DRI UPDATE

SIMA

Sponge Iron Manufacturers Association

Indian voice for the ore based metallic & steel industry

SPECIAL SUMMIT 2024 ISSUE

APRIL 2024

Deependra Kashiva
Editor, Director General,SIMA

Dear Readers,

We are bringing out this special issue deliberating mainly about our recently held event – **6th India International DRI Summit 2024**. The theme of this summit was Multi Pathways for Mitigation of Carbon Footprint. It may be recalled that in the 5th Summit organized in 2022, the theme was Decarbonization of Indian DRI & Steel Industry - Way Forward. This event with exposition was attended by more than 250 delegates from India and 7 countries. The Ministry of Steel was represented by Secretary, Addl. Secretary, Joint Secretary, Addl. Industrial advisor and other senior officers

Some of the presentations of the this year's event from Danieli, Tenova HYL, Tata Steel, IIT Roorkee, Jindal Steel & Power, Sulb Company have been included. These presentations throw light on the prospects of mitigation of CO2 emissions. There was consensus that CO2 emission can be reduced by 15 – 20% on short term basis by replacing thermal energy with renewable energy, adopting energy efficiency, material efficiency measures. On a medium-term basis, emissions can be brought down to 50% by adopting BATs, increasing use of recycled steel, better operating practices etc. On a long-term basis, we have to wait for the commercially proven disruptive technologies using green hydrogen.

It may be mentioned that many countries have initiated exploring and adopting hydrogen based DRI and steel production. Baosteel Zhanjiang Iron & Steel, China have installed largest reactor to produce 1 MTPA DRI by using natural gas, coke oven gas and hydrogen based on Energiron technology. Earlier similar plant of HBIS was commissioned in May 2023. Vulcan Green Steel DRI plant of 2.5 MTPA based on Energiron technology is being set up in Oman. Likewise, Thyssenkrupp Steel have decided to setup 2.5MTPA Midrex Flex ™ plant in Duisburg, Germany. Another 2.1 million tons per year MIDREX H2™ Plant will be located in Boden, Sweden. We in India, already have about 12.20 MTPA gas based DRI capacity operating on NG, coke oven gas, corex gas, syn gas. Ministry of Steel is contemplating to set up a R&D project to explore the use of Indian raw materials and green hydrogen to produce DRI and reduce the consumption of PCI in blast furnaces in consortium with the various stakeholders.

We are confident that **future of the Indian DRI is bright** and will play significant role in augmenting the steel production in India. We take this opportunity to express our gratitude to all stakeholders to support our efforts to produce clean and green DRI & steel.

MESSAGE

Rahul Mittal
Chairman,SIMA and MD Janki Corp. Ltd

I am happy to know that SIMA is bringing our special issue of their in- house magazine DRI UPDATE featuring salient features of recently held **6^{th} India International DRI Summit 2024 in Delhi**. The event was a resounding success, drawing speakers and delegates from seven countries, alongside senior government officials, technology and raw material suppliers, as well as DRI and steel producers. It's wonderful to learn about the profound impact of the India International DRI Summit 2024 and the ongoing follow-up initiatives that have stemmed from it. It's always encouraging to see dedicated individuals like Shri Deependra Kashiva and the team at SIMA working hard to make such events a success. I consider it as my privilege to be associated with vibrant organization like SIMA who is continuously working for the sustainable growth of Indian DRI and DRI based steel industry.

I'm delighted to share that SIMA is collaborating closely with the government and technology suppliers to pioneer a compact gas-based DRI module. Despite facing significant challenges such as high capital expenditure and uncertainties surrounding the price and availability of reducing gas, I'm confident that our collective efforts will lead us to discover the right solution.

Amidst the current volatile global geopolitical landscape, uncertainty looms over our sector. However, I remain optimistic that this situation will soon stabilize, allowing India to persist on its path towards economic global prominence.

I am sure this issue will enlighten our readers. We look forward to their suggestions/contribution for our next issue.

I extend my best wishes to our readers

Gajraj Singh Rathore
Vice Chairman,SIMA and Director & Group COO,JSW Steel Ltd

I had the distinct privilege of attending the 6th India International DRI Summit, organized by SIMA. It was an enlightening experience to listen to the industry leaders on their views to make a sustainable future of steel.

The summit's theme, "Multi Pathways for Mitigation of Carbon Footprints," resonated deeply with me and underscores the need of a shared mission to embrace diverse approaches to tackle environmental challenges. It was a reminder of the significant impact that our industry has on our planet and the critical role innovation plays in our journey towards sustainability.

I am also thankful for the opportunity to moderate the session on "Technical Advances in Gas Based DRI and DRI Based Steel Production". The discussions not only highlighted the remarkable growth in DRI production technologies but also reinforced the need for innovation, collaboration, and a collective commitment to eco-friendly practices.

Gratitude to Sponge Iron Manufacturing Association for orchestrating the summit. Let's continue to drive towards a more sustainable, efficient, and resilient steel industry.

SIMA

Sponge Iron Manufacturers Association

Indian voice for the ore based metallic & steel industry

MESSAGE

It is a matter of great satisfaction that **Sponge Iron Manufacturers Association (SIMA)** has once again taken initiative to sensitize all stakeholders to reduce carbon footprints and is organising – **6th India International DRI Summit 2024** with a focus on Multi Pathways for Mitigation of Carbon Footprints. The focus of 5th India International DRI Summit 2022 was on Decarbonisation of Indian DRI and Steel Industry - Way Forward.

India continues to be the world's largest DRI producer since last 19 years and supplement more than 40% of the global DRI production. Presently, Indian DRI industry is expanding at the growth rate of more than 18%. With this growth rate, it is expected that India's production would be more than 51 million tonnes in the current F.Y. as compared to about 43 million tonnes of last year. Due to the uncertainty about the availability and the prices of natural gas, Indian DRI industry continues to expand through the coal-based route which is not so eco-friendly. All over the world, DRI industry is expanding through the gas-based route. India does not have a choice but to follow the same trend.

Government of India have announced many pragmatic policies to promote the production of coal gasification (syngas) and green hydrogen. Many incentives have been announced by the Government. I am confident that syngas and green hydrogen would be available in early 2030's at affordable prices and India will see substantial increase in the DRI production through gas-based route.

This Summit is focusing on different aspects of mitigation of CO2 emissions like technical advances in the gas based DRI production route, innovative ideas in the coal-based route, multi pathways, the role of major raw materials etc. I am sure the deliberations will enrich the knowledge of participants and will help them to prepare the roadmap to reduce their carbon footprints.

Wishing all the best to all the stakeholders.

