how the future develops. ●



# THREE PHASES TO GREEN STEEL

THE SUSTAINABLE METALS REVOLUTION

1.

## THE OPTIMIZATION PHASE

Readily available solutions  
for sustained impact



**3.**

**ACHIEVING  
GREEN STEEL**

The new standard  
of production

**2.**

**THE TRANSITION  
PHASE**

Redefining metals  
production



Green steel, as a term, has come to define a global transformation taking place in the metals industry. With the emergence of artificial intelligence, energy transitions, and new groundbreaking technologies, metals producers are participating in a global revolution for heavy industry. At its core are sustainability principles, fundamentally changing how metals are produced.

As an emitter of 7 to 10 percent of global carbon emissions, the iron and steel industry is positioned to redefine its role in the sustainable future of society. Steel is a highly sustainable product that is nearly infinitely recyclable and crucial to the infrastructure necessary for developing industries, including e-mobility and renewable energy. However, the amount of CO<sub>2</sub> generated from crude steel production is nearly double that of steel produced. With readily available technologies, the industry is transforming toward one defined by decarbonization and eco-friendly production routes.

### ECO-FRIENDLY GLOBAL DEMAND

Without question, climate change is playing a decisive role across the globe, impacting politics, trade, industry, the environment, and society. In response to climate change, more and more countries are pledging to reach carbon-neutral targets within the coming decades. Following COP27 in Sharm-El-Sheik, Egypt, 153 countries have now proclaimed net-zero targets and discussed a complete phase-out of coal in industry. Focusing on global steel production, with 153 countries setting net-zero targets, approximately 90 percent of the steel industry also has carbon-neutral targets. To this end, many steel companies have set CO<sub>2</sub> reduction targets for 2030 and carbon neutral targets for 2050, with an average target of a reduction of 34 percent by 2030.

Recognizing that the transformation of this vital industry rests not merely with steel producers themselves, the E.U. has begun to implement carbon pricing mechanisms to fund eco-friendly investments. The E.U. Emis-

sions Trading System (ETS) and the Carbon Border Adjustment Mechanism will motivate a steady decline in carbon emissions from “hard to abate” industries. (For more on emissions trading systems and carbon pricing, see “The Cost of Carbon” on pages 86–89). These pricing mechanisms are designed to limit carbon emissions through the trade of carbon certificates and contribute directly to funding projects, such as the Clean Steel Partnership and Carbon Contracts for Difference.

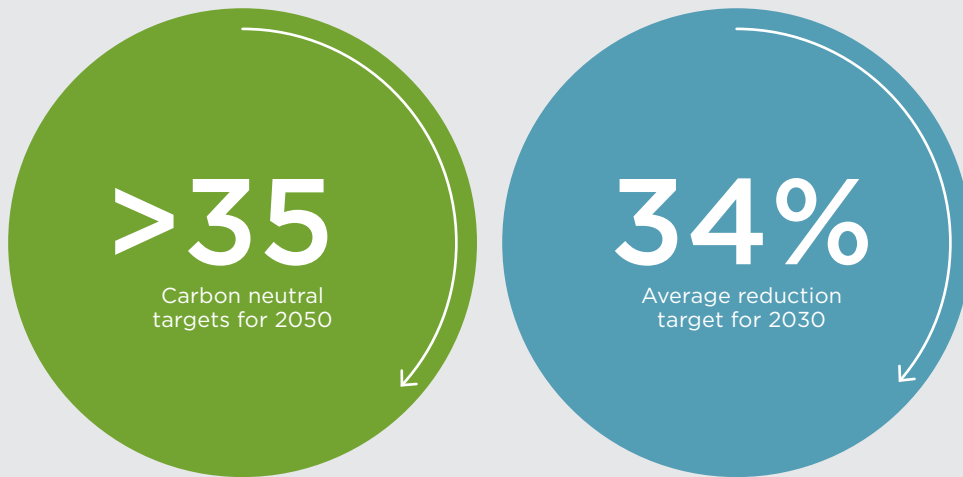
### A TRANSFORMATION IN PHASES

What is fundamentally clear amidst the challenges and pressures to decarbonize the industry, is how deeply steel is engrained in our society and how vital it is to our sustainable future. Moreover, these demands for eco-friendly production coincide with a steady increase in green steel demand. Alongside increased demand, a premium price for green steel will emerge, funding the transformation of production routes and creating a sustainable steel industry.

Commitments from leading European steel producers like voestalpine, ArcelorMittal, thyssenkrupp Steel Europe, and Salzgitter set the tone for the rest of the industry worldwide. These commitments are transitioning into actions. Whether bold or calculated, industry leaders at the forefront of this transition will reach decarbonization targets for the betterment of their businesses and society. Moreover, this transition will not occur overnight. Our specialists are well-versed in the need for calculated action in an industry as impactful as this. With this in mind, we present the three phases to green steel. »

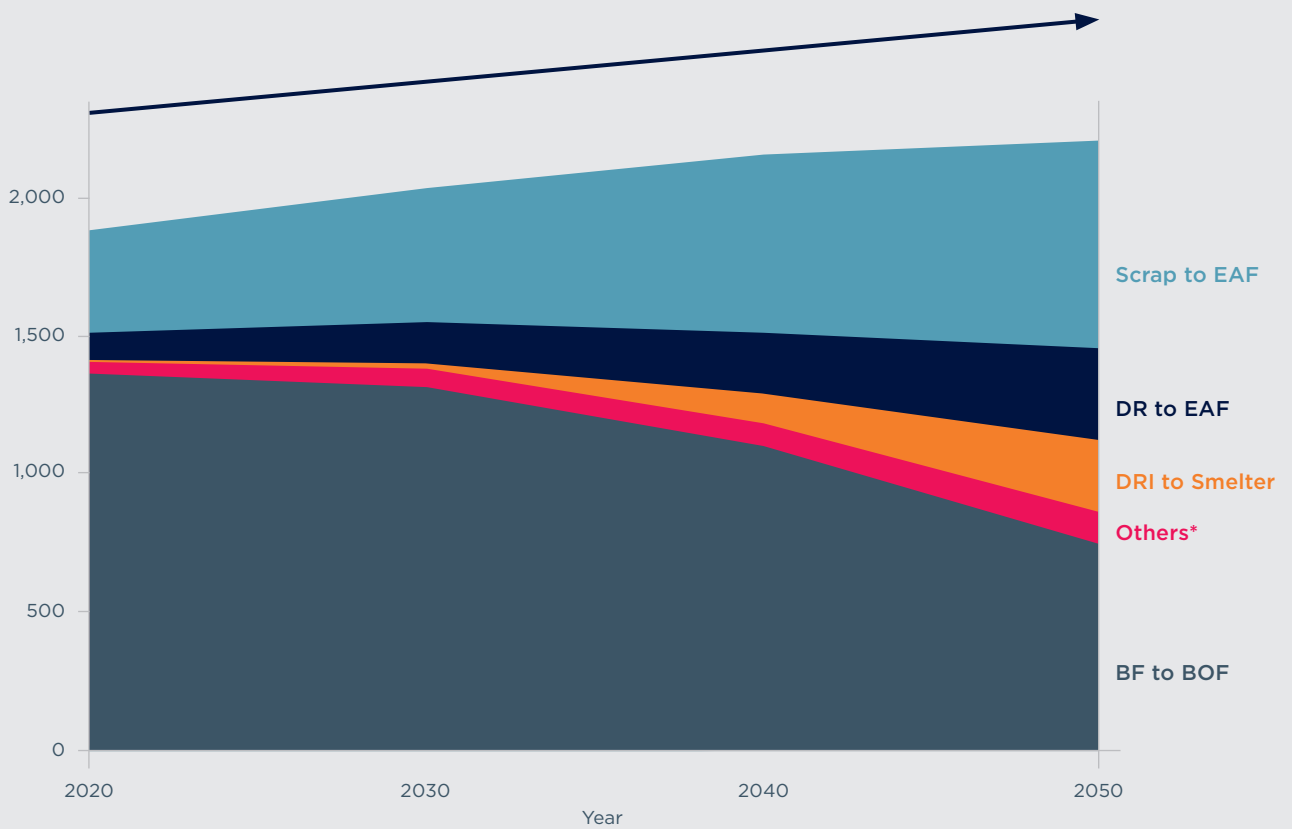


### CO<sub>2</sub> REDUCTION AND NEUTRAL TARGETS FOR 2030 AND 2050



**FIG. 1:** Major steel companies around the world have already declared carbon neutral targets for 2050 and are reaching their goals ahead of schedule with interim targets for 2030.

### STEEL PRODUCTION VOLUME BY ROUTE



**FIG. 2:** Experts at Primetals Technologies anticipate clear growth in electric steelmaking, direct reduction, and Smelter application heading toward 2050.



THE TRANSITION PHASE

ACHIEVING GREEN STEEL

# THE OPTIMIZATION PHASE

## READILY AVAILABLE SOLUTIONS FOR SUSTAINED IMPACT

Today, the technological landscape of the metals industry, filled with readily available technologies, offers ideal opportunities for producers to begin their transformation toward a sustainable production process. What's more, when implemented with the future in mind, these solutions will lay the foundation for decades of advancement.

Developed over 70 years ago, the LD process (basic oxygen furnace) revolutionized the steel industry. Today, the blast furnace (BF) and basic oxygen furnace (BOF) route comprise approximately 70 percent of worldwide steel production. However, around 1,770 kilograms of CO<sub>2</sub> per ton of steel is emitted from coke plants, sinter plants, and blast furnaces during pig iron production. In the BOF, an additional 170 kilograms is added as the iron is refined into steel. These figures present the most significant challenge for many producers on the path toward decarbonization. For pioneers, these figures are an opportunity.

### IMMEDIATE POTENTIAL

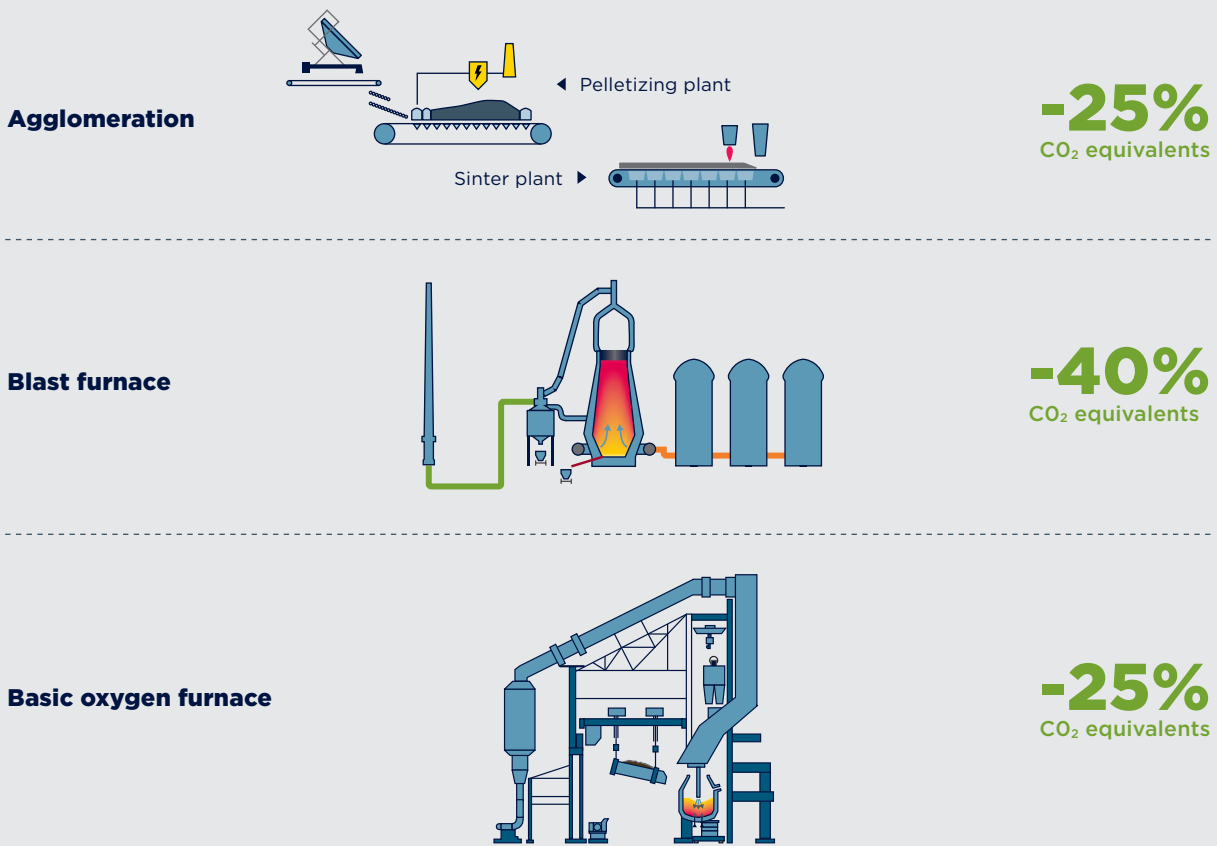
As increased pressures to improve the environmental impact of the steel industry emerge throughout the world, the immediate opportunities available to producers can see their CO<sub>2</sub> emissions reduced by approximately 30 percent by investing in technologies to improve material and energy efficiency. The potential

of these improvements also translates to increased yield and performance and reduced maintenance costs. Zeroing in on the two most predominant assets in the BF-BOF route, optimal improvements to the blast furnace and basic oxygen furnace can help reduce emissions by improving performance and efficiency.

The Sequence Impulse Process (SIP) developed with thyssenkrupp AT.PRO provides immediate improvements to blast furnace performance, shifting the coal-coke ratio to more coal. SIP functions, in summary, by producing pulsations of oxygen into the blast furnace in addition to the existing air flow. The opening and closing of the valve rapidly allow for deeper penetration into the raceway and improve the conversion behavior of the coal and coke. The results mean that cheaper injection coal can be utilized in the blast furnace, and thanks to improved throughput and drainage, production can also increase.



## REDUCTION OPPORTUNITIES IN THE OPTIMIZATION PHASE



**FIG. 3:** Upstream processes demonstrate immediate potential for CO<sub>2</sub> emissions reduction, most of which can be achieved with reasonable alterations to the production process.

Remaining with the blast furnace, the energy consumption of the blast furnace, in addition to its carbon emissions, also makes up about 75 percent of the total energy consumption of a steel plant. Top-gas Recovery Turbines (TRT) take the off-gas pressure and turn it into mechanical and electrical energy. Furthermore, for blast furnaces undergoing a relining process, copper staves from Primetals Technologies also offer increased fuel efficiency by five percent and a slight reduction in carbon emissions.

### INCREASED SCRAP USE

The increased scrap use in steel production is a clear focal point throughout all phases progressing toward green steel, from applications in the BOF to electric steelmaking. As a nearly infinitely recyclable material, steel is inherently sustainable. However, from scrap sorting to increasing scrap rates in existing integrated plants lies an immense opportunity for decreased emissions and improved efficiency.

Integrated steelworks operating a basic oxygen furnace confronted with the challenge of reducing carbon emissions may often turn to increased scrap use, but this is not without its challenges. Firstly, scrap logistics from the scrap yard presents a primary problem for producers that will continue even as producers transition to electric steelmaking. While the transportation of scrap to the meltshop is an essential consideration for interplant logistics, scrap sorting and separation are vital. By partnering with SICON, Primetals Technologies has developed “crafted scrap.” A term associated with both innovative automation and digital solutions as well as an improved standard for scrap, crafted scrap refines scrap coming from the scrap yard, improving on the status quo, which has producers operating on a “worst-case-scenario” basis. In the future, scrap supplies will contain low amounts of contaminants that ensure the production of high-quality scrap-based steel as more producers adopt scrap sorting solutions into their plants.



**FIG. 4:** Injection units located above the casting platform at thyssenkrupp's plant in Duisburg. SIP has already demonstrated improvements in performance and a reduction in emissions.

### EMISSIONS REDUCTION IN THE BOF

Beyond scrap sorting solutions, the BOF also has immense potential regarding an increase in scrap use. However, current BOF operation limits the amount of scrap processing from 15 to 20 percent. Thankfully, available solutions can increase the scrap rate. Firstly, as with many optimization solutions, the application of process models and digital solutions can reveal the ideal melting conditions of the converter to operators, reducing the use of cooling agents to reach the ideal tapping temperature late in the production process. Process models for the BOF from Primetals Technologies decrease the number of reblows, stabilizing production, which preserves the energy required for scrap melting and helps reach target temperatures.

Scrap preheating can also provide immediate benefits and reduce the energy required to melt scrap in the BOF. Heating scrap to an average of 800 degrees Celsius using a burner lance and natural gas can increase the scrap rate by approximately five percent. Implementing a dual-flow post-combustion lance can also increase the rate of CO combusted to CO<sub>2</sub> from 12 to 20 percent, where a second control line allows for additional oxygen injection for post-combustion. Finally, the Jet Process utilizes a bottom-blowing con-

verter with lime, coal injection, and hot-blast lance for the highest-possible post-combustion in a BOF. This process ensures the maximum use of chemical energy from the coal with an efficiency greater than that of an electric arc furnace using electricity from a coal-based power plant. By implementing the previously mentioned solutions, the scrap rate can increase to as much as 30 percent. However, thanks to the bottom-blowing converter technology of the Jet Process, the scrap rate in the BOF can reach 50 percent, and thanks to the efficient use of coal, carbon emissions are nearly 40 percent lower.

### OPTIMIZING FOR A TRANSITION

The technologies listed are just the beginning of an immense portfolio of readily available technologies designed to optimize production routes and energy efficiency. With these solutions in mind, producers can rest assured that they will see a rapid return on their investment, securing the additional capital for transitional technologies. Furthermore, the foundation of a sustainable future for the industry consists of many of these technologies. From scrap sorting to increased scrap rates in the BOF, these technologies will benefit electric steelmaking and increased use of HBI, respectively, as producers transition toward green steel. ➤





## DIGITAL DECARBONIZATION

Digitalization is essential for material and energy efficiency, from measurement technology to data management. Today, producers no longer look at individual assets but optimize the entire production process from raw material input to finished steel. These technologies are crucial to a sustainable metals industry.



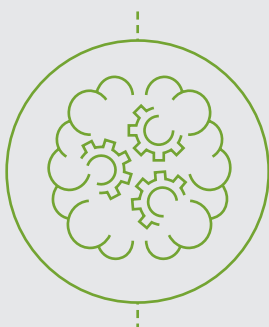
### CREATING HARMONY

When implementing solutions for optimizing production routes, the number of digital and automation solutions can often appear as daunting as the data they will process. Terms like “data lakes,” “machine learning,” and “data processing and analysis” are becoming commonplace in an industry traditionally focused on the quintessentially tangible. The network of the actual steel plant, recorded by sensors and process models, lies beneath the surface of digital tools and solutions. Producers benefit from seeing their entire production route transform into a digital orchestra, where each asset and component of the process interact in perfect harmony.



### ELIMINATING DOWNTIME

Unscheduled downtime can be detrimental for a metals producer. Thanks to digital twins, automation tools, and software, unplanned downtime can become a thing of the past. When implementing new solutions, changes to logistics, assets, and operations can be tested for a plant’s offline digital twin, and simulations can inform real-world operation. Moreover, with the installation of a digital and automation infrastructure, digital assistants provide continuous updates analyzing the conditions of assets, allowing for predictive maintenance. Digitization also facilitates plant maintenance, including condition monitoring and spare part orders.



### ANTICIPATING CHANGES

On the journey toward green steel, through-process digital solutions play an essential role in laying the foundation for a sustainable metals industry. What’s essential is that the transformation of production toward a digital and automated process translates into a seamless integration of new technologies and emergent green steel technologies down the line. These solutions optimize current production and accelerate transformation. Producers forging a path toward green steel by transitioning their production to one reinforced by digital tools, are securing success for decades.



THE OPTIMIZATION PHASE



ACHIEVING GREEN STEEL



# THE TRANSITION PHASE

## REDEFINING METALS PRODUCTION

New technologies have emerged that are redefining production. With an increased demand for steel, these technologies provide an opportunity for sustainable transition while increasing performance and yield. Metals production is being redefined as production routes shift toward direct reduction and electrification.

While the BF-BOF production route dominates the steel industry, the realities of this route present tremendous opportunities for sustained success. In a cycle of approximately every fifteen years, blast furnace relining occurs. With about 70 percent of all blast furnaces requiring relining by 2030, producers can decide whether to reinvest in the blast furnace or to convert their production toward green steel. The time to transition toward green steel is here.

### TRANSFORMING RAW MATERIALS

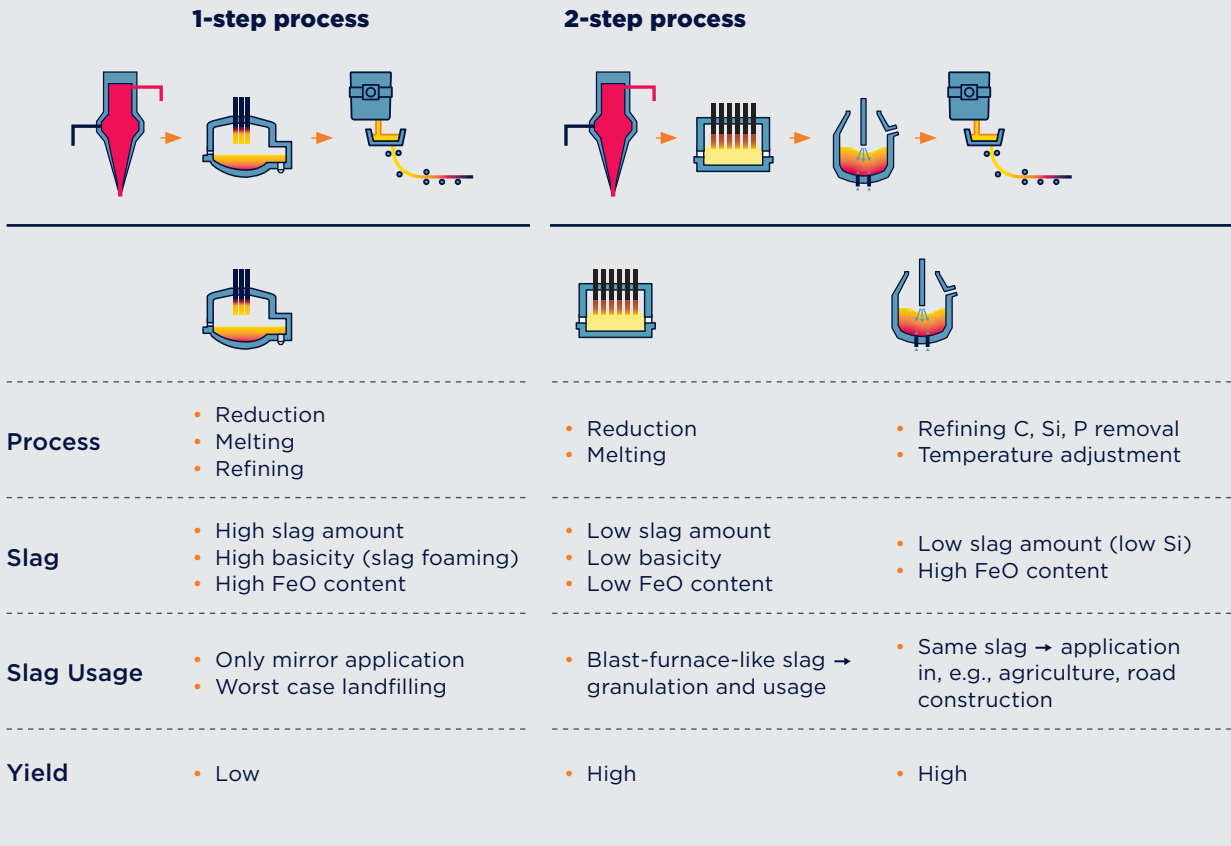
The blast furnace is one particular focus of the transition toward green steel, the most significant contributor to carbon emissions in the steel industry. However, despite the challenges associated with replacing the blast furnace, innovations for the direct reduction of iron ore offer immediate emissions reduction opportunities. New emergent technologies can accelerate a return on investment to make direct reduction a key part of a plant's transformation.

The MIDREX direct reduction process has gained traction worldwide as one of the most standard processes for the direct reduction of iron ore with immediate benefits for the reduction of CO<sub>2</sub> and the production of high-quality merchant hot-briquetted iron (HBI). HBI is a valuable material due to its ability to be easily transported worldwide, implemented in existing integrated steel plants, and used in electric steelmaking. Moreover, a MIDREX direct reduction plant operating entirely on natural gas significantly reduces overall emissions compared to a blast furnace. Capable of 100 percent hydrogen operation, MIDREX plants can transition as the hydrogen economy expands.

With immense numbers of direct reduction plants to be built in the coming years, one additional challenge for producers is the low amount of high-grade iron ore on the market. The Smelter, an innovation for melting low-grade hot charged direct reduced iron, was developed to take advantage of an increased amount of low-grade



# STEEL PRODUCTION WITH LOW-GRADE IRON ORE



**FIG. 5:** With the implementation of direct reduction, producers considering a transition to electric steelmaking may implement a two-step process into existing plants for low-grade iron ore.

iron ore on the global market. (Read more about the Smelter from Primetals Technologies on pages 66–71) With liquid hot metal coming from melting low-grade direct reduced iron in the Smelter, producers can take advantage of direct reduction’s carbon emissions reduction capabilities while still operating a BOF-dominant meltshop. Operating on electricity, the Smelter is also a characteristic sign of further transformation in the industry—the electrification of production.

### ELECTRIFICATION OF PRODUCTION

Today, scrap-based electric steelmaking offers producers the most environmentally friendly means of steel production. One key consideration for producers implementing and transitioning to electric steelmaking is incorporating an electric arc furnace into existing meltshops, replacing a BOF. By investing in electric arc furnaces while continuing operation with existing assets, producers can cater to and anticipate any necessary changes to plant logistics. Once online, the

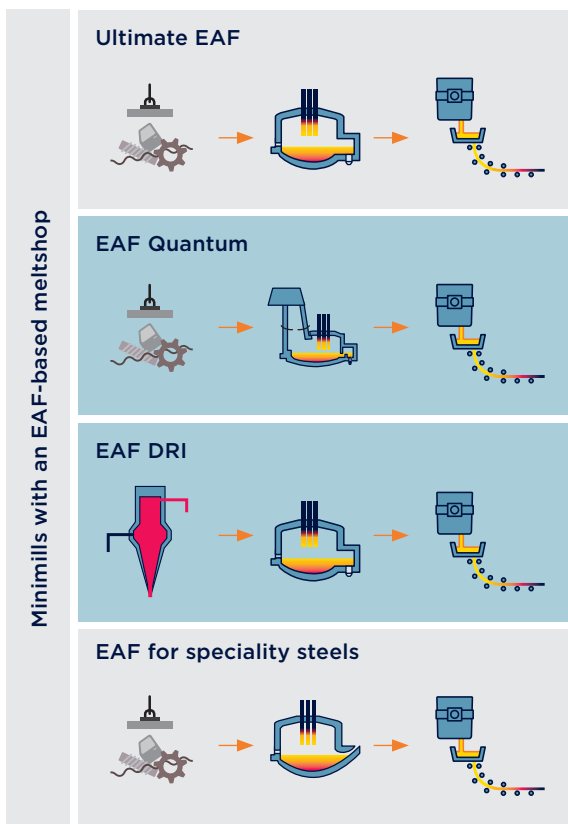
electric arc furnace can take on the lion’s share of steel production, lessening the impact of replacing further BOFs. With an EAF online, producers can immediately take advantage of the environmental advantages, including 100 percent scrap charging and increased direct reduction.

Primetals Technologies has two primary electric arc furnaces for the transition to electric steelmaking: the EAF Ultimate and EAF Quantum. Each with similar advantages, including fast tap-to-tap time and proprietary automation solutions for efficient energy regulation, these electric arc furnaces are oriented toward a sustainable steel industry. The EAF Quantum also features scrap preheating, making it ideal for scrap-based steelmaking. With shifts toward electric steelmaking on the horizon, capacity and energy consumption are primary concerns for which these electric arc furnaces meet the capacity demands of the industry while maintaining energy efficiency. »

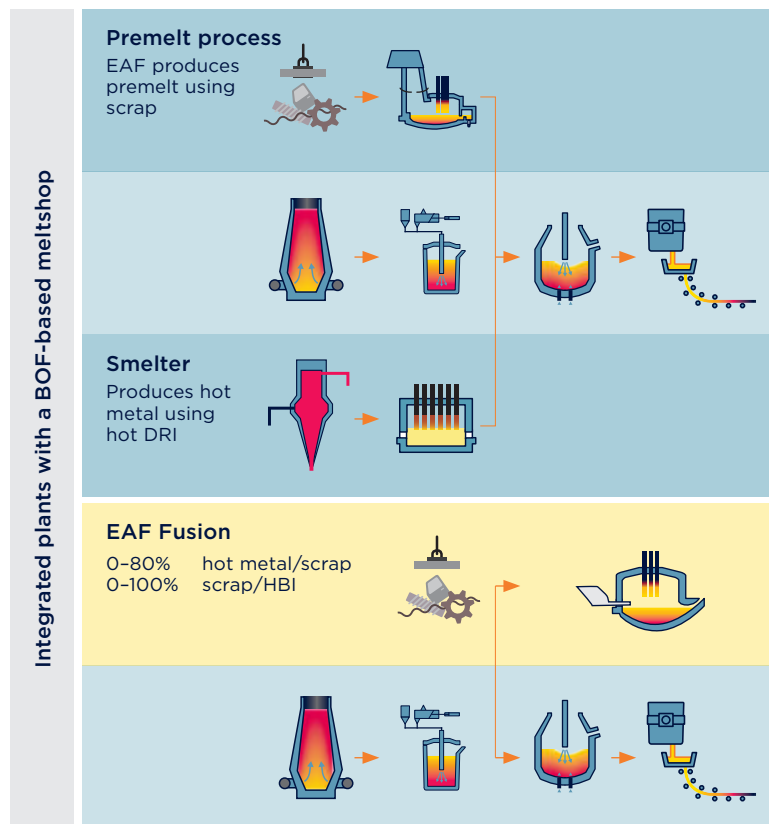


## READILY AVAILABLE TECHNOLOGIES

### Minimills / Integrated plants



### Integrated plants



**FIG. 6:** For an electric steelmaking transition, how production routes function and interact is essential. Illustrated are various applications of electric steelmaking from minimills to integrated plants.

### STREAMLINING QUALITY END PRODUCTS

Whether incorporating changes into the raw material value chain or the meltshop itself, downstream production processes, such as continuous casting and rolling, present further immediate improvement opportunities. Fulfilling the Best Available Technologies requirements for near-net shape casting, Arvedi ESP is the most advanced, energy-efficient, and compact means of immediate casting and rolling of direct application end products. The process effectively shortens the entire production chain, allowing producers to go from liquid metal to rolled end products in record time with less energy consumption and in an ultra-compact format, removing additional reheating steps.

Arvedi ESP benefits from nearly fifteen years of references and experience to become a reliable solution for hot-rolled end products. For revamping projects or producers looking to build efficient plants by integrating direct reduction, electric steelmaking, and endless

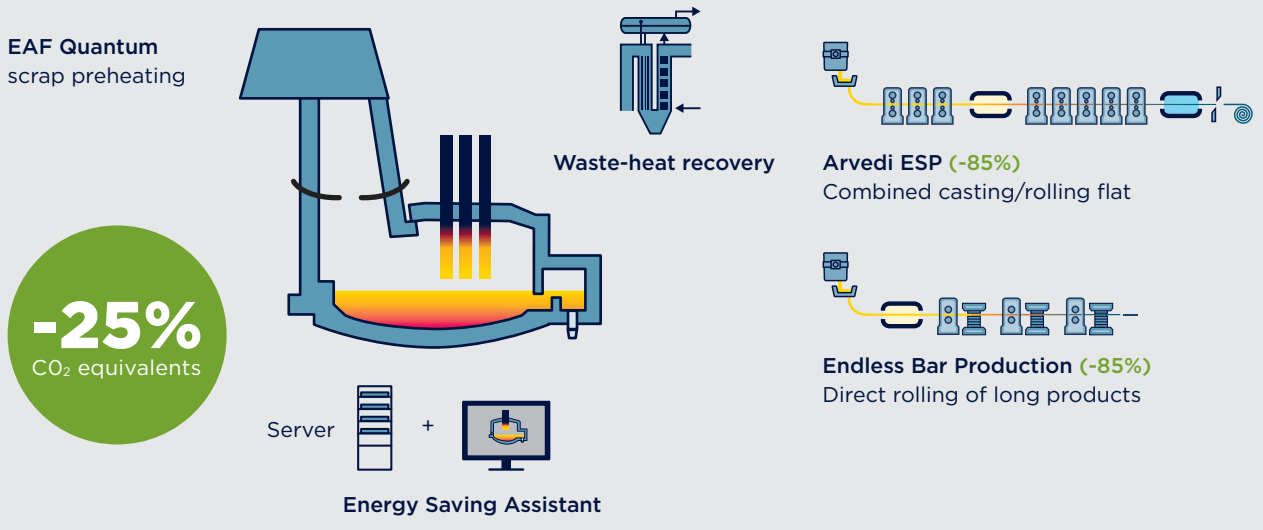
strip production (ESP), the possibility to transform production routes comes with lucrative opportunities to meet growing demands for high-quality steel, while securing one's position on the global market by avoiding setbacks incurred through rising prices of carbon emissions certificates and the implementation of carbon taxes.