DKashiva

(Deependra Kashiva)
Director General

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सचिव
Nagendra Nath Sinha, IAS
Secretary

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

भारत सरकार
इस्पात मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF STEEL

20th February, 2024

MESSAGE

It gives me immense pleasure to know that Sponge Iron Manufacturers Association (SIMA) is organizing **6th India International DRI Summit 2024.** The topic of this summit has been rightly chosen as ***Multi Pathways for Mitigation of Carbon Footprints.*** Iron and steel industry consumes around 20% of the total energy in India. This sector is the 3rd largest polluter in the world.

National Steel Policy 2017 envisages 300 Million Tonnes annual capacity against the current capacity of about 165 Million Tonnes and production of 255 Million Tonnes by 2030-31 against the last year production of 127 Million Tonnes. We are having double digit growth in steel production and are hopeful that we will be near to that target. This calls for immediate action to reduce our CO_2 emissions from the current level of about 2.5 tonnes CO_2/tonne of steel to the global average of 1.7 tonnes CO_2/tonne of steel. Ministry of Steel has constituted 14 Task Forces on various policy levers relating to decarbonization in addition to working with industry through their active engagement in various initiatives such as PAT Scheme of BEE, use of renewable energy, use of hydrogen and other alternative fuels. As we all know, Hon'ble Prime Minister has pledged India's commitment to be carbon neutral by 2070, all the stakeholders must come together to reduce our carbon footprints. I am happy to say that many steel producers have started to focus to reduce their carbon footprints.

There is a need to develop innovative ideas keeping in view of the indigenous resources. This calls for serious focus on Research & Development. I am happy to say that Ministry of New & Renewable Energy has earmarked Rs.455 crores for usage of green hydrogen in the blast furnace and DRI production. SME and large steel producers must join the Government's efforts to develop indigenous capabilities to produce green DRI/steel.

One must celebrate India's DRI industry, which is the largest in the world. However, its emission load is also very high. We believe that Indian DRI industry is going to play an important towards decarbonization of steel making in India. I appreciate the continuous efforts being made by SIMA as voice/will of this industry to reduce carbon footprints and to supplement metallic requirement to meet fast growing demand of steel.

I am sure the deliberations of the summit would be very useful. I congratulate SIMA collective and wish for success of the said Summit.

(Nagendra Nath Sinha)

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ENERGIRON HYL
DRI TECHNOLOGY BY TENOVA AND DANIELI

ENERGIRON: a flexible technology

M. Zampa, Deputy CTO, Danieli Group

SUMMARY

Within the available direct reduction technologies, ENERGIRON – the innovative DRI technology jointly developed by Tenova and Danieli – stands out for being capable to use a unique and well consolidated process in a wide range of operating scenarios.

This allows to efficiently use the different raw materials available in different locations of the world and to produce high-quality DRI with the characteristics that are required by the end user, which as well may vary from case to case. Finally, this unique technology provides additional value in use to both the operators of ENERGIRON plants and to DRI users.

The same ENERGIRON process scheme can be applied for:

- The production of high quality DRI in any of its commercial forms: cold DRI, hot DRI and HBI. Metallization and carbon content can be easily and promptly adapted to the steelmaking needs. Consistency of DRI quality is the ENERGIRON trademark.
- Processing a wide variety of iron oxides. Not only DR-grade pellets, but also BF-grade and lump ores.
- The usage of any reducing gas rich in hydrogen. Energiron has the unique characteristic to process natural gas of any quality and chemistry, but also hydrogen, syngas, reformed gas, coke oven gas and others…
- Green steel projects to be implemented in phases. The same ENERGIRON plant can operate today with natural gas, which eventually can be replaced by green hydrogen in future, with no changes to the equipment. A carbon capture system is embedded in the ENERGIRON process, therefore up to approx. 60% of the CO2 generated by the reduction of iron ores can be utilized for CCU/CCS applications.

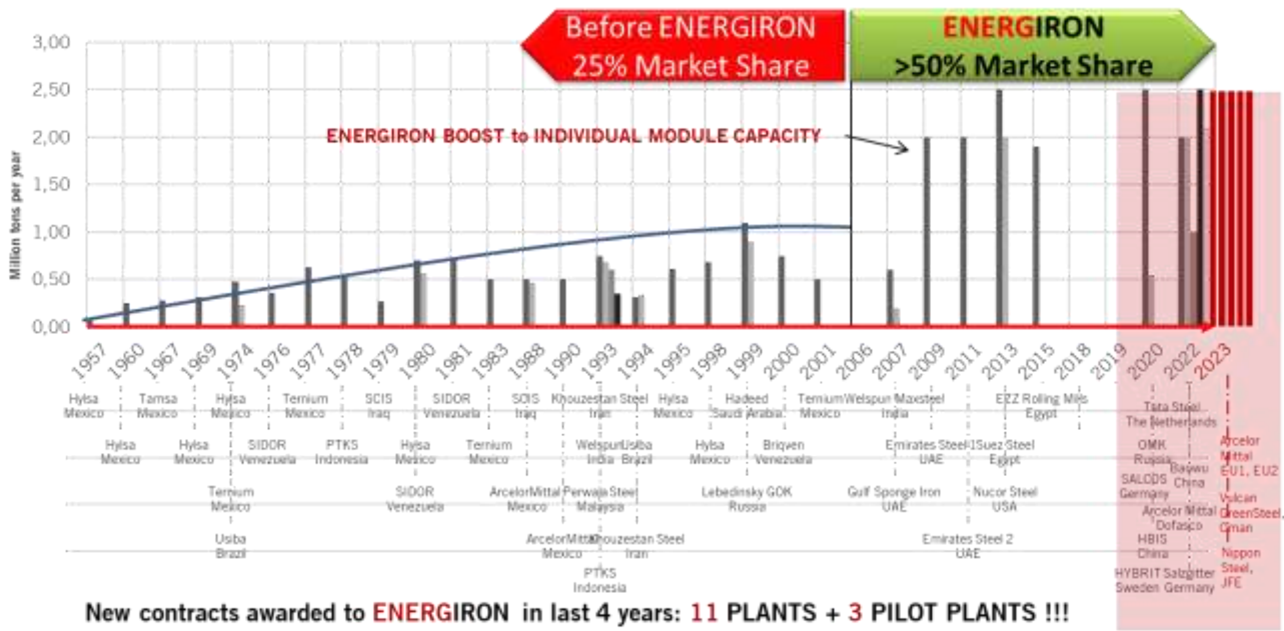
And most importantly, this operational flexibility comes with no compromises on energy efficiency, which allow owners of ENERGIRON plants to take the advantages of lower OPEX!

Read more if you want to discover why ENERGIRON has been selected for 11 new projects in the last 4 years.

Introduction:

In modern steel production, technological advancements are paramount to meet the demands of efficiency, sustainability, and quality. Among the pioneering innovations in this field stands the ENERGIRON Direct Reduction Iron (DRI) technology jointly developed by Tenova & Danieli, which is one of the most viable gas-based DR technologies. Renowned for its flexibility and adaptability to different operating requirements, ENERGIRON represents a huge shift in the production of high-quality DRI, characterized by high metallization and adjustable carbon content.