### FROM INDUSTRY TREND TO REALITY

These improvements represent ideal opportunities for leading producers to gain a competitive edge. They redefine steel production and lay the foundation for a carbon-neutral steel industry. As global shifts toward sustainability impact various industries, including e-mobility, renewable energy, and hydrogen, the metals industry is in a key position to turn a global trend into reality. By investing in these transformative technologies, the global metals industry can serve as a model of how heavy industry can reach carbon neutrality and achieve green steel. »

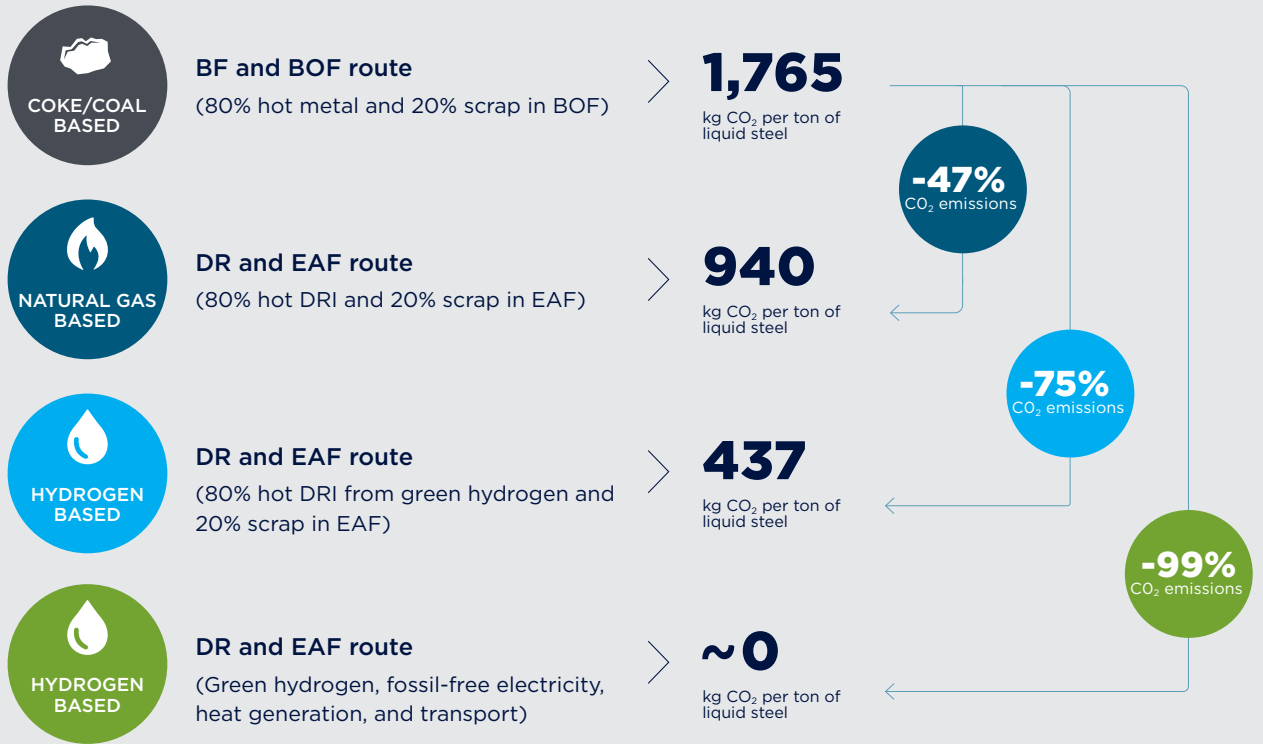


### EAF EMISSIONS REDUCTION POTENTIAL



**FIG. 7:** Combining electric steelmaking with endless casting and rolling solutions, such as Arvedi ESP, reveals immediate potential for emissions reduction.

### COMPARISON OF EMISSIONS BETWEEN ROUTES



**FIG. 8:** Comparing CO<sub>2</sub> emissions of different process routes for liquid steel. Unless otherwise noted, calculations are based on emissions from electricity production on European OECD level.



THE OPTIMIZATION PHASE

THE TRANSITION PHASE



3.

# ACHIEVING GREEN STEEL

## THE NEW STANDARD OF PRODUCTION

The transformation of the global metals industry is underway. The steel industries focus on decarbonization, and reducing their environmental impact defines the path forward for sustainability. Green steel is a term that has come to represent sustainable initiatives and a focus on eco-friendly technologies. With producers already beginning their optimization and transition to green steel, reaching sustainable targets are no longer a theoretical possibility.

Ninety percent of the steel produced worldwide is in countries that have pledged carbon-neutral goals in the coming decades. As seen in the previous phases toward green steel, the potential for carbon emissions reduction is significant. Implementing the latest technologies and those currently in development will secure a new standard of production, redefining steel as a low-carbon and sustainable product for the globe.

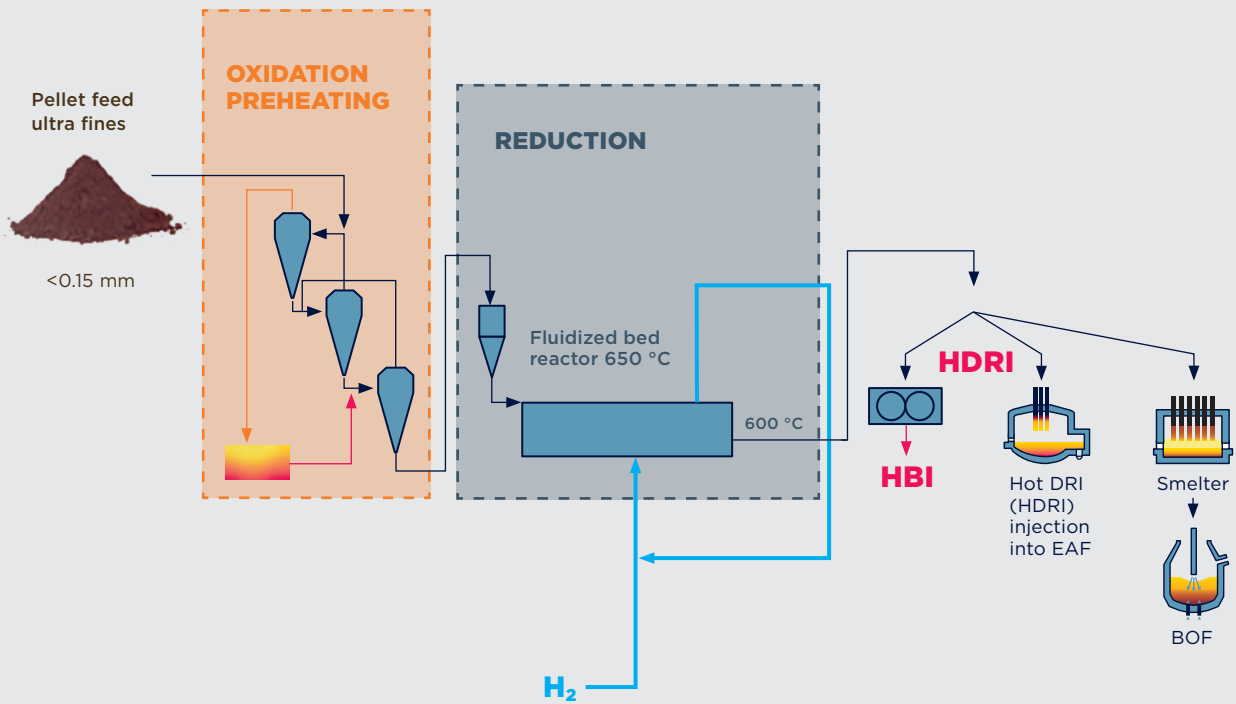
### CARBON DIRECT AVOIDANCE

Green steel can be defined as an approach to metals production that focuses on the direct avoidance of carbon emissions altogether. Technologies for the direct reduction of iron ore represent one piece of the puzzle for avoiding carbon emissions. MIDREX direct reduction and hydrogen-based direct reduction processes, such as HyREX and HYFOR, avoid carbon emis-

sions to reduce iron ore, utilizing hydrogen as the reducing agent. Hydrogen-based reduction with the Smelter powered by renewables leaves a manageable amount of subsequent carbon emissions on the way to the refining process. Hydrogen-based direct reduction of iron ore fines (HYFOR) also circumvents the beneficiation process and allows for the direct reduction of iron ore fines, sparing additional energy costs and emissions. Primetals Technologies is investigating an industrial demonstration plant in Linz, Austria, with voestalpine and the mining company Fortescue for this unique fluidized bed-based direct reduction technology—HYFOR—which combines with the Smelter solution to produce green pig iron. However, the impact of the iron and steel industry's transformation will be felt in adjacent industries and help progress a global shift toward sustainability. »

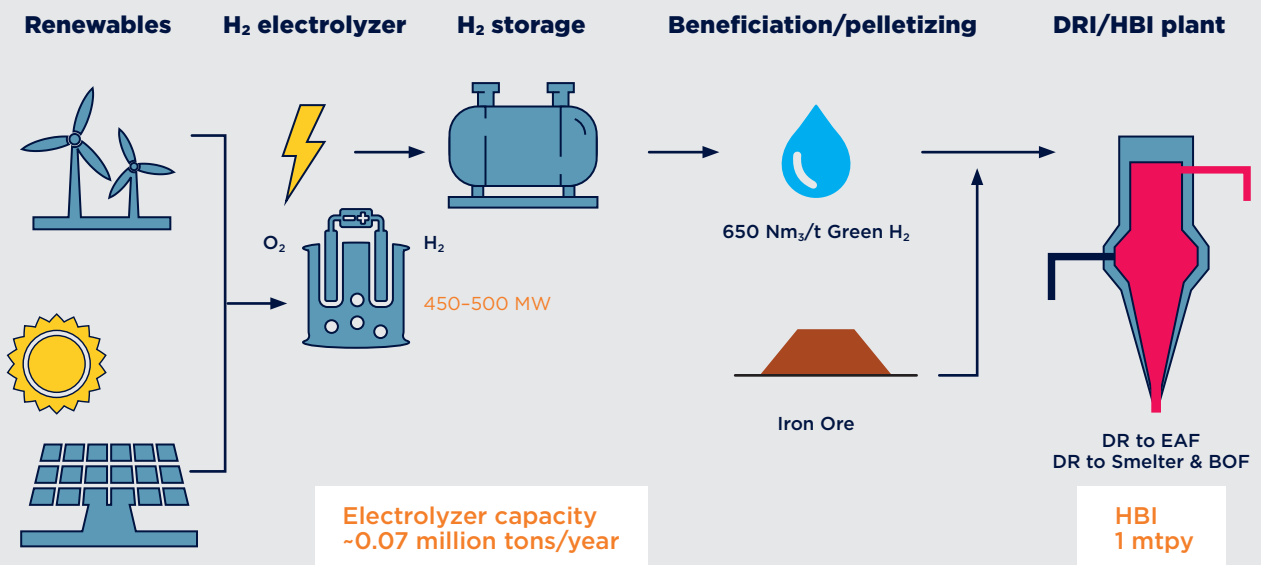


### HYDROGEN-BASED FINE-ORE REDUCTION (HYFOR)



**FIG. 9:** Depicted above is a flowsheet for Hydrogen-based Fine-Ore Reduction, or HYFOR, an essential technology defining the future of the steel industry.

### THE ENERGY TRANSITION



**FIG. 10:** A transition to hydrogen-based production is a crucial motivator for the energy sector to rapidly transition along with the steel industry toward renewable energy for the production of green hydrogen.



## EXPANDING MARKETS AND OPPORTUNITIES

The amount of energy required to produce steel is immense. Transferring the weight of production from a carbon-heavy production process to one based mainly on electrical energy may appear daunting, but it presents exceptional opportunities for the steel industry. The expansion and application of renewables to produce green energy will require revitalization and expansion of the energy sector in favor of new technologies, which require vast amounts of steel. Expansion of renewable energy technologies implies that, amid the energy transition, steel producers can manufacture the steel that will create the foundation for their sustainable future. Moreover, digital technologies, combined with waste heat recovery and gas recycling, encourage energy preservation, providing exceptional opportunities to keep energy costs low.

The market for renewable energy is set to expand to support heavy industry alongside the hydrogen economy. Hydrogen plays a key role in the chemical processes associated with green steel. Already, producers are focused on incorporating hydrogen production into their plant infrastructures—e.g., H<sub>2</sub>Future, a pilot facility to test the application of hydrogen in steel production, located at voestalpine's steelworks in Linz, Austria. The focus on these expanding economies also includes recycling previously wasted carbon emissions. Partnering with LanzaTech, Primetals Technologies helped to establish a gas-fermentation "Steelanol" plant at ArcelorMittal's facility in Gent, Belgium, recycling blast-furnace waste gas into bioethanol.



**FIG. 8:** A view of LanzaTech's Steelanol plant at ArcelorMittal Gent in Belgium, reducing blast furnace emissions

**The future of sustainable metals is defined by green steel technologies that reshape the landscape of steel production, pioneering zero-waste, carbon-neutral heavy industry.**

## THE FUTURE OF SUSTAINABLE METALS

Converting waste into valuable by-products, recovering raw material, contributing to the circular economy, and becoming a flagship zero-waste carbon-neutral industry—the future of sustainable metals is defined by green steel technologies that reshape the landscape of steel production. As one of the most sustainable products in the world, steel is synonymous with strength, endurance, and recyclability. It is only just that the metals industry is behind the global production of steel for expanding markets that will reshape a sustainable society and forge a path toward carbon neutrality.

The steel industry is not alone in its pursuits. Primetals Technologies, leveraging its position as part of the Mitsubishi Heavy Industries Group (MHI), is also expanding carbon capture, utilization, and storage to the steel industry. Using MHI's unique KS-1 solvent, the Kansai Mitsubishi Carbon Dioxide Recovery (KM CDR) process has been applied to the energy sector. Today, it is finding new applications as specialists at Primetals Technologies explore applications for plants operating carbon-heavy integrated routes. The future will see industrial-scale carbon capture and storage technology rollouts at steel plants worldwide. An industry-wide shift toward electric steelmaking and hydrogen-based production will be supplemented by carbon capture utilization and storage to define a carbon-neutral metals industry that has achieved the new standard of green steel. ●

**Dr. Alexander Fleischanderl**, Head of Green Steel

**Adam Merki**, Lead Editor

(Both with Primetals Technologies Austria)





## THREE GROUNDBREAKING REFERENCES



### SALZGITTER LOW CO<sub>2</sub> STEELMAKING: SALCOS

Salzgitter AG has begun investing in the transformation of an integrated 6 MTPY steel plant to a hydrogen-based DRI and electric arc furnace plant. Producing green hydrogen utilizing renewable energy and shifting production to direct reduction to replace the blast furnace, the first phases of the project will see a reduction of emissions by 30 percent and up to 95 percent by 2033.

### GRAVITHY

A company comprised of EIT InnoEnergy, Engie New Ventures, Plug Power, Forvia, Groupe IDEC, and Primetals Technologies launched GravitHy in 2022 with the goal of becoming a sustainable green ironmaking company in France. GravitHy is focused on producing green direct reduced iron and reducing emissions by as much as 95 percent.



### ACCIAIERIA ARVEDI

Achieving carbon-neutral targets years in advance of initial goals, Arvedi has become the first steel mill certified with net-zero carbon emissions in 2022. Arvedi continues to invest in their existing electric steelmaking plant and finding room for improvement to maintain their carbon neutrality for scope 1 and 2 emissions.

# GREEN HOT METAL INTRODUCING THE SMELTER

## LOW-GRADE DRI MELTING FOR A LOW-CARBON STEEL INDUSTRY

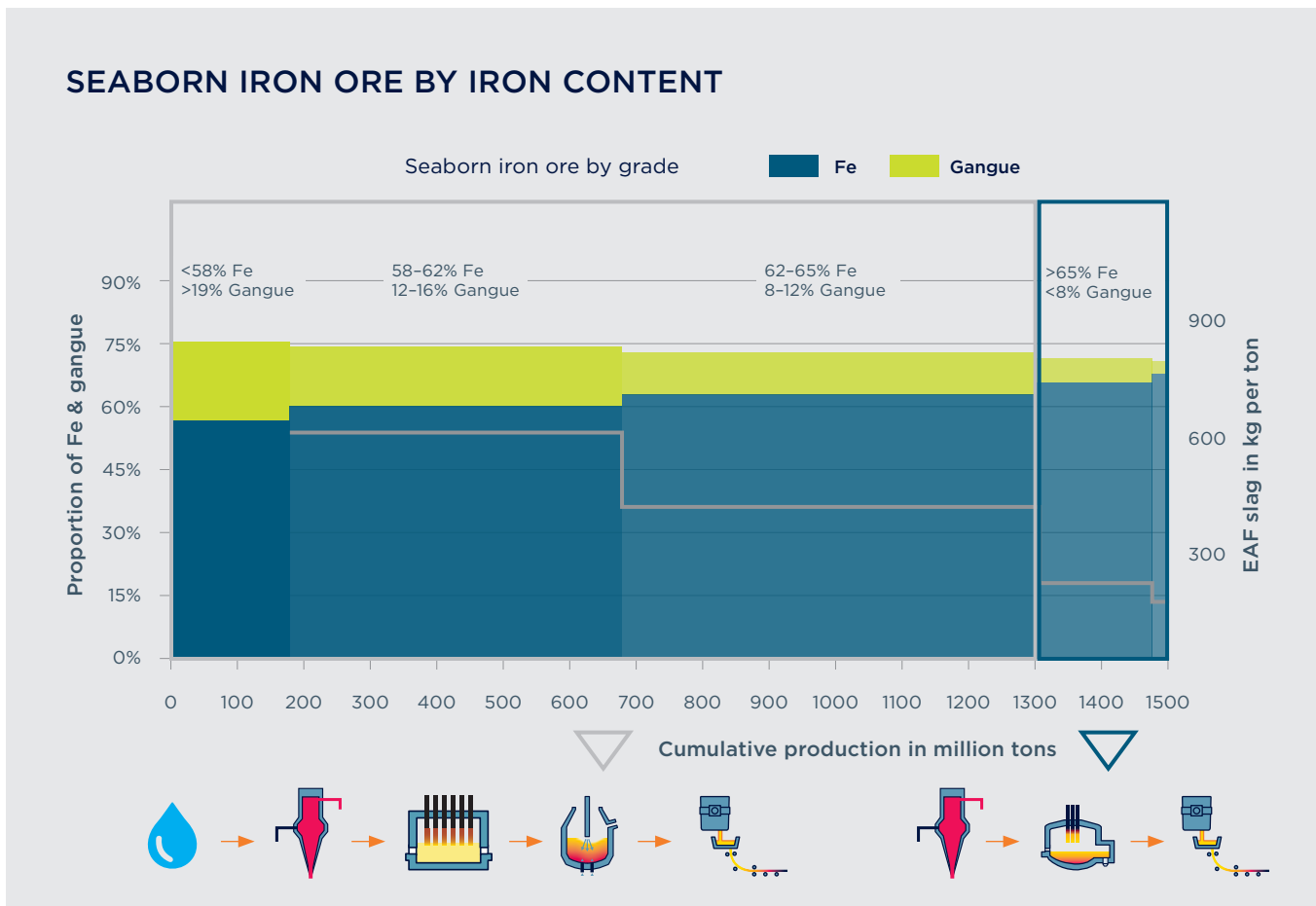
With the demand for high-grade iron ore increasing, the availability and cost of low-grade iron ore reveals immense potential to reduce emissions and maintain production. Introducing the Smelter, a new solution for the final reduction and melting of low-grade direct reduced iron.

Designed for flexible integration, the Smelter is compatible with existing plants in various arrangements and adapts to plant logistics.





The Smelter shifts production routes and optimizes the use of low-grade iron ore.



**FIG. 1:** The diagram above shows the amount of seaborn iron ore in production with iron and gangue content, as well as the amount of EAF slag produced.

Accounting for anywhere between 7 to 10 percent of global CO<sub>2</sub> emissions, the steel industry is experiencing increased pressure to reduce carbon emissions. With demands on the rise, the industry has begun a revolutionary transformation impacting all aspects of steel production. However, an industry-wide transformation presents a challenge that new technologies are able to solve—introducing the Smelter. The Smelter provides a solution for low-grade direct reduced iron (DRI), taking advantage of the availability of low-grade iron ore on the global market as the blast furnace is phased out.

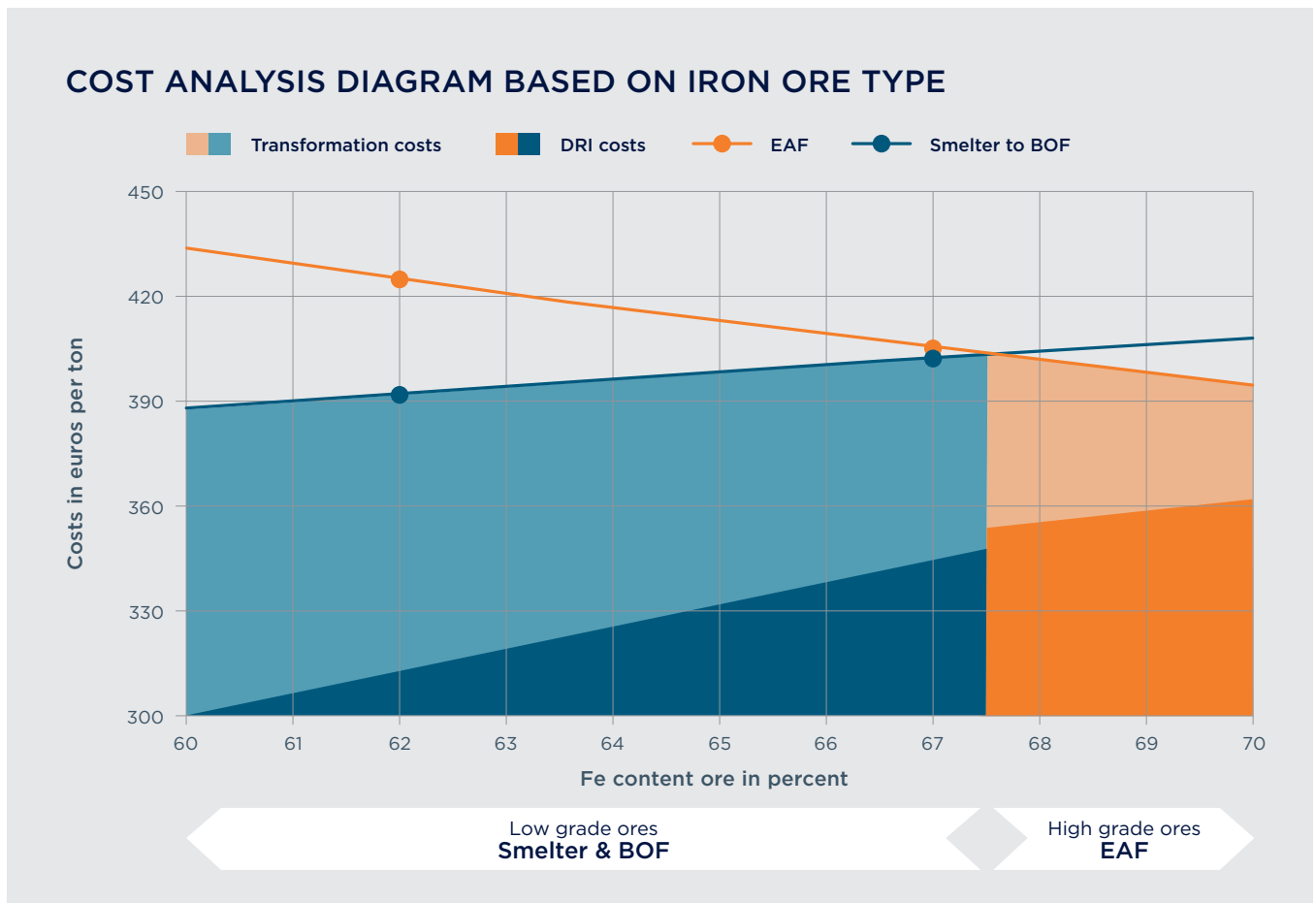
### LOW-GRADE REDUCTION

The integrated route—i.e., blast furnace and basic oxygen furnace (BOF) route—is the dominant steelmaking method worldwide, making up more than 70 percent of global steel production. With this in mind, the blast furnace is responsible for the largest share of carbon emissions in steelmaking. Thus, a clear means of reducing emissions is the replacement of the blast furnace with direct reduction processes, such as MIDREX, HyREX and HYFOR. Combine these solutions with an

electric arc furnace and producers have the potential for the lowest amount of emissions using virgin materials. However, this transition is faced with a challenge—the availability of iron ore.

When talking about the challenge of availability when it comes to the iron ore feedstock for the steel industry, we are talking clearly about the availability of direct-reduction-grade iron ore—i.e., iron ore with ferrous content of 67 percent or more. Even with various mineral processing and beneficiation technologies to increase the ferrous content, reaching high enough levels for quality performance in an electric arc furnace remains difficult. The electric arc furnace performance relies on high-grade DRI to keep slag production low and melting efficiency and yield high. With an abundance of low-grade iron ore on the market, the Smelter provides a means for melting hot-charged low-grade DRI.

The Smelter intervenes in the steelmaking process by melting and reducing low-grade iron ore hot-charged



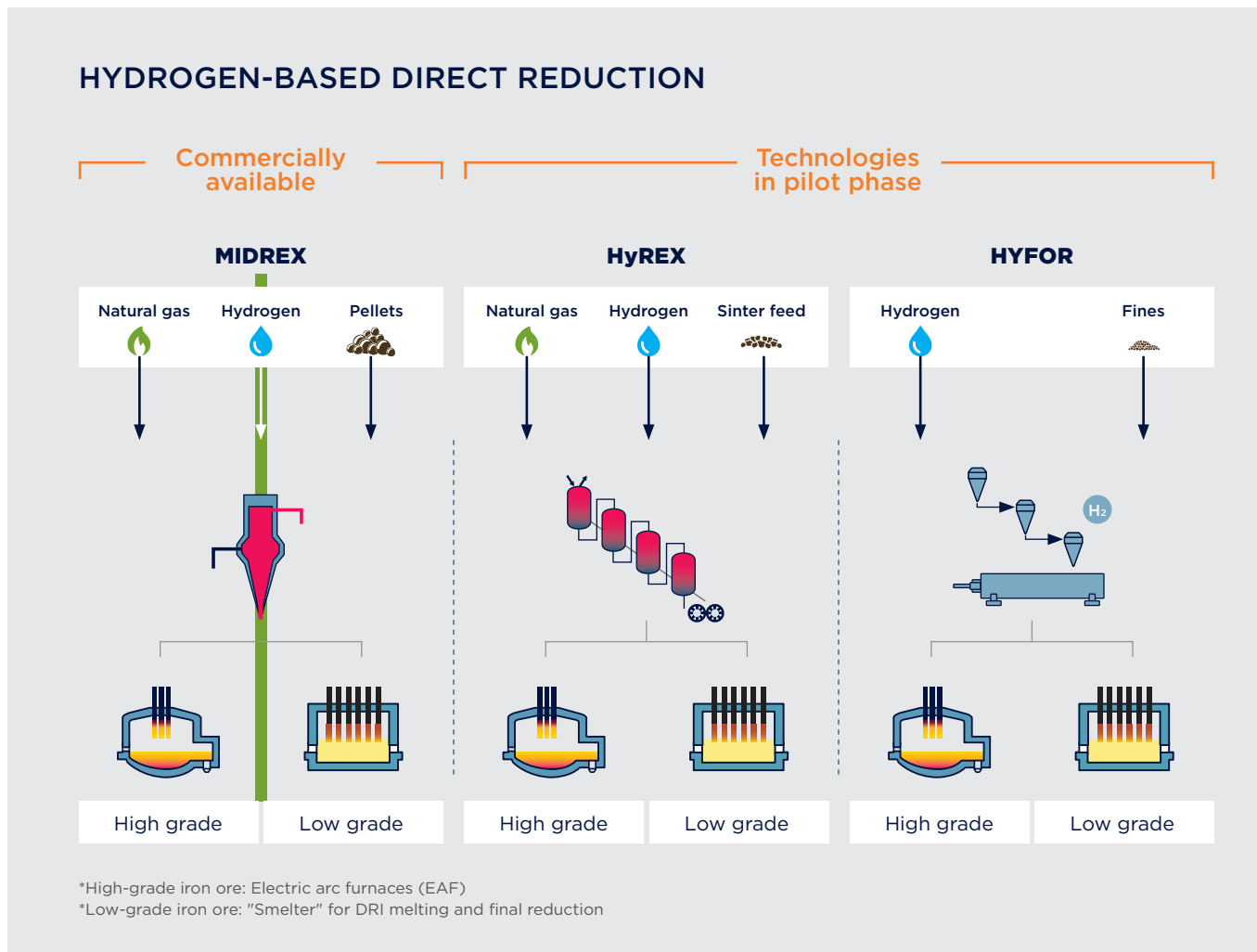
**FIG. 2:** The graphic above illustrates the cost balance between transformational expenditures and the cost per ton of production according to the type of ore.

**The Smelter is designed to handle various low-grade iron ore input materials, including hydrogen-based direct reduced iron ore fines, and can be integrated into existing steelworks.**

from the direct reduction process. The Smelter is also flexible and can manage low-grade pellets and hot compacted iron—e.g., from the MIDREX direct reduction process or direct reduced iron from hydrogen-based direct reduced iron ore fines made using HYFOR technology. The Smelter is also capable of adjusting the carbon level of the output material and produces slag similar to that of the blast furnace.

#### ENVIRONMENTAL IMPACT REDUCTION

While reduction of emissions is a top priority for the steel industry, reduction in landfilled slag and waste materials plays an equally important role for the industry and to benefit the circular economy. In the separation of valuable hot metal from the slag, the Smelter can adjust the composition of the slag to achieve high levels of glass content. This type of slag is ideal for reuse in the cement industry, which has become a reliable recycler of blast furnace slag. Furthermore, the Smelter can also benefit from advanced solutions for dry slag granulation. Additionally, beyond slag recycling, the air-tight operation of the Smelter makes »



**FIG. 3:** Hydrogen-based direct reduction can successfully replace the blast furnace to help producers reach carbon neutrality. With routes in development, producers will see increased opportunities in the near future.

it an optimal recycler for iron and iron oxide-containing by-products—dust, mill scale, and even slag.

### MODULAR AND FLEXIBLE DESIGN

With an excess of low-grade iron ore emerging onto the market, the adaptation of a Smelter allows producers to take full advantage of the decreasing cost of low-grade iron ore while maintaining production. The Smelter can reach 1.5 million tons of DRI charged annually and can be built in parallel for increased capacity and integrates with existing plant logistics easily. High yield is also an essential benefit of the Smelter, thanks to the long setting time. While implementation presents the challenge of additional operational expenditure—i.e., the operation of the Smelter unit and BOF—cost analysis demonstrates the effective low energy prices and the ability to take advantage of the market price for low-grade iron ore make the Smelter an ideal transformational technology.

Producers modifying their production routes benefit from the ability to incorporate the Smelter into an existing BOF operation with only minor adaptations. The only real change is the blowing scheme of the BOF, which sees improved blowing time, due to lower carbon and silicon levels in the liquid hot metal from the Smelter. Despite certain factors impacting the scrap rate of the Smelter and BOF, the overall benefit of reduced emissions and improved yield reveal the benefit of Smelter adoption. Moreover, as producers invest and implement the Smelter, regular operation of the blast furnace may continue thanks to the flexible sizing and engineering of the Smelter. The Smelter is therefore the ideal transitional technology, lessening the environmental impact of steel production. ●

**Dr. Gerald Wimmer**, Vice President of Converter Steelmaking  
**Dr. Alexander Fleischanderl**, Head of Green Steel  
 (Both with Primetals Technologies Austria)

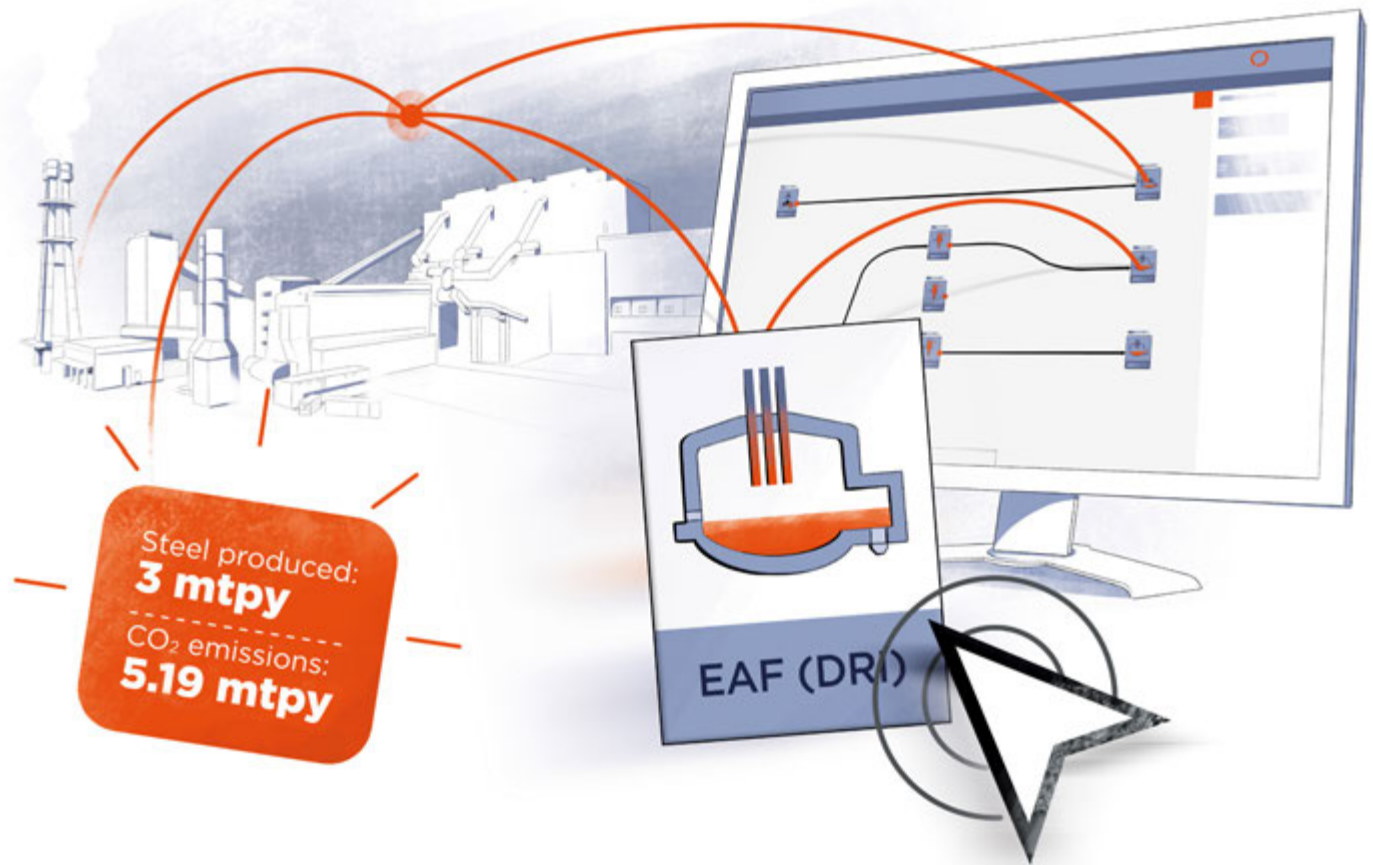
**FIG. 4:** The HYFOR plant in Donawitz, Austria, has laid the foundation for the pilot plant in Linz, currently in development.