At its core, the ENERGIRON DRI technology embodies a synthesis of cutting-edge engineering and process design. What sets it apart is its remarkable ability to accommodate and integrate diverse qualities of DRI pellets, and to utilize various gases as feedstock through employing natural gas, syngas, hydrogen, coke oven gas or a combination of them, all within a single process configuration that remains unchanged.



Started in the 50th with plants of small capacity and after the ENERGIRON Alliance, the capacity of the single unit increased up to 2,5 MTY (Cold DRI plant Zero Reformer commissioned by Nucor Steel), largest single-module size at that time, that nowadays is the most requested capacity for the new DRI modules. In the figure above we can also see the major improvements that ENERGIRON Technology introduced to the DR industry.as the most remarkable ones are : carbon capture in the technological circuit, first zero water consumption plant, first pilot plant using 100% H2, use of COG paving the road for greener steel production with improved plant efficiency. The latest plants are all highlighted in green since they are already ready to move from natural gas to 100% H2 as reducing agent.

These unique traits of the ENERGIRON process, allow plants' adaptability and versatility, ensuring that the ENERGIRON DRI meets the most stringent industry requirements, granting producers greater autonomy in selecting feedstock, which finally results in competitiveness and resilience in facing fluctuations of market dynamics and resource availability, by ensuring consistent and reliable outcomes, irrespective of pellet and gas quality. All these aspects, which are of outmost importance in the modern ironmaking sector, set ENERGIRON as a frontrunner within the DRI Production Technologies.

ENERGIRON PROCESS:

The ENERGIRON process is designed for converting iron ore into metallic iron using reducing gases in a solid - gas moving bed reactor. Here's a breakdown of the process:

1. **Feed Material:** Iron ore (either pellet or lump ore) is coated and continuously fed into the system.

2. **Alternative Sources of Reducing Gases:** In addition to natural gas of any quality, alternative sources of reducing gases such as hydrogen, syngas, COG (coke oven gas), and other gases can be utilized in ENERGIRON plants while maintaining the same basic process scheme.

3. **Generation of Reducing Gases:** Natural gas is typically used as makeup feed to the reducing gas circuit and reducing gases, primarily hydrogen (H2) and carbon monoxide (CO), are generated through the self-reforming process in the reduction reactor upon contact with the solid material inside the reactor. Cracking and reforming of gases occur due to the catalytic effect of metallic iron.

4. **Humidifier:** allows a fine control of the reforming of methane and carbon deposition in DRI inside the reactor

5. **Iron oxide reduction:** Oxygen is removed from the iron ore at solid state through chemical reactions with hydrogen and carbon monoxide. These reactions produce highly metalized Direct Reduced Iron (DRI). Metallization can be set at the desired value, up to 96%.

6. **Gas recirculation:** to enhance the system's efficiency, the reducing gas is recirculated in a closed circuit. centrifugal compressors compensate the differential pressure of the circuit and taking advantage of the operating pressure (6/10 barg) of the ENERGIRON process, the electrical energy consumption can be minimized.

7. **ENERGIRON Process Gas Heater:** heats up the gas up to 950 °C. This unit has been developed by ENERGIRON to fit and satisfy the peculiarity of the DR process in terms of reliability and efficiency.

8. **Injection of Oxygen:** Oxygen is injected at the reactor inlet,the resulting partial oxidation of reducing agents with oxygen increases the operating temperature of the process gas entering the reactor up to the level is required for reforming and iron ore reduction.

ENERGIRON HYL
DRI TECHNOLOGY BY TENOVA AND DANIELI

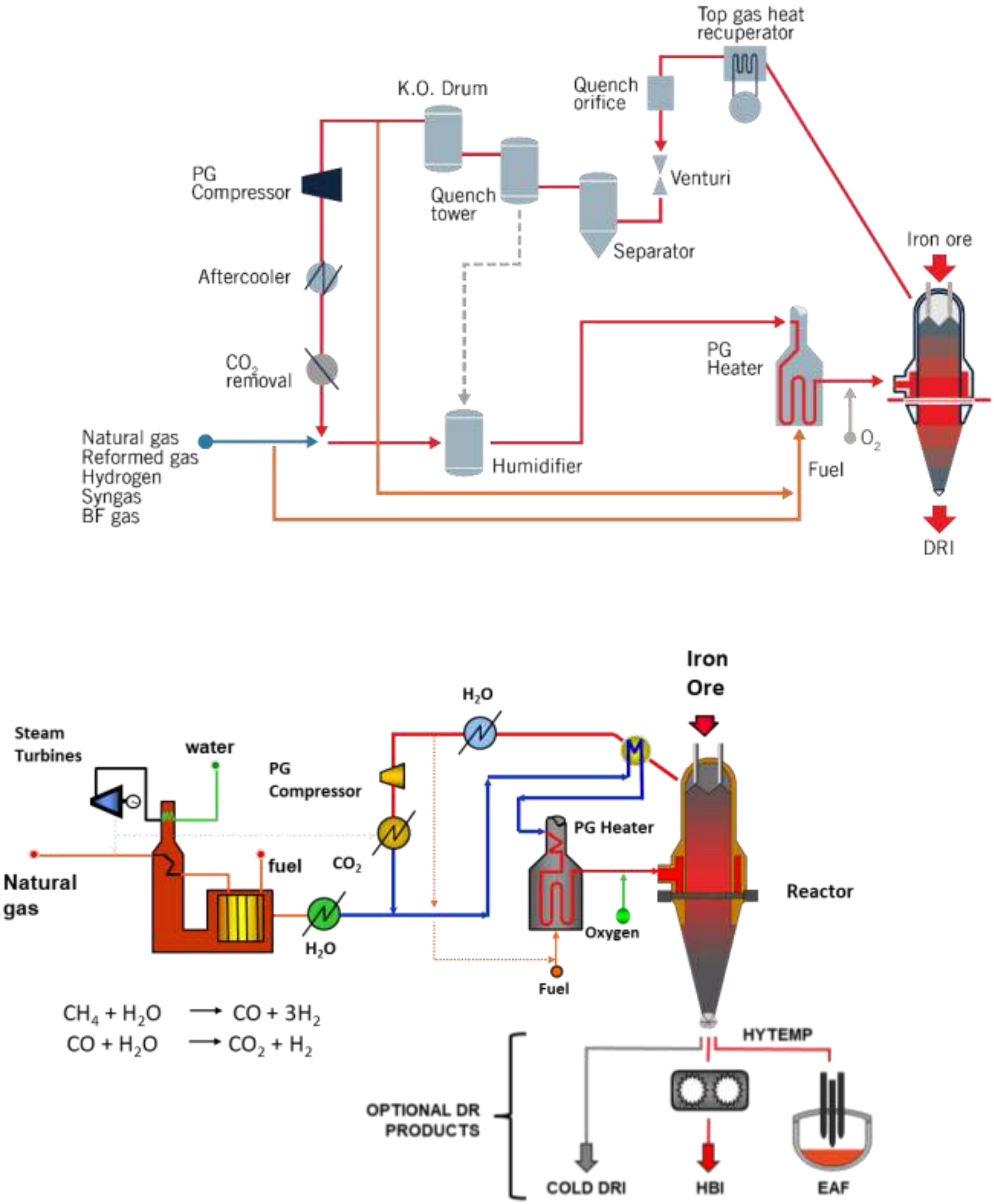


Figure 1. ENERGIRON scheme with and without reformer

ENERGIRON HYL
DRI TECHNOLOGY BY TENOVA AND DANIELI

Technological Advantages of ENERGIRON:

The ENERGIRON technology stands out in the direct reduction (DR) process landscape due to its commitment to energy recovery and efficiency. Here's a breakdown of its key features and advantages:

1. **Iron Ore Pellets Quality:** ENERGIRON Technology is flexible in using different grades of iron ores including BF pellets. Iron ores with common impurities such as Sulphur and phosphorous, which can be present in some ores in relatively high concentrations, can be used with no limitations in ENERGIRON plants, moreover due to inherent process scheme characteristics, most of the Sulphur of the iron ore is converted to H_2S in the reduction reactor and eliminated from the process in subsequent separation steps. This allows using the resources locally available at the most competitive price. Moreover, the high operating pressure of ENERGIRON plants allows to use smaller granulometry iron ores, recovering part of those valuable natural resources that other technologies would discard.

2. Higher Pressure Operation: The Operating Pressure (6-8 bar(a) against approx. 2,5 bar(a) for other DR technologies) brings several advantages:

- Contain the desired amount of reducing agents in a smaller volume, thus lowering the Process gas velocity compared to other Technologies allows to process also fine materials, that otherwise would be rejected.
- Less possibility for gas channeling as the diameter to the height ratio in the ENERGIRON Technology is 1:2 Compared to 1:1.5 in the other Technologies and with less gas channeling, leading to a better and more homogeneous metallization.
- proprietary mechanical sealing of the ENERGIRON Reactor increase the safety of the system.
- Reduced residence time of iron oxide inside reactor (2 hours instead of 3 hours) allows to boost productivity with a smaller reactor size.
- Reduced fines carry-over in the Top gas.

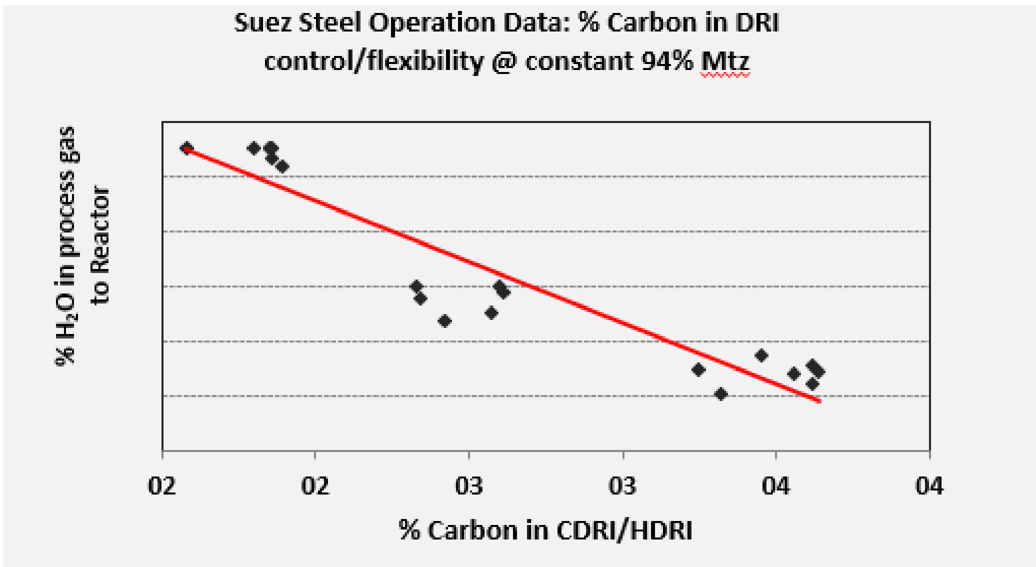
3. Highest Energy Efficiency: the outstanding energy efficiency of ENERGIRON plants (typical Natural Gas Consumption of 2.35 Gcal/t) is possible thanks to the proprietary auto-reforming technology and to the use of energy recuperation systems like Top Gas heat recuperator. This equipment optimizes and recovers energy from the sensible heat of process gas leaving the reactor. The recovered heat is used either to produce steam or to preheat the reducing gas before it enters the PGH. By efficiently utilizing this heat, the overall energy consumption of the process is minimized.

4. Lowest Electrical Energy Consumption: Since the largest Electrical Load is for the Process gas compressor, operating with High Pressure means higher suction pressure at Compressors inlet leading to smaller Compression Ratio and work done by the compressor helping in minimizing the overall process electrical energy consumption, making the process more energy efficient.

5. Lowest CO_2 Emissions: Thanks to CO_2 removal system embedded in the reduction circuit, ENERGIRON is the best fitted technology to provide CCU (Carbon Capture and Use) and CCS (Carbon Capture and Storage) solutions applied to the steelmaking industry. Among the other possible applications, CO_2 generated by ENERGIRON plants is captured and used to produce beverages, conglomerates, dry ice and used in EOR applications with no requirements for additional OPEX and/or CAPEX. This not only helps in minimizing environmental emissions but also provides an opportunity to clean the absorbed CO_2 for sale as a by-product.

6. Highest Quality DRI: ENERGIRON DRI boasts top-tier quality, enabling steelmakers to optimize overall liquid steel production costs for superior steel grades. The highly metallized DRI with controlled carbon content (ranging from 1% to 4.5%) sets it apart from traditional DRI products.

7. Efficient Carbon Utilization: ENERGIRON ZR can produce DRI with any Carbon content, giving to the steelmaker the possibility to go for the most economical mix of chemical and electrical energy input to the EAF. The carbon content, primarily in the form of cementite (Fe3C), is efficiently and completely utilized in the Electric Arc Furnace (EAF). This results in a high yield close to 100%, whereas injected coal and graphite additions typically achieve around 60% yield. The conversion of Fe3C into iron and carbon in the EAF is also an exothermic reaction, further enhancing thermal efficiency and reducing electric power requirements. Additionally, it promotes easy foamy slag generation, akin to adding chemical energy to the EAF. Further efficiencies can be achieved thanks to the proprietary Hytemp® system, a safe and reliable solution to convey the DRI to the EAF at high temperature. This unmatched efficiency of the ENERGIRON technology provides the lowest OPEX and a responsible use of the natural resources.