## HYDROGEN-BASED FUTURE

The application of a Smelter in integrated steelworks and combination with a BOF offers steel producers a clear alternative toward the transition to high-grade iron ore DRI and the operation of an electric arc furnace. With a carbon-neutral steel industry in mind, the Smelter is also designed to integrate with direct reduction plants

operating at 100 percent hydrogen, including Hydrogen-Based Fine Ore Reduction (HYFOR). With hydrogen-based direct reduced iron and with the potential for being powered by renewables, the Smelter could see reductions in carbon emissions go beyond the sixfold reduction by simply replacing the blast furnace.



# DETERMINE YOUR CARBON EMISSIONS

**THE CO<sub>2</sub> CALCULATOR IS A FREE TOOL THAT LETS YOU QUICKLY BENCHMARK ANY PRODUCTION ROUTE.**

Developed by Primetals Technologies, CO<sub>2</sub> Calculator was designed to make it easier than ever before to determine a plant's approximate carbon footprint. The tool's intuitive interface lets anyone with an interest in metals production build new production routes and establish how much CO<sub>2</sub> would be emitted from the respective configuration. CO<sub>2</sub> Calculator is not only ideal for building the production routes of the future. Another use case is making adjustments to your existing plant in order to find areas that could be further optimized for an overall reduction in carbon emissions—or to test-drive new and inspired ideas for innovative plant configurations.

## **DISCOVER HOW TO SAVE CO<sub>2</sub> EMISSIONS**

The user interface of CO<sub>2</sub> Calculator is self-explanatory and features an interactive tour for new users. The following pages are merely a preview of what's possible, as CO<sub>2</sub> Calculator covers a wide range of production units and material sources, so that almost any setup can be mirrored in the tool. In essence, users can establish the carbon footprint of any steel production route; tweak a specific production route for optimized CO<sub>2</sub> emissions; compare a particular production route to standard routes that are common in the industry; and discover new approaches to optimize plant performance. ●



## CO<sub>2</sub> CALCULATOR: A QUICK-START GUIDE

If you want to get started fast, here's an overview of the core functionality of CO<sub>2</sub> Calculator. A built-in interactive tour is, of course, also available: it starts automatically when you first log in to the tool and can be easily revisited by clicking the "Show Tour" button (see below). All routes that you craft can be saved for later use.

### Choose your production units

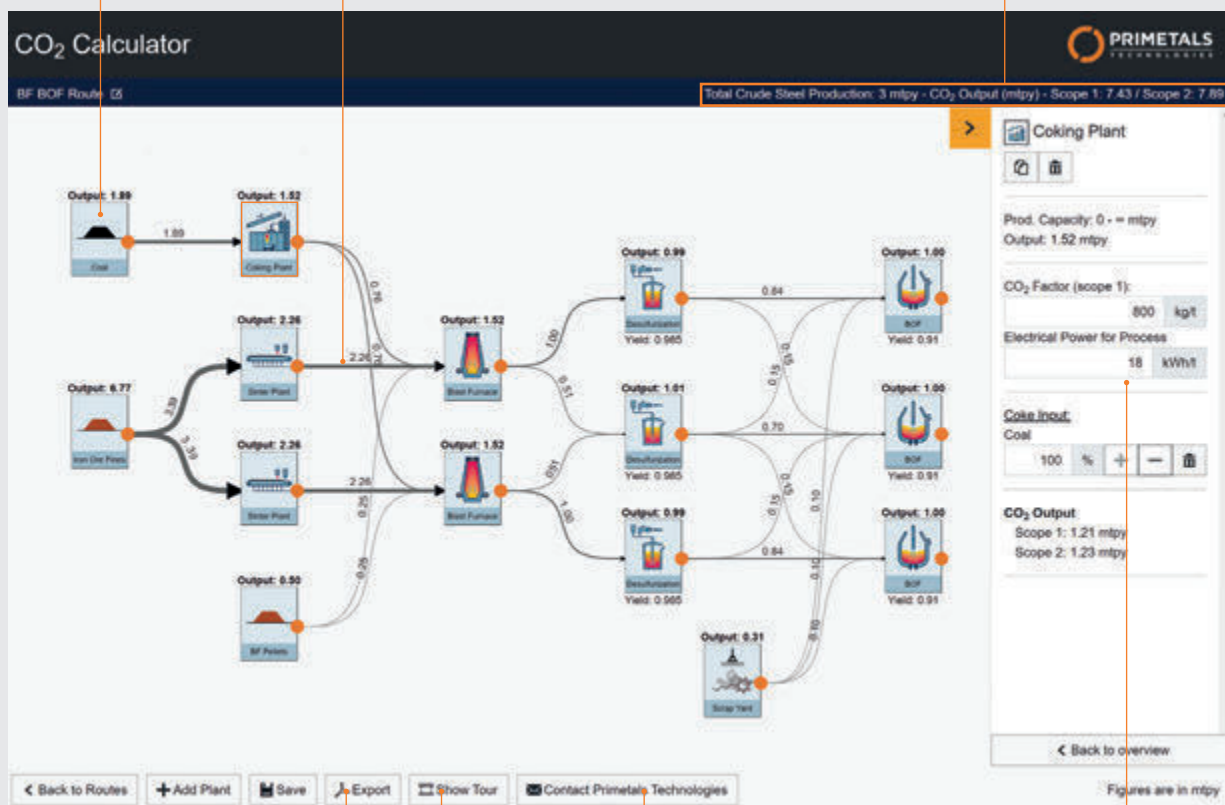
CO<sub>2</sub> Calculator features a large selection of raw-material sources and aggregates that can be combined in a new production setup.

### Define the material flow

Once the production route(s) have been defined, you can set the percentages that each material source will contribute to the overall output.

### Get the CO<sub>2</sub> emissions total

This area indicates total production capacity and CO<sub>2</sub> emissions. Scope 1 refers to direct emissions, Scope 2 includes those from energy purchase.



### Export plant-specific reports

While you can save any plants you design to your user profile, there is also the option of generating reports in pdf format for printing or sharing.

### Reach out for support

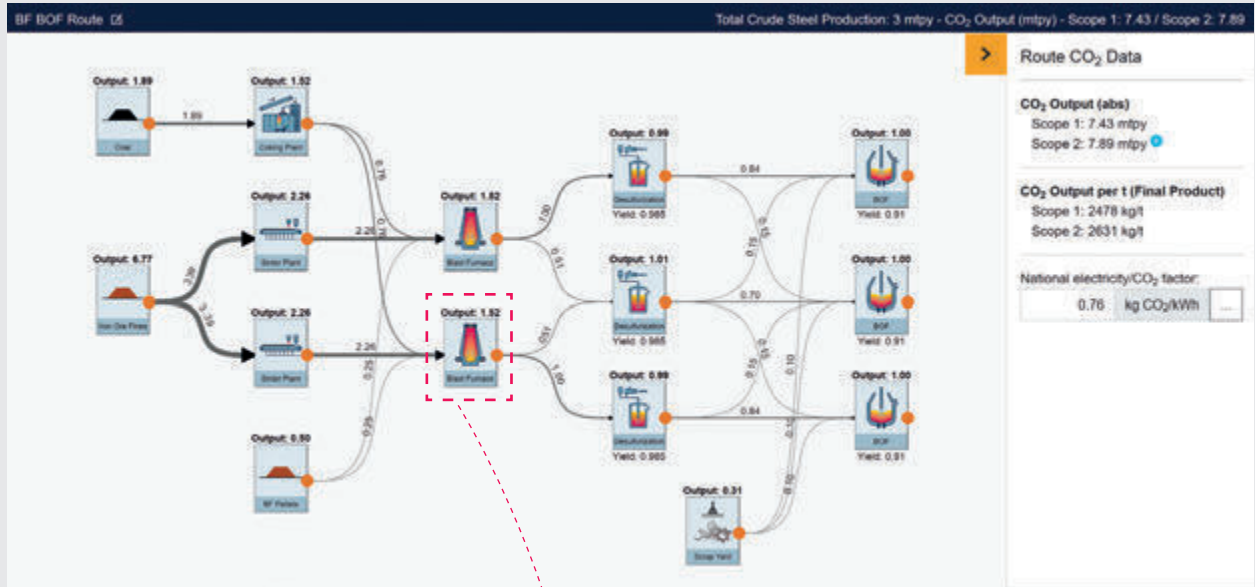
The quick tour is always available if you are looking for a CO<sub>2</sub> Calculator introduction. Additionally, feel free to contact our specialists.

### Customize your setup

Clicking on any production unit or material source brings up this box, where you can set parameters and customize your route even further.

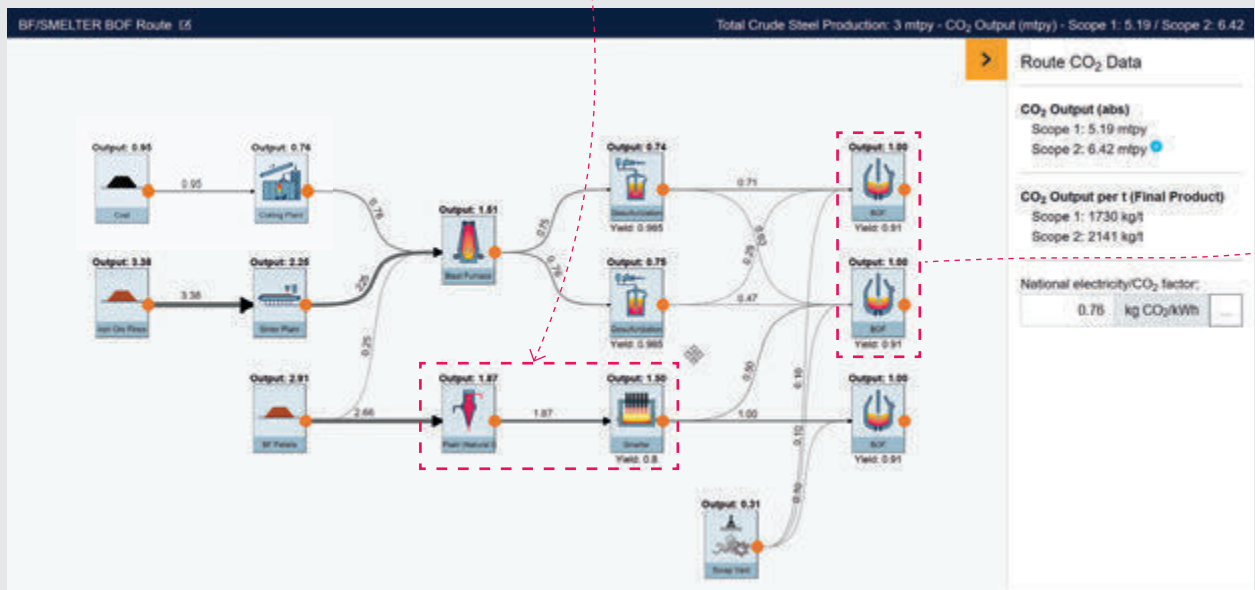
# OPTIMIZING YOUR ROUTE FOR CARBON SAVINGS

Whether real or imagined, CO<sub>2</sub> Calculator lets users craft almost any production route—and then apply various modifications. This enables you to change the aggregates in use and compare the results in terms of production capacity and carbon emissions. You can also add further lines and implement future-oriented solutions.



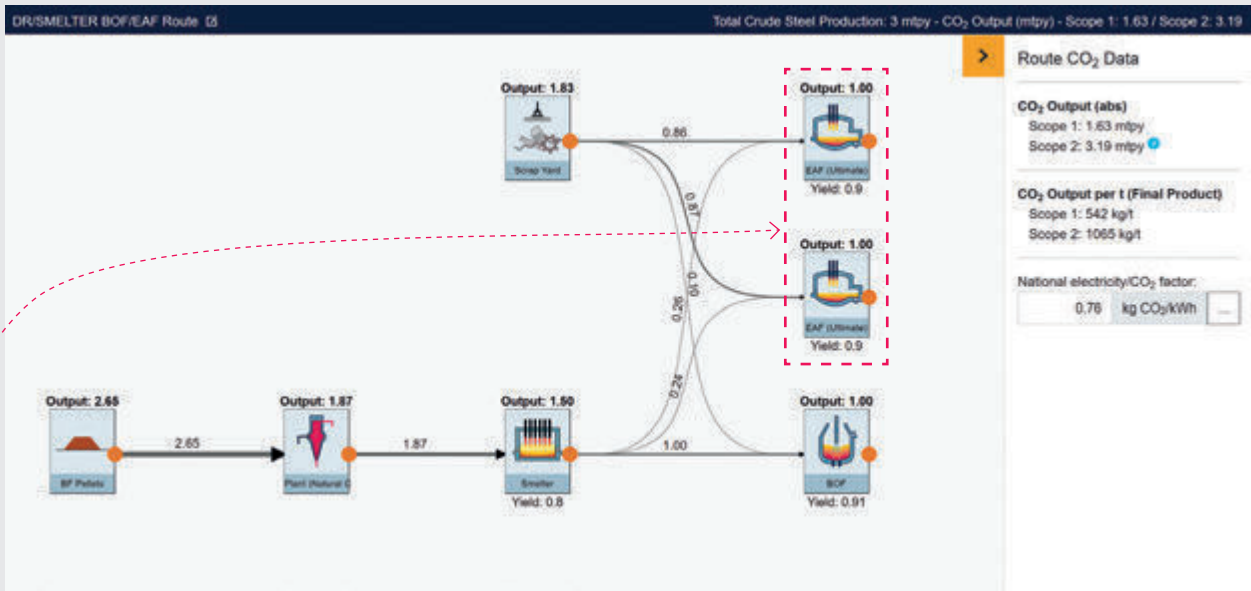
**1. Blast furnaces to LD converters (BOF)**  
 Around 70 percent of today's steel production is executed via the integrated route—meaning with blast furnaces and LD converters. Despite its widespread use, climate targets suggest that this route will be replaced in the coming decades.

Steel produced: **3 mtpy**  
 CO<sub>2</sub> emissions: **7.43 mtpy**  
 (Scope 1)  
 CO<sub>2</sub> per ton of steel: **2,478 kg**



**2. Blast furnace to LD converters (BOF) with direct reduction and Smelter**  
 By replacing one blast furnace with direct reduction and a Smelter, the overall carbon emissions drop by 2.24 million tons per year (Scope 1)—while maintaining a production capacity of 3 million tons of high-quality steel grades. It is a very effective modification.

Steel produced: **3 mtpy**  
 CO<sub>2</sub> emissions: **5.19 mtpy**  
 (Scope 1)  
 CO<sub>2</sub> per ton of steel: **1,730 kg**

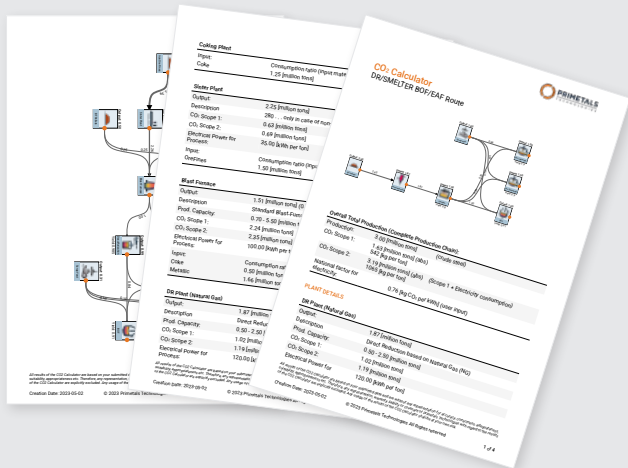


**3.** **Direct reduction plant with Smelter and electric arc furnaces**  
 By replacing two of the three LD converters (BOFs) with two EAF Ultimate furnaces, which are operated on scrap and hot metal from the Smelter, CO<sub>2</sub> emissions decrease even further—to 1.63 million tons per year, a 78 percent reduction compared to plant 1.

Steel produced: **3 mtpy**  
 CO<sub>2</sub> emissions: **1.63 mtpy**  
 (Scope 1)  
 CO<sub>2</sub> per ton of steel: **542 kg**

**4.** **EXPORT**

**Save, print, and share your reports**  
 Once you have found a production setup you are happy with, CO<sub>2</sub> Calculator makes it easy to export a pdf file with a summary of the respective route—completely free of charge. Pdf files generated this way can then be printed or shared with colleagues. They are also an excellent basis for a deeper conversation with an expert from Primetals Technologies about any questions you may have—or about any ideas that you may have had while you were using CO<sub>2</sub> Calculator.