8. Possibility to use various reducing gases:

- **Natural Gas with any quality**

There is no limitation on the natural gas quality being fed to any of the ENERGIRON Process schemes (ENERGIRON ZR or ENERGIRON IIII)

In case of presence of Natural gas with:

- high % of heavy parts (like Propene, Butene etc)
- High Sulphur content
- High N_2 Content in the NG

ENERGIRON III Configuration should be used In Case the Above Gas quality is Present.

Otherwise, the ENERGIRON ZR Configuration is Proposed.

- **Syngas**

With similar approach to the Reformed Gas, we can proceed to use also Syngas coming from Coal Gasifier, according to the following scheme:

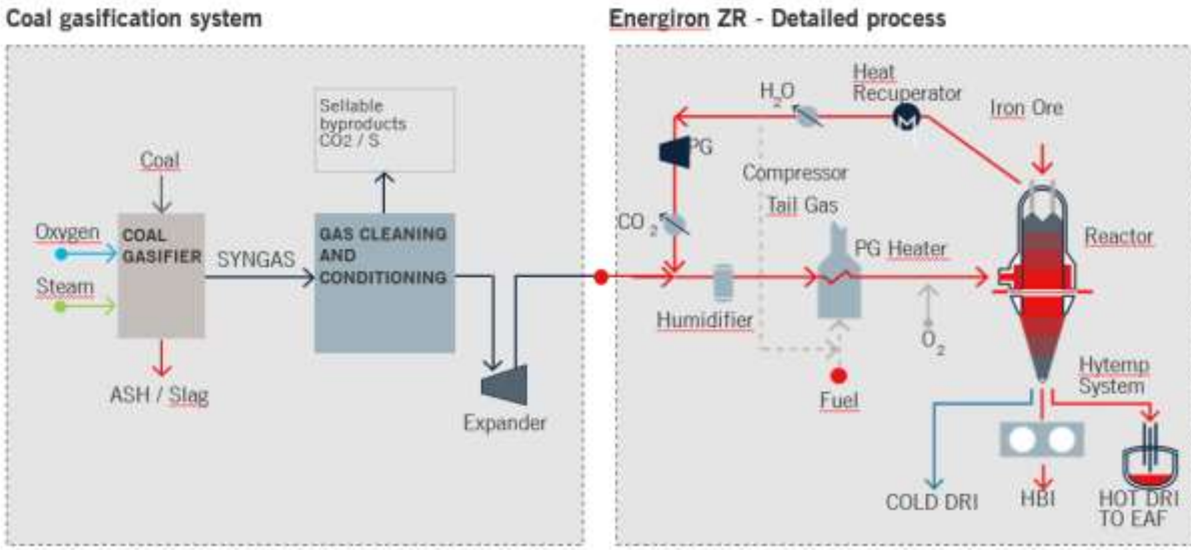


Figure 2.Plant Configuration for Syngas Usage

In this case the makeup gas (see below typical composition) coming out from a coal gasifier can be directly use the process circuit, without any major change in the process scheme.

H_2 / CO	> 1,5 (preferred)
CO_2	< 3%
N_2	< 6%
H_2S	<100 ppmv
Pressure	13 barg (min)
Temperature	Ambient

- **COG (Coke Oven Gas)**

Traditionally, COG has been viewed as a waste product, often flared off or left unused, contributing to environmental pollution. However, ENERGIRON technology flips this narrative on its head. Instead of letting COG go to waste, it becomes a valuable resource in the steelmaking process.

The integration of COG within ENERGIRON technology significantly enhances energy efficiency. COG, rich in carbon monoxide and hydrogen, serves as an excellent reducing agent, aiding in the reduction of iron ore to produce high-quality steel. This not only reduces the reliance on traditional fossil fuels but also lowers greenhouse gas emissions, aligning with global efforts towards sustainability.

In this case the process scheme and equipment are always the same, the only difference that the COG is inject in the cone of the reactor where the presence of HDRI assure to destroy the typical impurities of the COG like heavy hydrocarbons, BTX (see typical composition in the table) as per the patented scheme here below:

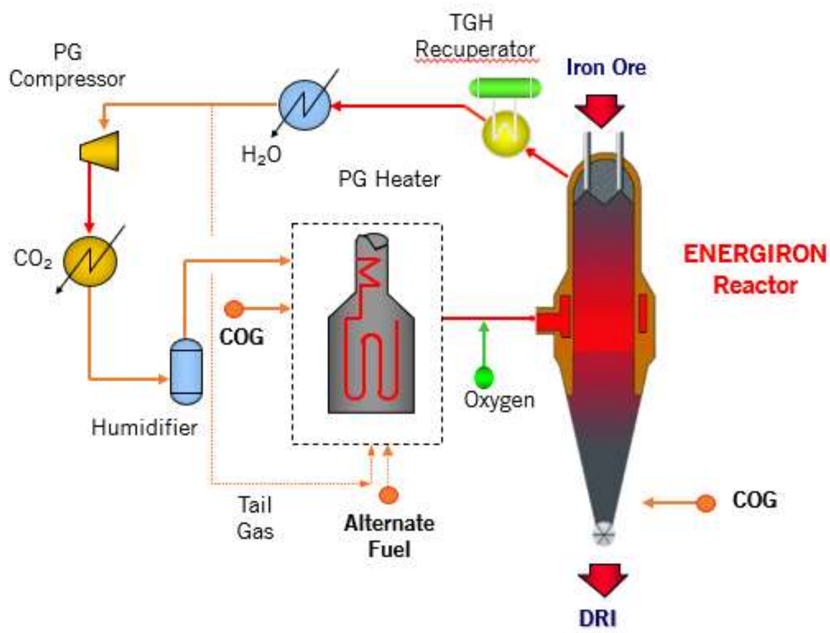


Figure 3. Plant Configuration for the Use of COG

Typical COG Analysis	
Description	Volume %
H_2	55 – 64
CO	8 – 10
CO_2	3 – 4
CH_4	20 – 25
N_2	0.1 - 6
Naphthalene	⩽0.3 gr/ Nm³
Tar	⩽0.04 gr/Nm³
H_2S	⩽20 mg/Nm³
BTX	⩽5 gr/ Nm³
C_mH_n	2.0 – 3.6
O_2	1.5 – 1.8
H_2O	saturated
Low caloric value (kcal/Nm³/h)	4,000 – 4,260 (dry basis)

With this configuration today are working the plant of HBIS (0.5 MTY) and Bawou (1 MTY) in China started up in May 2023 and Jan 2024:

2023年5月，项目一期工程实现安全顺利连续生产绿色DRI产品。从开工到连续运行历时24个月，创造了世界氢冶金建设最快速度。
The first stage of the project achieved safe and continuous DRI production in May 2023.
It creating the world's fastest speed of hydrogen metallurgy construction.

Reduction system

HBIS 张宣科技

Since our DRP was still in hot commissioning stage during the 1st production month, the plant was not in perfect condition, some trips occurred due to different reasons, the optimization of the plant was also not done, so some of the cost were higher than designed.

Performance comparison ("1st month" vs "design" vs "after optimized")

Parameter	UNIT	1st month	Design Value	August
Metallization(DRI)	%	93.65	≥94	94.5
C(DRI)	%	3.16	~2	2.7
Pellet consumption	t/tDRI	1.37	~1.4	1.38
COG consumption	Nm³/tDRI	778	~680	594
N_2 consumption	Nm³/tDRI	22.37	~38	33.7
O_2 consumption	Nm³/tDRI	25.18	~35	31.6
Steam consumption	t/tDRI	0.1	~0.09	0.07
Water consumption	t/tDRI	1.7	~1.63	1.78

The reason why to use COG can be easily explain with the following numbers considering a complex of 4 MTY BF bases:

- Typical we need 350 kg of coke for each ton of hot metal produced.
- For each ton of coke, we can produce 380 Nm3 of COG, so considering the 4 MTY capacity we have the possibility to have 532 MNm3/year of COG.

Now if we consider that:

- For each ton of DRI is need 660 Nm3 of COG, means that with the availability of 532 MNm3/year we can install a DRP with the capacity of 800.000 tonDRI/year plant, that combine with a EAF (or using the DRI in the BF) means to have 700.000 tonLS/year.

If we look in terms of emission of the overall complex we can have:

- CO2 emission in BF+BOF route → average 2.000 kg/tonLS

- CO_2 emission in DRP with COG +EAF route → 735 kg/tonLS (considering 343 kg on DRP and 390 kg on EAF due to Electric Energy consumption)

Means that in this way we can have:

- Increase Steel Production: from 4 MTY to 4,7 MTY → + 17,5 %
- Decrease specific CO_2 emission: from 2.000 kg/tonLS to 1660 kg/tonLS → - 17%

Of course, the a.m. values are typical one, so our suggestion is to proceed in advance with a prefeasibility study for tailored evaluation of best applicable solution.

Moreover, ENERGIRON's utilization of COG translates into economic advantages. By transforming what was once considered waste into a valuable resource, steel producers can optimize their operations, reducing costs and improving competitiveness in the market.

- Hydrogen

The next phase in reducing CO_2 emissions can be accomplished through the utilization of Hydrogen. The ENERGIRON ZR process is specifically engineered to utilize Hydrogen-rich gases as a reducing agent, eliminating the need for additional equipment or modifications beyond its basic setup.

ENERGIRON facilities typically operate with a ratio of Hydrogen to Carbon Monoxide (H_2/CO) ranging from 3 to 5, indicating their inherent design to handle high levels of Hydrogen. Indeed, Hydrogen has always been the primary agent for reducing in this technology. Consequently, ENERGIRON is inherently equipped to harness this promising energy source, as reduction with Hydrogen in ENERGIRON reactors proves to be significantly more efficient and rapid compared to Carbon Monoxide, approximately five times faster from a kinetic standpoint.

the main benefits of reduction with hydrogen are:

$Fe_2O_3+3H_2 \rightarrow 2Fe+3H_2O$ Hydrogen Reduction

Reaction with Hydrogen is endothermic, taking out heat from the system because the energy in the products is higher than in the reagents. Hydrogen reduction tends to cool the burden inside the furnace. Furthermore, Utilizing Hydrogen not only capitalizes on an alternative reducing agent but also helps minimize CO_2 emissions. While the by-product of iron ore reduction using CO is CO_2, the by-product of reduction with H_2 is water. Ultimately, thanks to the ENERGIRON technology, the production of high-grade steel is now feasible in an economically viable and environmentally sustainable manner.

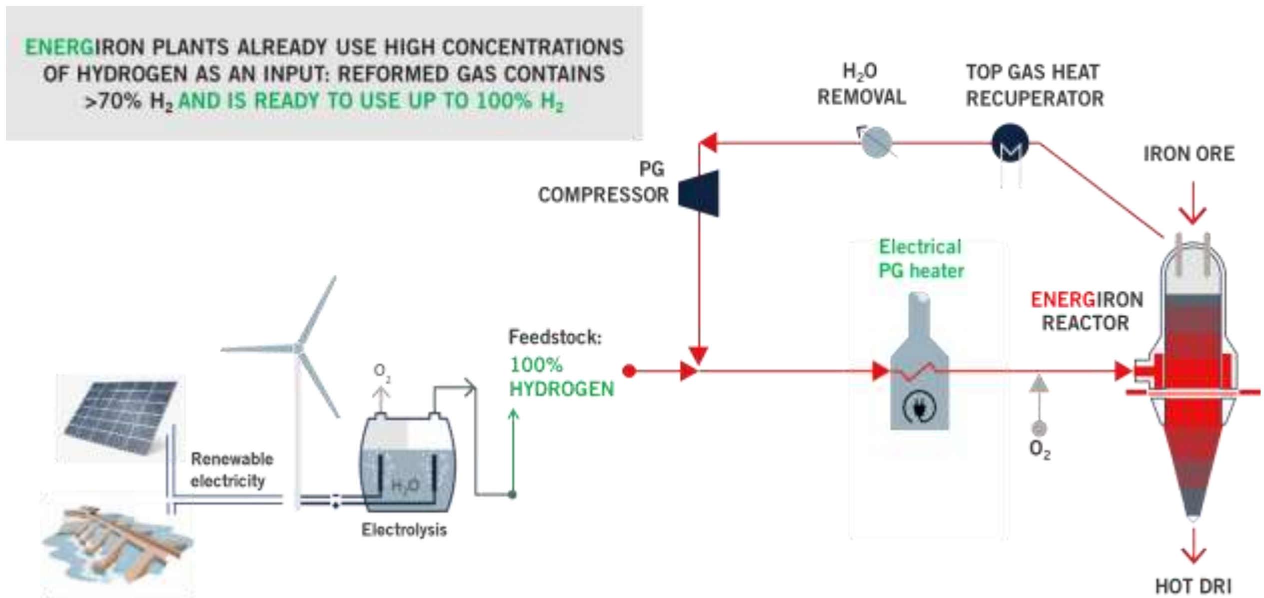


Figure 4.ENERGIRON plants Can use up to 100% of H2 with the same plant Configuration.

In summary, ENERGIRON technology offers a comprehensive solution that not only maximizes energy efficiency and minimizes environmental impact but also delivers high-quality DRI with superior metallurgical properties, ultimately optimizing the overall steel production process.