**TRY IT FOR YOURSELF**  
 Scan the QR code or follow the link below to test-drive CO<sub>2</sub> Calculator for free—and to design the perfect plant.  
[meta.ls/co2calc](https://meta.ls/co2calc)

# MEET ALEX

## THE ASSET LIFE EXPERT

**KEEP YOUR PLANT FULLY  
FUNCTIONAL WITH ALEX**

For the day-to-day operation in metals plants, working knowledge of the status and functions of all units in the production process is essential. Operators and maintenance engineers work tirelessly to avoid decreased performance, unplanned maintenance, or unscheduled downtimes. However, this job is not only 24/7/365 but involves an unimaginable amount of information. To assist these maintenance staff and operators, Primetals Technologies developed the Asset Life Expert, or ALEX, the condition monitoring assistant for the metals industry.



**FIG. 1:** ALEX connects operators with their plants like never before. Providing realtime, clear condition monitoring.

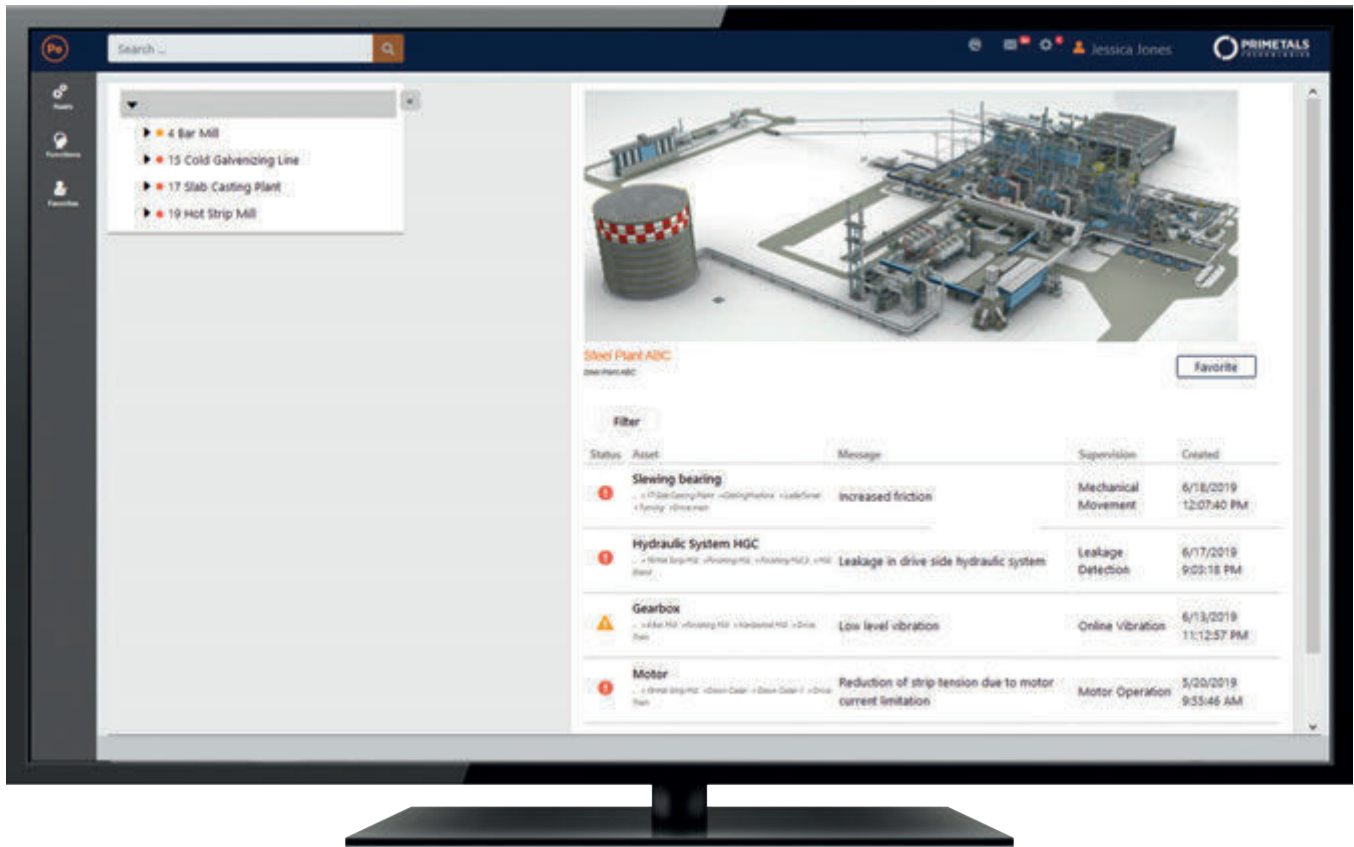


Today, the modern metals production plant includes innumerable sensors and data-generating systems, which produce a high amount of information. While experienced operators and maintenance engineers bring their years of expertise to the table to monitor and check each step in the production process, navigating “big data” and arriving at the appropriate decision can be challenging. In many cases, an operator makes a decision based on a single alert but loses sight of interdependencies. As a result, these skilled operators, maintenance staff, and engineers become “firefighters,” running from one problem to the next. They do not have the time to analyze errors in greater detail to address an issue that may be the actual source. Specialists at Primetals Technologies recognized this issue and developed a digital assistant named ALEX, or Asset Life Expert. Populated by databases full of equipment, process, and production data

previously collected, ALEX assists operators and engineers in ensuring plants are operating efficiently, effectively, and safely.

### DAY-TO-DAY CHALLENGES

Producers strive to maintain a high-efficiency level to meet global metals demands. Producers rely upon digital tools to record and track production to compensate for various changes. Operators can use sensors, triggers, and alarms to identify areas where production is lacking or where attention is needed to maintain production. Data provided by sensors can orchestrate human resources and maintenance activities around current production to avoid unscheduled shutdowns. However, this information is not simply about detecting a problem and scheduling maintenance, but predicting problems and providing information to operators how to solve them step-by-step. »



**FIG. 2:** The ALEX user interface quickly displays alarms and alerts.

Thus, the main tasks of a modern condition monitoring system are

- Monitoring a complete factory
- Early detection of a deterioration in the monitored assets
- Helping to find the source of the problem using an expert system
- Reliable and fully automatic 24/7 monitoring
- One centralized system for the whole plant

### THE CONDITION MONITORING ASSISTANT

When developing ALEX, Primetals Technologies identified the crucial requirements for a digital assistant in a plant. First, various data sources must be able to connect with a digital assistant, including event recorders, (smart) sensors, vibration monitors, technology control systems, process models, and existing monitoring systems. Data should also be able to be provided directly by operators.

Once the data is collected, solutions are derived by looking at the information from multiple angles. Multiple angles mean ALEX must identify correct and rele-

vant information, detect interdependencies between different pieces of information, and consider operational practice for the plant to find the answer. It is important to note that ALEX will assist the operator in finding the solution for the given alarm with know-how-based recommendations. This process involves examining new recommendations for current errors and alarms based on valuable historical information regarding corrective actions. This information is then displayed in an easy-to-understand description so the operator can select and set a corrective action in motion. This decision is then recorded and will help ALEX improve further.

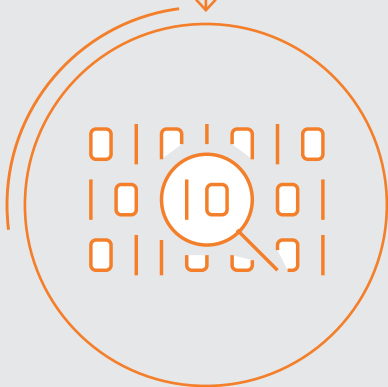
Finally, ALEX is an assistant. The most crucial factor is the operator in charge of the production and maintenance staff managing the line. The system provides a simple user interface with a clear overview of errors and alarms. It offers in-depth analysis via graphs, links to real-time data for specific sensors, and similar features that quickly and efficiently provide the operator with all the necessary information. For more details, the operator should be able to access technical documentation quickly, for example, circuit diagrams and operation manuals. ALEX is the perfect assistant »»

## HOW ALEX HELPS



### ALARMS AND WARNINGS

As a steel plant operator, you might be frequently overwhelmed by a steady stream of alarms, warnings, and other information from various sources.



### SMART CENTRALIZED EXPERT SYSTEM

ALEX evaluates the data and information using advanced analysis techniques, factoring in additional signals and information such as operational practice know-how, and provides a clearer and faster overview of the condition of your plants.



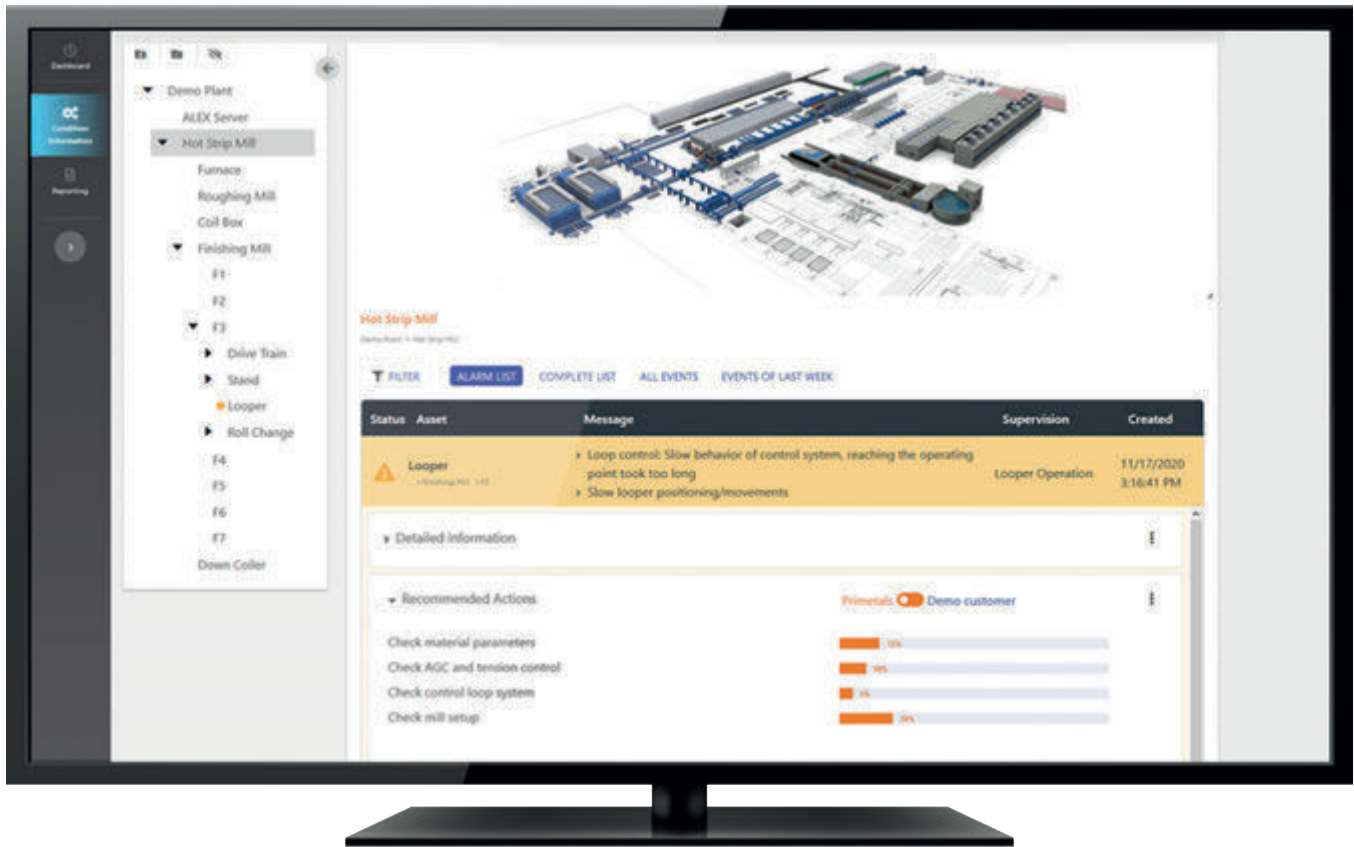
### CONDITION MONITORING ASSISTANCE

ALEX provides a fast overview of the status of your plants, with precise and validated information. ALEX recommends intelligent actions that help you to avoid unplanned downtimes and achieve consistently high product quality.



### IMPROVED LIFE QUALITY OF YOUR ASSETS

ALEX increases your plant availability, reduces maintenance costs, provides online information about the health status of your plant, and helps you to optimize equipment lifetime.



**FIG. 3:** ALEX presents information regarding the warning and provides recommendations to find and address the problem with a graphical display of solution relevance (orange bar graph).

that provides operators with all the information they need to perform their tasks efficiently and effectively.

### KNOWLEDGE MANAGEMENT

One of ALEX's key features is its ability to maintain a vast database and collection of knowledge, including input from operators. ALEX can assess decisions made by plant operators in various situations and arrive at the optimal choice to maintain productivity. The benefit here is that the correct decision is no longer based on an individual operator's instinct, but on their ability to apply their knowledge. Focusing on the solution and application of knowledge means a more direct response to problems and smoother operations overall.

### REAL CASES DETECTED BY ALEX

In one case, ALEX was in operation at a roughing mill. It issued a warning regarding the edger's control behavior being too slow. An edger is an actuator for the width control at a roughing mill, which keeps the strip width within a specified range. The edger is monitored automatically by analyzing different functions and operations. In this case, a controller performance test, performed during the calibration of the edger, led to a warning.

After detecting an error, ALEX sent the following warnings:

- Slow reaction of the controlled system: dead time too long
- Slow behavior of the controlled system: rise time too long

After providing detailed information involving an error in the control loop, ALEX provided various recommended actions with a graphic rating of the relevance of each solution. The primary recommendation was to check the accumulators at the valve stands and edger assembly. As the first relevant suggestion, ALEX correctly identified low pressure in an accumulator in the hydraulic system. The accumulator supports fast dynamic reactions as needed by the width controller. After refilling the gas into the accumulator, the function was back to working at top speed.

In another case, ALEX warned the maintenance department of inaccuracy in the wrapper roll at the re-coiler. An abnormal vibration was found and indicated in the drive train by analyzing the motor current and voltage in ALEX. As previously shown, ALEX presented recom-



## WHERE CAN ALEX ASSIST

ALEX assists almost anywhere in the metals industry, from steel and aluminum to copper production.

- Blast furnaces
- Converters
- Electric arc furnaces
- Continuous casting machines
- Endless Strip Production
- Plate and hot strip mills
- Cold rolling mills
- High-speed rod, wire, bar, and section rolling mills
- Processing lines
- Dry dedusting systems
- And more ...

### Typical examples of assets and functions monitored by ALEX:

- Monitoring mechanical equipment, like the looper, coiler, or edger in a hot strip mill, influencing material quality or equipment lifetime
- Monitoring hydraulic systems, like the wear of servo valves or loss of pressure in the accumulator, ultimately influencing product quality
- Monitoring control loops, which can lose their dynamic behaviors and cause a drop in product performance
- Monitoring of slow-rotating bearings, e.g., as used for steelmaking converters and ladle turrets, can significantly influence productivity
- Supervising smaller drives of bearings, such as those in processing lines, by analyzing the motor current and voltage
- Classic vibration monitoring for rotating parts, either automatically or via route-based measurements
- Monitoring work roll and coil eccentricity that influence process KPIs
- Monitoring of automation equipment such as CPU load, memory space, run time, bus system check, etc.

**ALEX and maintenance engineers can work together with their digital counterparts to analyze and evaluate the best possible actions to keep operations running smoothly.**

recommendations and graphically displayed the most relevant solution based on a cross-check of the database.

The answer provided by ALEX was to check the transmission elements, and after the work was completed during the next planned maintenance stop, operations could proceed accordingly. Here, misalignment after prior maintenance triggered an alarm, preventing damage and any unplanned stoppage.

### CONDITION MONITORING WITH ALEX

Global demand for metals drives producers to continuously look for product quality, productivity, and flexibility improvements. Thankfully, incremental improvements can easily be determined and achieved. Still, to ensure production remains steady, a plant has to be well maintained, and any equipment deterioration or decrease in yield has to be detected early to avoid unplanned production stoppages.

For modern producers, a condition monitoring system is essential but involves massive amounts of data unmanageable by human operators. However, when paired with ALEX maintenance engineers can work together with their digital counterparts to analyze and evaluate the best possible action to keep operations running smoothly. With a well-designed software architecture, comprehensive database, and flexibility regarding data input, ALEX is the condition monitoring assistant for the metals industry. ●

**Andreas Maierhofer**, Head of ALEX - The Asset Life Expert  
**Arno Haschke**, Head of Condition Monitoring  
 (Both with Primetals Technologies Germany)

# GREAT PIONEERS

## THAT INSPIRE US



At Primetals Technologies, we constantly strive to pioneer new and groundbreaking solutions for the steel industry. We work with passion, inspired by our close partnerships with steel producers from all around the world. Another source of inspiration are the great pioneers that have come before us—innovators who have made a profound impact on the way we live and changed the course of history. In this series, we look at the life, the challenges, and the achievements of some of the most outstanding pioneers of all time. This time, we present visionary inventor Nikola Tesla.

TIMELINE

**1856**

Born on July 10th in Smiljan, Croatia, to Serbian Orthodox parents.

**1875**

Enrolls at the Austrian Polytechnic in Graz, Austria, where he studies physics and mathematics.

**1881**

Moves to Budapest, Hungary, to work for the Central Telephone Exchange as an electrical engineer.

**1884**

Emigrates to the United States and begins working for Thomas Edison's company, the Edison Machine Works.

**1887**

Develops the alternating current motor and transformer, which revolutionizes the field of electrical power transmission.