Parameter	Unit	Value
Yield	t_{Oxide} / t_{DRI}	1,4
Metallization	%	>94%
Carbon Content	%	1.5 ÷4.5
Natural Gas Consumption	Gcal / t_{DRI}	2.35
Electrical Energy Consumption	kWh/ t_{DRI}	90
Oxygen	Nm^3/ t_{DRI}	60

Figure 5.Typical OPEX For ENERGIRON Plant for Reference

CO2 emissions in ENERGIRON plants:

ENERGIRON includes in its basic process a CO2 capture system, as shown in Fig. 1. This allows to further decrease the DRP emissions by approx. 60%, leading to a Carbon footprint of just 156 kg CO2/Tdri using Natural Gas as reducing agent.

In general, the carbon footprint of a DR-EAF plant is about 50% of that of an integrated mill.

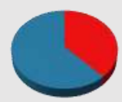
		ENERGIRON ZR	OTHER TECHNOLOGIES
SELECTIVE CO_2 EMISSIONS Captured and sold as by-product	kg_{CO2}/t_{DRI}	256	0
NON-SELECTIVE CO_2 EMISSIONS Released to atmosphere	kg_{CO2}/t_{DRI}	156	~ 500
		NON-SELECTIVE 38%  **SELECTIVE 62%**	**NON-SELECTIVE 100%** 

Figure 6. CO2 Emissions Selective Removal

Conclusion

The ENERGIRON DR technology is the most efficient method for reducing CO2 emissions in the steelmaking sector, thanks to its inherent qualities. It not only meets the most stringent global environmental standards but also facilitates the reuse of effluents & emissions as valuable resources. In essence, ENERGIRON DRI technology stands as a testament to the convergence of innovation and sustainability, its unparalleled flexibility in accommodating diverse pellet qualities and feedstock gases, coupled with its steadfast commitment to producing high-quality DRI, Embodies the spirit of progress driving the modern steelmaking landscape. As the industry continues to evolve, ENERGIRON stands at the forefront, reshaping the contours of steel production for generations to come.

Danieli is committed to assisting its clients by offering sustainable, customized solutions for CO2 emission reduction, covering everything from initial feasibility studies to the implementation of turnkey projects. Tailored solutions are crafted based on ENERGIRON plants, which can operate independently or be integrated seamlessly with electric minimills or blast furnaces. These solutions are designed to optimize OPEX while maintaining high steel quality, within sustainable capital investment strategy.

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HYDROGEN-ENRICHED SYNGAS PRODUCTION FROM BIOMASS

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Introduction

Synthesis gas (Syngas in brief) is a gas mixture of predominantly CO and H_2. It is produced from different sources such as natural gas, coal, biomass, waste, etc. In the present study, biomass is used to produce syngas through gasification process. Biomass gasification is a thermo-chemical process where temperature and chemical reactions play a key role. For gasification required temperature is more than 700°C and chemical change occurs in partially oxidised atmosphere. Further, gasifier is the primary unit to produce syngas, which are mainly of three types i.e. fixed bed, fluidized bed and entrainment bed. In the present study, fluidized bed, more precisely bubbling fluidized bed, gasifier is selected because of the high efficiency and better heat and mass transfer.

This study mainly focuses on the design of continuous system of gasification unit, gas composition with maximum H_2 content, usage of syngas and availability of biomass.

Design of Continuous System

The continuous system for gasification includes number of units such as bubbling fluidized bed gasifier, steam generator, cyclone separator, condenser, water and tar collector, flame arrester, gas sampling system, etc. The batch system for gasification is shown in Fig. 1 (Kumari and Mohanty, 2020) in which gasifier is designed for continuous feed as can be evident from Fig. 2.

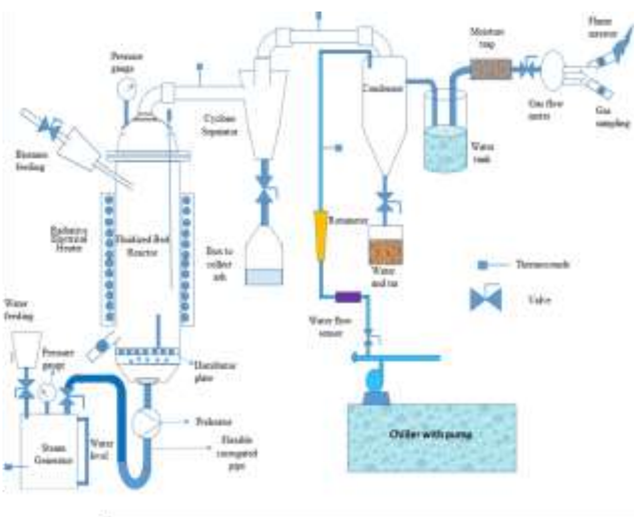

Fig. 1 Set-up for fluidised bed gasifier (Batch)

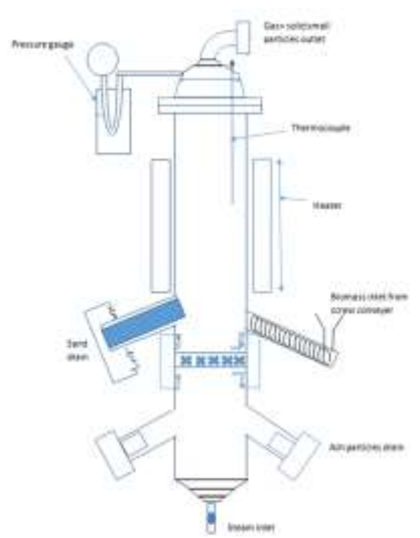

Fig. 2 Continuous fluidised bed gasifier

Gas Composition with Maximum Hydrogen Content

In the gasification set-up, shown in Fig. 1, pine needle is used as biomass to produce syngas. Total 20 sets of experimental runs are identified considering three parameters such as temperature of gasifier, steam/biomass ratio and particle size based on design of experiments. Considering these sets, experiments are performed and composition of syngas for each set are analysed as shown in Table 1 (Kumari and Mohanty, 2020). It shows that maximum H_2 concentration is found as 60.86 Vol%.