# NIKOLA TESLA

## THE VISIONARY WHO PERFECTED THE AC MOTOR AND PIONEERED WIRELESS TRANSMISSION

Who is the man whom Edwin H. Armstrong, American electrical engineer and inventor, regarded "one of the greatest geniuses of all time?" What is the story behind the person who lent his name to the car company led by world-famous entrepreneur Elon Musk? Hollywood movies like Christopher Nolan's 2006 picture "The Prestige" have done much to add to the aura of the name Tesla. But while Nikola Tesla undoubtedly had a brilliant mind and was the father of many inventions, his life was also complicated and not without personal struggle and disappointment.

Nikola Tesla was born in Smiljan, Croatia, on July 10, 1856, into a very religious family, with Tesla's father being a Serbian Orthodox priest. Tesla's early life was already marked by hardship: His brother died in a riding accident when Tesla was five years old, and his father had a tendency to rigorously demand perfection from his son. Despite these challenges, Tesla showed an early aptitude for science and invention. He attended the Austrian Polytechnic in Graz, Austria, and later worked for the Continental Edison Company in Paris, France.

Tesla moved to the U.S.A. in 1884 to directly collaborate with Thomas Edison, the inventor and businessman who had patented the electric light bulb. However, the two men had a falling out over the design of Edison's electrical supply system. Edison was a proponent of direct current (DC) power, while Tesla believed that alternating current (AC) was more efficient and versatile. The pair became bitter rivals, with Edison even publicly electrocuting animals with AC power in a misguided attempt to discredit Tesla's work.

When the relationship with Edison went astray, Tesla decided to continue pushing the boundaries of electrical engineering on his own. Tesla was fascinated with wireless power transmission, envisioning a future »



### DID YOU KNOW ...?

- ... that Nikola Tesla was fluent in eight languages, including Serbian, English, French, German, and Italian.
- ... that Tesla was known for his eccentricities, such as his practice of staying up all night and his aversion to round objects and jewelry.
- ... that the innovator was a lifelong bachelor and claimed to never have had a romantic relationship. Tesla stated that his work and inventions were his only passions in life.
- ... that Tesla had a photographic memory and was known for being able to visualize his inventions and designs in his mind before ever putting them down on paper.
- ... that a rivalry existed between Tesla and Thomas Edison, because the two disagreed over the use of AC versus DC electricity.
- ... that Tesla held over 300 patents during his lifetime, including for his invention of the Tesla coil—a device that produces high-voltage, low-current electricity.
- ... that the basis of Teslas pioneering work in wireless communication was his belief that he could develop a system for transmitting messages and power without any wires.
- ... that Nikola Tesla was a vegetarian.

**1891**

Becomes a naturalized citizen of the United States.

**1893**

Performs demonstrations of the potential of alternating current at the World's Columbian Exposition in Chicago, Illinois, U.S.A.

**1895**

Begins work on the wireless transmission of power, a project that he continues to work on for the rest of his life.

**1915**

Files for bankruptcy and loses control of his company, the Tesla Electric Company.

**1943**

Dies on January 7 in New York City, at the age of 86.



“**Tesla is the most original mind in American history.**”

**Thomas Edison**

Inventor of the electric light bulb and founder of Edison Electric Light Company

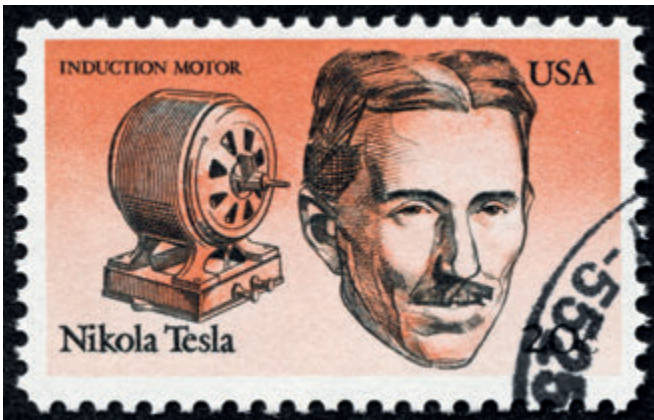
where electricity could be transmitted wirelessly through the air, without the need for wires or cables. Over the course of his experiments with wireless power distribution, Tesla made several observations about the nature of electromagnetic waves. He started to think that radio waves could be used for communication, and patented a number of radio designs in the early 1900s. Unfortunately, his patents were eventually invalidated by the United States Patent Office in favor of Guglielmo Marconi, an Italian inventor who is often credited with the invention of the radio.

Tesla achieved greater success and more widespread recognition with the “Tesla coil,” a core component for wireless long-distance communication systems. The Coil laid the groundwork for the development of modern broadcasting and consists of a primary and a secondary coil. The primary coil is connected to a power source and produces a high-frequency alternating current that creates a magnetic field. This field induces a high voltage in the secondary coil, which then generates a spark. By demonstrating the principles of resonant induction, the Tesla Coil was instrumental in the development of technologies such as Wi-Fi, Bluetooth, and cellular networks. Tesla may not have been able to fully realize his vision of wireless communication and wireless power in his lifetime, but his work paved the way for many later inventions. Today, not only wireless communication but also wireless charging are realized by smartphones and many other devices.

### **AN ECCENTRIC GENIUS**

Tesla’s life was marked by many eccentricities. He was known for his seemingly outlandish behavior and was a recluse later in life, often spending long periods of time in solitude. Tesla was also plagued by financial difficulties, and he died penniless in a New York hotel room in 1943. Tesla had a strong aversion to germs and dirt, and would frequently wash his hands and change his clothes. A believer in numerology, he thought that numbers had a mystical significance. Tesla was also a vegetarian and reportedly subsisted on a diet of milk, bread, honey, and vegetable juices. Known to work incredibly long hours, he often stayed up for days at a time without sleep. Tesla claimed to have never had a romantic relationship in his life, and that his experiments and his inventions were his only passions.

Tesla was also known for his showmanship and love of spectacle. He would perform public demonstrations of his inventions, such as lighting up entire buildings with his wireless lighting system. He also had a flair for the dramatic and would often make grandiose statements about his work and the future of technology. Far ahead of his time, he advocated that humanity should embrace renewable energy sources. Tesla believed that it was possible to harness the power of the sun to provide clean energy to everyone. He also saw a world where transportation was powered by electricity, and he designed a prototype electric car in 1931, decades before the widespread adoption of electric vehicles.



## NIKOLA TESLA GOES TO HOLLYWOOD

Nikola Tesla has not only adorned banknotes and stamps (pictured) but has also become a popular figure in Hollywood films, appearing as a character in a number of movies over the years. Tesla's genius, eccentricity, and mystique have made him a compelling subject for filmmakers, and his life and work continue to captivate audiences.

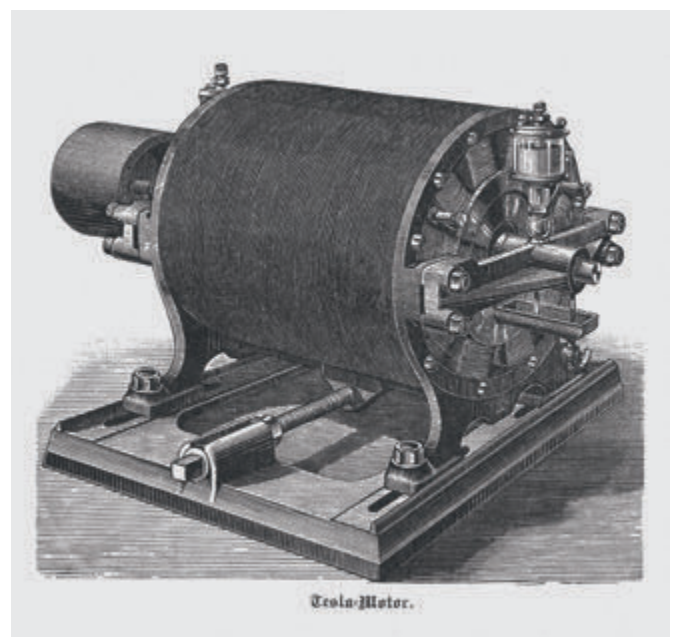
One of the most prominent portrayals of Tesla in recent years was in the 2006 film "The Prestige," directed by Christopher Nolan. The film, which is set in the late 19th century, follows two rival magicians who become embroiled in a bitter competition to create the most spectacular illusions. Tesla, played by singer and actor David Bowie, is brought in by one of the magicians to help him create a groundbreaking new trick that will amaze audiences and win him the competition. Much like Tesla in real life, the magician ends up paying a high price for flying quite so close to the sun. Tesla also appeared as a character in the 2019 biopic "Tesla," which explores the inventor's life and work in more detail. The film, which stars Ethan Hawke as Tesla, delves into the complexities of Tesla's personality, his relationship with Thomas Edison, and the challenges he faced as he tried to bring his inventions to life.

Overall, Nikola Tesla's legacy as an inventor and electrical engineer continues to inspire filmmakers and audiences alike. Through his appearances in Hollywood films, Tesla has become an icon of innovation and creativity, and his work remains a testament to the power of the human mind to transform the world around us.

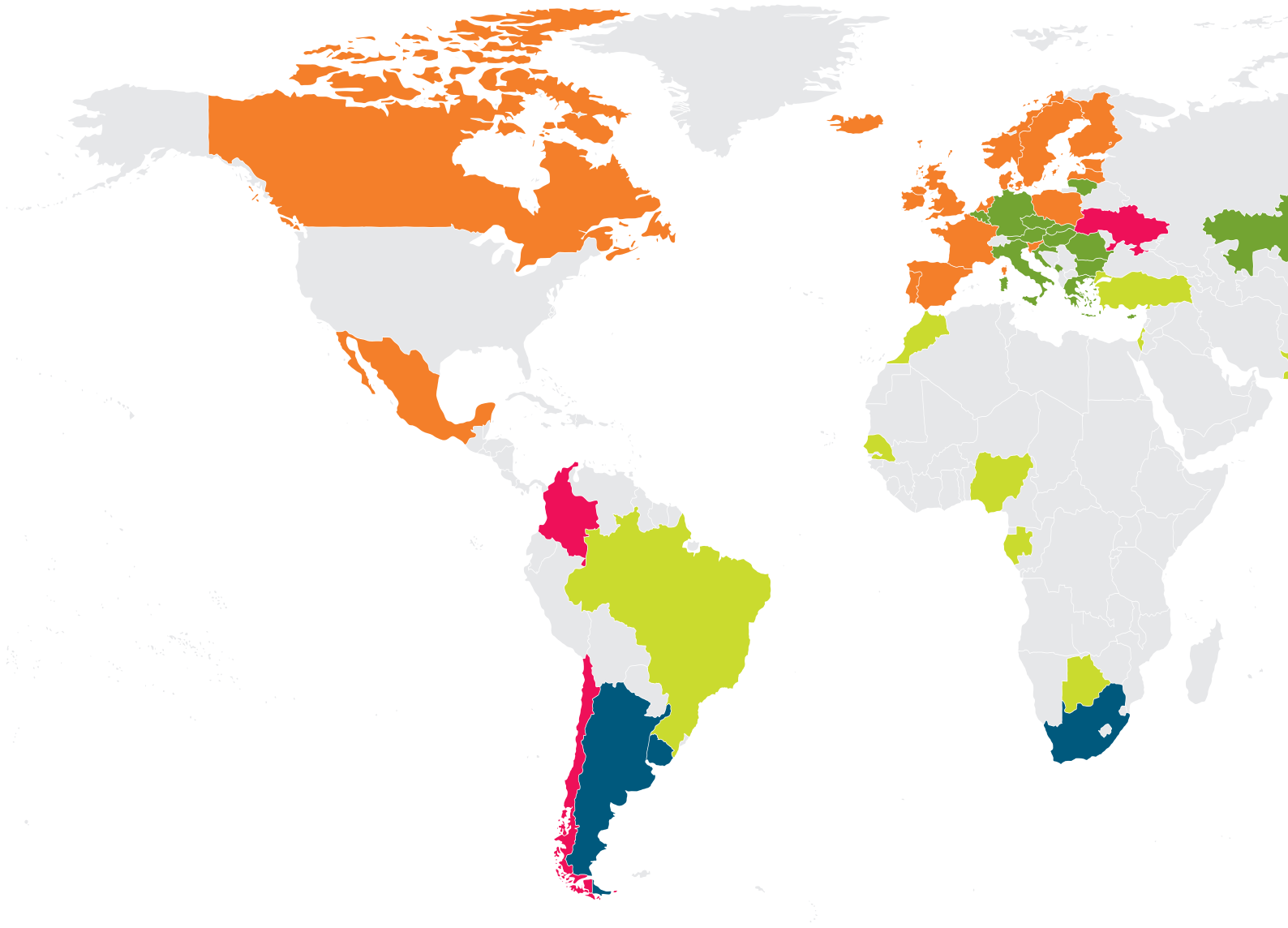
## CHANGING THE WORLD

Tesla's contributions to science and technology have transformed the world we live in, and his visionary ideas continue to shape our understanding of the universe and our place in it. AC generators, motors, and transformers have made it possible to transmit electricity over long distances, and to power homes, businesses, and industries. Without Tesla's inventions, it's unlikely that our modern world would have access to the abundance of electrical power that we take for granted today. In addition to his technical achievements, Tesla was also a forward-thinking visionary who imagined a future filled with scientific wonders. He predicted the development of today's mobile phones and drones, long before these technologies became a reality. His conviction that, by turning sunlight into electrical energy, the world could tap into an endless supply of sustainable energy can be seen as a window into the future—a future in which solar and wind have become a central part of many countries' renewable energy strategies.

Tesla's legacy is also a reminder of the importance of pursuing one's passions and pushing the boundaries of what is possible. Despite facing numerous setbacks and obstacles throughout his life, Tesla remained dedicated to his work and never gave up on his dream of creating a better world through science and discovery. His example is an inspiration to pioneer new things, to be brave enough to take risks, and to never lose sight of your vision, no matter how daunting the challenges. Tesla's personal problems and eccentricities only add to the allure of his story and make his legacy all the more compelling. He remains an inspiration to scientists, inventors, and futurists around the world—a testament to the power of imagination, innovation, and perseverance. ●



**FIG. 1:** Tesla's AC motor design featured a rotating magnetic field that allowed for efficient and reliable power transmission.

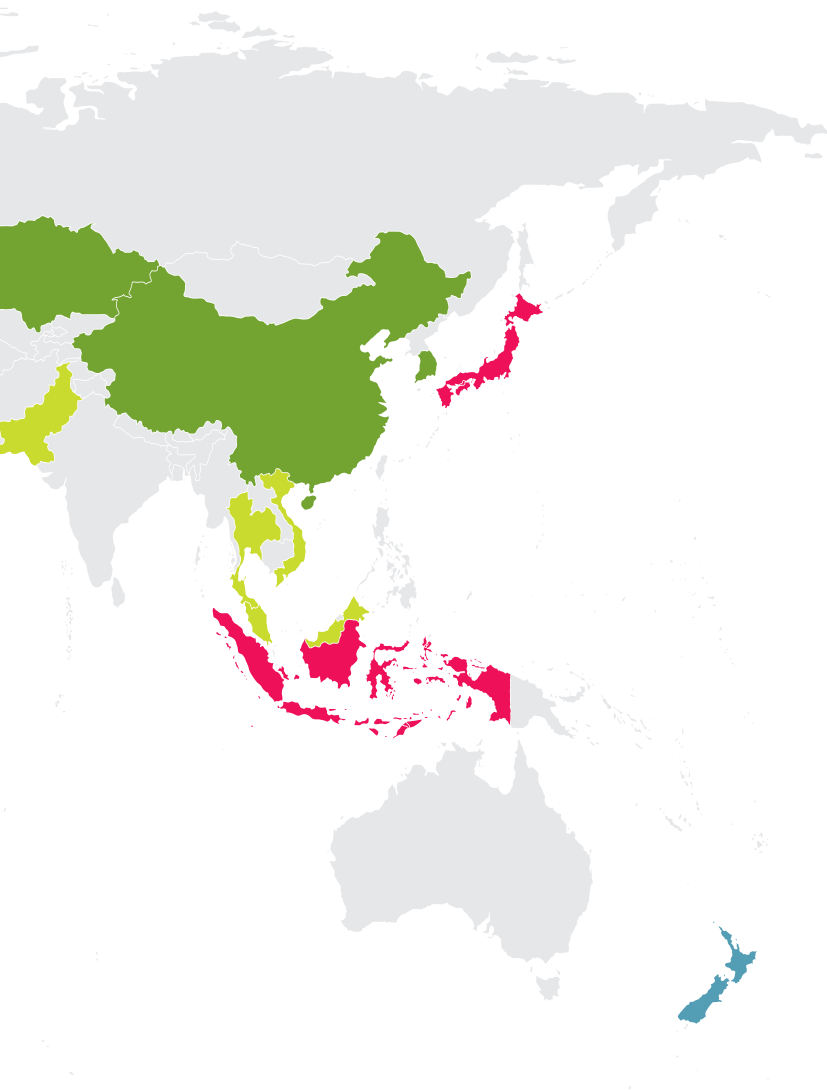


# EMISSIONS TRADING SYSTEMS

## THE COST OF CARBON

### HOW GLOBAL CARBON MARKETS ARE DRIVING THE RACE TO DECARBONIZE

While perhaps more commonplace in many parts of the world than others, emissions trading systems are becoming a global trend to motivate heavy industry on the road to decarbonization. Yet, emissions trading systems are as diverse and complex as the industries they impact. The difference and relationships between terms like “emissions trading system” (ETS), “carbon taxes,” and “carbon credits” can be just as complicated but are crucial to grasping the impact of these systems. Here, we take the opportunity to unpack these terms, uncover what they mean for the metals industry, and begin to understand the cost of carbon.



The map (source: World Bank) visualizes ETSs worldwide, including implemented systems, upcoming implementations, and countries considering implementation of an ETS. With environmental pressures on the rise, the relevance of these types of systems and taxes will increase as the cost of carbon becomes a deciding factor for the sustainability of heavy industries.

- ETS implemented or scheduled for implementation
- Carbon tax implemented or scheduled for implementation
- ETS or carbon tax under consideration
- ETS and carbon tax implemented or scheduled
- ETS implemented or scheduled and carbon tax under consideration
- Carbon tax implemented or scheduled and ETS under consideration

More than simply a buzzword, decarbonization is a serious topic, both for the steel industry and climate change. Decarbonization is key to curbing the effects and impacts of climate change, and redefining heavy industry to be more environmentally friendly. Unfortunately, the technologies available today demand a high amount of capital investment to be implemented. Large capital investments are one of the significant hurdles regarding the widespread adoption of environmentally friendlier technologies. Therefore, to accelerate this transition, governments look toward implementing systems that add a cost element to the emissions from heavy industries that make the investment in decarbonization technologies more appealing, and distribute pressure more evenly across sectors allowing for gradual transformation.

### TRADING VERSUS TAXATION

Before we delve into the details regarding emissions trading systems, one valuable distinction is the difference between an emissions trading system and a car-

bon tax. Plainly stated, carbon taxes are a direct tax on fossil fuel emissions. However, carbon taxes themselves can often vary from country to country, and in many cases, governments will opt for a carbon tax or an ETS. Carbon taxes are unique in a few areas essential to understanding the difference to an ETS.

One clear distinction is that carbon taxes are applied to all emissions but can vary within a country and even apply to different sectors. For example, since 2019, Canada has set a price on carbon pollution. The latest legislation has also adapted their pricing to increase from 2023 to 2030, based on the latest information regarding climate change. Their tax system provides an ideal backdrop for understanding the difference between putting a price on fuel, and overall carbon output from industries. For Canadians, the carbon price is a fuel tax, including gasoline, diesel, natural gas, and other hydrocarbon fuels. These taxes are placed directly on the fuel, impacting heavy industry and consumers. The output-based pricing system »

## E.U. CARBON PERMITS PRICES 2005–2023



**FIG. 1:** As the longest standing emissions trading system, the E.U. ETS carbon pricing trend shows a dramatic shift upwards and is projected to continue to rise (May 2023).

applies a carbon tax to large industrial emitters for their overall emissions, but does not apply to emissions from individual households or consumers.

On the other side of the globe, Germany implemented a price on CO<sub>2</sub> for vehicles and buildings in 2021. With the new additions in Germany, individual households and vehicle owners will also experience a regulated price on CO<sub>2</sub> emissions. In terms of costs and offsets, consumers will be able to receive credit and support if the price causes financial difficulties. However, additional charges are intended to encourage “greener” investments and a shift toward environmentally friendlier practices. The fixed price on carbon in Germany operates similarly to a tax, and the price will remain fixed until 2026. After that, carbon pricing will be negotiated on the open market. Thus, the system gradually transitions from something akin to a carbon tax, to a cap-and-trade system for emissions.

### CAP, TRADE, REDUCE

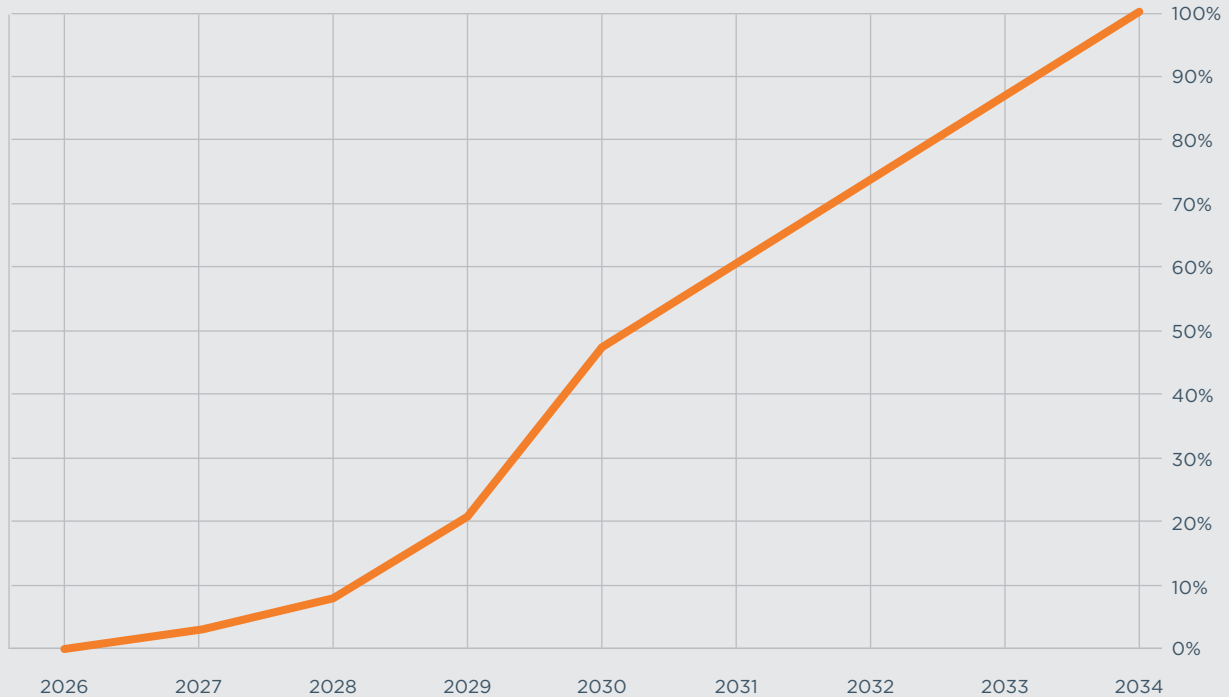
Turning the page from carbon taxes to emissions trading systems (ETS), the application of a cap-and-trade system brings the logic of the open market to carbon

emissions. Focusing on the first and largest ETS system, the E.U. ETS sets a cap on the amount of greenhouse gas emissions companies can emit each year. Each company purchases carbon certificates that meet its needs in terms of emissions. If they exceed this amount, they face fines. Still, if they need more, they can either reduce their emissions by investing in environmentally friendly technologies or purchasing excess certificates from another company.

For industry, the financial incentive to reduce emissions is directly impacted by the price set on carbon certificates. With an ever more limited number of carbon certificates available, the cost of investing in emissions-reducing technologies will become more and more appealing. After their revision in 2021, emissions cuts will also increase by 2.2 percent every year. Additionally, the number of allowances that industries can hold from year to year will only reflect the auction volume of the previous year after 2023, reducing the ability of an emitter to stockpile allowances. Beyond that, several funds have been established to aid the industry transition, particularly for energy-intensive industrial and power sectors.



## PHASEOUT OF FREE ALLOWANCES



**FIG. 2:** Pictured above, the gradual phaseout of free allowances to industries in the ETS accelerates until 2030 before proceeding linearly toward 2034/35.

### ETS AND THE METALS INDUSTRY

As a hard-to-abate industry, emissions trading systems and carbon taxes will have specific implications for the metals industry, primarily due to carbon-intensive processes like the blast furnace/basic oxygen furnace steelmaking process. What is clear is that steel producers in countries with strict carbon emissions pricing schemes, whether carbon taxes or emissions trading systems, should begin looking at decarbonization technologies early to avoid incurring costs in the future.

For example, the E.U.'s Carbon Border Adjustment Mechanism (CBAM) has begun to come into play to manage emissions and mitigate the phenomenon known as "carbon leakage." Carbon leakage occurs when industries move the carbon-intensive portion of their business to countries or regions with weaker legislation regarding carbon emissions. The carbon thus "leaks" through the cracks in the system. Currently, producers in the E.U. only need to report direct and indirect emissions from 2023 until 2025. However, from 2026 onwards, the free allocation period for steel producers will be phased out, and the actual cost of carbon will play a significant role.

### FUNDING A SUSTAINABLE FUTURE

While the E.U. ETS and carbon taxes worldwide aim to motivate heavy industry to transform, the funding of these projects ties emissions trading systems and carbon taxes to actionable changes. In the E.U., the ETS provides revenue for the "Innovation Fund," estimated to amount to around 38 billion euros from 2020-2023, estimating a cost of 75 euros per ton of CO<sub>2</sub>. The Innovation Fund may then be used for innovative and flagship projects to reduce capital investment risk and further drive climate innovation.

Regardless of each producer's approach, what is clear is that the future of heavy industry requires sustainable technologies and a commitment from CO<sub>2</sub> emitters to lessen their environmental impact. With carbon-neutral targets being set for the coming decades, carbon-intensive industries, such as the metals industry, will have to factor in the cost of carbon to their bottom line. Additionally, as more countries roll out various ETS and carbon pricing schemes, early investment in optimization and decarbonization technologies anticipates future costs and ensures sustainability and resilience against the cost of carbon. ●

**Naum Gabo**  
**Constructed Head No. 2**  
1916, enlarged version 1964

Gabo was inspired by his contemporaries and cubism. Toying with the representation of space, Constructed Head No. 2 explores dimensionality.



# EVERYDAY STEEL

**STEEL IS FUNCTIONAL, SUSTAINABLE,  
VERSATILE, AND AESTHETIC**

Steel is a crucial material in our society. Its strength and malleability have allowed it to be transformed into varying shapes and structures, from automobiles to towering skyscrapers. In this series, we explore how steel has become a part of our world—in the most conspicuous and inconspicuous ways. Here, we explore the aesthetics of steel and the meeting point between strength, scale, and art.

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**“ I try to make pieces that are durable. One of the reasons that I work in steel is durability.”**

**Jeff Koons**

Contemporary American artist

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Steel has often been categorized as a “cold” material. However, its association with the avant-garde, futurists, constructivists, modernists, and brutalists, to name a few, demonstrates how aesthetically charged the material itself truly is. Steel speaks to a specific aesthetic, but can it be beautiful and awaken aesthetic considerations like a painting or piece of music? Apart from being a part of our infrastructures and buildings, steel has broken and redefined boundaries of what is considered art over the last century.

### **AN ART HISTORY OF STEEL**

The use of metal in artworks dates back several centuries. Whether in engravings or bronze moldings, various metals have been applied to produce objects of aesthetic value. However, at the turn of the century in 1900, the artistic landscape began to transform. Amidst revolution and war, the avant-garde movements of Europe began to reshape aesthetics according to a quickly emerging modern landscape. From the

cubist redefinition of space on a two-dimensional plane to the revolutionary mindset of the constructivists, the materials embraced by the artistic community began to incorporate metal, plastics, and concrete. Among these famous incorporations of steel in sculpture was “The Constructed Head no. 2” by Naum Gabo, using galvanized iron sheets. The original work reflects the cubist influence of the early twentieth century.

As the price and cost of steel production decreased into the mid-twentieth century, thanks to industry advancements and new techniques for treating steel, steel quickly became more common for artists in the twentieth century. Moreover, the movements pushing the boundaries of aesthetic expression also began to shift focus. Minimalism and post-minimalism both began to emerge in the 1960s. With a flair for the dramatic, minimalist sculptures utilized industrial materials and favored anonymity. The subject of the art was no longer any suggestion of symbolism or emotional con-

**Vladimir Tatlin**  
**Monument to the Third International**  
 1919–1920

While never realized at scale, "Tatlin's Tower" was a testament to the use of steel for monumental architecture and its inspiring material character.

tent but focused on the material itself. Post-minimalism attempted to reimburse emotional and expressive qualities while maintaining abstraction, anonymity, and a focus on the material.

Artists like Richard Serra, Tony Smith, and Beverly Pepper are well-known for their monumental and minimalist artworks installed worldwide. Pushing the limits of space, often literally, minimalist and post-minimalist artists have significantly impacted contemporary modern art and sculpture.

### **A TRULY MODERN MATERIAL**

With the subject of minimalist and post-minimalist art that emerged in the 1960s being primarily the material itself, steel became synonymous with grand modern sculpture. Its flexibility and malleability allowed artists to play with space on a scale that the early avant-garde only dreamed about—e.g., Vladimir Tatlin's "Monument to the Third International" conceptualized in 1920 (pictured above). Steel technologies and access to industrial materials for artists meant that colors, materials, and space itself could become the artists' canvas. These influences can be seen in con-

temporary art that produces large-scale artworks and often plays with steel as a material, creating a mirror surface and shapes to suggest a sense of lightness.

Two types of steel appear to be most prominent for artists—Corten or weathering steel and stainless steel. Corten steel has gained a degree of popularity in modern design and architecture. The design principle behind the steel is to eliminate the need for painting. Instead, Corten steel "weathers" as a rust-colored patina develops over the surface, protecting the steel from the elements. Alternatively, stainless steel does not rust and offers malleability and flexibility. For example, stainless-steel sculptures can be welded, machined, bent, finished with various surface treatments, and even colored. What's more, something about the material character of steel sees its lasting impact into the twenty-first century.

### **MONUMENTAL STEEL**

Perhaps it is something inherent in the material of steel as a durable and sustainable material that makes it the preferred choice for monumental outdoor sculpture. Looking at Richard Serra's work "Tilted Arc" from 1981,

**Richard Serra****Tilted Arc**

displayed in 1981-1989

Serra's "Tilted Arc" is disruptive and imposing as an artwork, but creates an awareness of space, direction, and intention with striking simplicity.

**Anish Kapoor****Cloud Gate**

2006

An iconic piece for the city of Chicago, Illinois, U.S.A., Cloud Gate invites visitors at Millennium Park to rethink the cityscape in imaginative ways.

one is struck by the images of a nearly 40-meter-long, 4-meter-high structure out of Corten steel that dissects the Foley Federal Plaza in Manhattan. Despite its minimalist characteristics and lack of emotional content, the response to the work was anything but emotionless. From signed petitions by frustrated commuters to a court hearing on freedom of speech, "Tilted Arc" created a space for individuals to consider space, presence, and art.

Unlike Serra's "Tilted Arc," some monumental pieces have come to define spaces. "Cloud Gate" in Chicago's Millennium Park is precisely one such structure that has become a part of the city of Chicago's culture. Revealed in 2004 and affectionately nicknamed "The Bean," the mirrored stainless-steel surface reflects the city's skyline and surrounding green space. The mirrored surface invokes playfulness as visitors move around the massive, polished structure. This type of playfulness in mirrored stainless steel has come to be associated with much of contemporary art.

Jeff Koons has become a household name in the art world. His balloon structures bring the utmost sense of

lightness to the room, apart from the fact that his stainless-steel sculptures are by no means light. His stainless-steel balloons, coated with a transparent color treatment, look and feel like the much-beloved inflatables one sees at the circus or an inflatable animal that could float away if you don't hold on tightly. Despite his controversy in the art world, his unwavering optimism creates a humorous challenge to the minimalist ideas of the steel monument.

From stainless steel inflatable animals to plants in polished stainless steel, Subodh Gupta creates monumental objects by combining stainless steel objects that reflect more than just the surface. Gupta's "People Tree" from 2017 is a recreation of India's banyan tree. The piece is a marvel of steel construction and expresses life in India for Gupta within its imagery. Ordinary stainless-steel pots, pans, and kitchen objects are polished, creating a gleaming metallic effect, reflecting a time when stainless steel was sought as a luxury item in India. While the sentiment may change today, given India's economic growth, the work demonstrates the ability to transform simple objects into extraordinary ones. ●

## FORUM METALL IN LINZ, AUSTRIA

Located in the heart of the “Steel City” of Linz, Austria, forum metall is a collection of sculptures from national and international artists, placed along the Danube River. With its beginnings in 1977, Helmuth Gsöllpointner and Peter Baum wanted to represent and visualize the intimate connection between art and industry unique to Linz. With several additions since 1977, forum metall remains one of the defining pieces of Austria's industrial city.



**Helmut Gsöllpointner**  
Evolution  
1979

A fascinating hollow construction, “Evolution” originally served as the entrance to an underground garage, but is now a part of the open gallery.

**Herbert Bayer**  
Fountain Sculpture  
1977

Inspired by minimalism and constructivism, the cylinders interact with the water from the fountain in a mathematically beautiful spiral motion.



**Amadeo Gabino**  
Hommage à Anton Bruckner  
1998

A new work added to forum metall years after its inception, the “dedication” to Anton Bruckner was implemented by VOEST-ALPINE MCE Steel.





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### **ORANGE IS THE NEW GREEN**

Technologies and innovations for a sustainable future are fundamental to the presence of Primetals Technologies at METEC 2023. Green steel has emerged on the global market, and sustainable steel requires a pioneering spirit and a willingness to explore new eco-friendly production routes. With our passion represented by the color of glowing steel and our sights set on transformative solutions, we're making orange the new green.

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