Table 1. Gas composition at different sets of experiment for pine needle

Run	Temperature (°C)	S/B ratio	Particle size (μm)	H_2 (vol%)	CO (vol%)	CH_4 (vol%)	CO_2 (vol%)
1	750	1.6	175	56.67	10.18	10.14	19.54
2	750	1	75	56.41	16.34	12.76	11.24
3	800	1.3	225	54.68	10.27	10.26	21.43
4	700	1.3	225	52.86	11.69	12.62	18.89
5	800	0.7	125	58.7	12.98	11.54	12.88
6	750	1	175	60.86	14.23	12.54	12.3
7	800	1.3	125	57.95	12.84	12.62	14.91
8	650	1	175	46.62	17.74	17.05	10.24
9	750	1	175	59.05	15.45	12.96	12.06
10	700	1.3	125	57.54	15.7	11.5	10.97
11	700	0.7	125	50.25	17.45	13.89	11.27
12	750	1	175	60.02	15.07	12.06	12.8
13	750	1	275	50.68	13.82	11.87	20.74
14	750	1	175	59.25	15.37	12.68	12.67
15	750	1	175	60.38	14.65	13.05	11.92
16	750	1	175	59.48	15.45	12.54	12.5
17	750	0.4	175	48.67	17.05	13.56	10.98
18	800	0.7	225	58.87	16.03	11.04	14.52
19	850	1	175	60.36	12.22	10.67	15.86
20	700	0.7	225	48.71	18.49	16.81	13.07

Further, to optimize H_2 concentration, Analysis of Variance is applied on data shown in Table 1. As a result, quadratic equation, Eq. 1, is obtained (Kumari and Mohanty, 2020).

$$\begin{aligned} H_2 \text{ concentration} = {} & 59.85 + 3.02A + 1.41B - 1.30C - 2.05AB \\ & + 0.39AC - 0.82BC - 1.58A^2 \\ & - 1.79B^2 - 1.57C^2 \end{aligned}$$

Eq. 1

Where, A, B and C are temperature, steam/biomass ratio and particle size, respectively. By varying these parameters, maximum H_2 concentration is found as 68.89 vol%. Further, this value is increased to 71.22 vol% considering CaO as catalyst with pine needle (Kumari and Mohanty, 2020).

Usage of Syngas

The syngas generated through gasification can be used to produce ammonia, naphtha, petrol, diesel, wax, ethylene, acetic acid, DME, polyolefins, methyl acetate, formaldehyde, etc. It is also used in sectors like steam and power, IGCC, iron and steel.

Availability of Biomass

India has significant production of biomass through out the year. The state wise surplus fraction of residue availability is shown in Table 2 (Hiloidhari et al., 2014). It shows that the average surplus availability in India is 34%, which is a significant amount. Arunachal Pradesh has minimum surplus amount of biomass as 21% whereas, Haryana and Punjab have maximum surplus of 48%. Based on these data, suitable site of gasification set-up can be identified. Further, Kumar et al. (2021) compiled data for month-wise availability of biomass specially in north India as can be seen from Table 3, which shows that throughout the year cow dung and rice husk are available. Based on this information, it can be concluded that for continuous production of syngas different biomasses, depending on the availability, should be used though it may affect the composition of syngas. The details for major crops growth in India is summarized in Table 4 (Negi et al., 2023). It shows that presently, India produces about 990 MMT of agricultural biomass annually.

Table 2 State-wise surplus availability of biomass residue (%)

State	Cereals	Oilseeds	Sugarcane	Horticulture	Pulses	Others	State avg.
Andhra Pradesh	29	26	40	44	23	38	33
Arunachal Pradesh	27	11	33	25	22	10	21
Assam	25	40	40	45	47	48	41
Bihar	27	32	33	20	23	10	24
Chhattisgarh	29	20	40	25	47	38	33
Goa	26	NA	38	39	NA	70	43
Gujarat	30	25	40	47	53	NA	39
Haryana	34	37	40	NA	40	90	48
Himachal Pradesh	35	17	38	25	35	48	33
Jammu & Kashmir	29	17	40	NA	NA	NA	29
Jharkhand	26	33	40	NA	47	10	31
Karnataka	30	31	38	32	47	33	35
Kerala	30	20	68	38	35	10	32
Madhya Pradesh	28	23	40	25	43	70	38
Maharashtra	28	33	33	43	47	40	37
Manipur	28	21	40	25	NA	NA	29
Meghalaya	26	15	40	20	35	30	28
Mizoram	29	18	40	32	35	48	34
Nagaland	27	16	40	43	35	38	33
Orissa	29	29	33	52	40	10	32
Punjab	34	30	40	NA	47	90	48
Rajasthan	29	18	40	NA	23	10	24
Sikkim	28	22	NA	NA	NA	NA	25
Tamil Nadu	33	19	40	48	30	29	33
Tripura	34	21	40	45	35	38	37
Uttar Pradesh	37	23	38	25	25	48	33
Uttarakhand	32	53	38	NA	55	NA	43
West Bengal	24	20	43	50	29	30	29
National avg.	29	30	39	42	38	38	34

Table 3 Month-wise availability of biomass

Month	Availability of biomass material				
January	Cow dung	Sugarcane trash	Rice-husk	Barley	Bagasse
February	C.D.	Sugarcane trash	R.H.	Pulse (Arhar)	Bagasse
March	C.D.	Mungre	R.H.	Pulse (Arhar)	Mustered
April	C.D.	Wheat straw	R.H.	Popular leaves	Mustered
May	C.D.	Wheat straw	R.H.	Maize	Mustered
June	C.D.	Wheat straw	R.H.	Maize	Mustered
July	C.D.	Wheat straw	R.H.	Maize	Mustered
August	C.D.	Wheat straw	R.H.	Maize	Pulses
September	C.D.	Cotton straw	R.H.	Maize	Sirkanda
October	C.D.	Cotton straw	R.H.	Maize	Sirkanda
November	C.D.	Cotton straw	R.H.	Maize	Potato waste
December	C.D.	Sugarcane trash	R.H.	Bagasse	Potato waste

Table 4 The cropping details of major crops grown in India

Crops	Area (Mha)	Production (Million Tons)	Yield (kg/ha)
Rice	4.51	122.27	27.13
Wheat	31.62	109.52	3464
Nutri/Coarse cereals	23.83	51.15	2146
Pulses	28.83	25.72	892
Foodgrains	129.34	308.65	2386
Oilseeds	28.79	36.10	1254
Sugarcane	4.86	399.25	82,205
Cotton	13.01	35.38	462
Jute and mesta	0.67	9.56	2595

Conclusions

Salient conclusions of the present study are:

1. Continuous and batch set-ups for gasification are discussed where screw conveyor is used to feed the biomass.
2. Hydrogen concentration can be increased by 10% while varying the operating parameters and selecting suitable catalyst.
3. Significant availability of different biomasses is found throughout the year in India.

Acknowledgement
Prof. Bikash Mohanty, Ex-Professor, Chemical Engineering Department, IIT Roorkee
Dr. Priti Kumari, Research Associate, Chemical Engineering Department., IIT Roorkee

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Dr. T.Bhaskar,
Chief Technical Officer
Tata Steel Ltd

The paper presentation will focus on **"Measures taken by our group / companies to reduce the CO_2 emissions particularly in the coal based DRI production route."**

Total Capacity of DRI production in whole Tata Steel Group with Technology

SL No	Location	Production Capacity	Production Rate	Technology Design
1	**DRI Gamharia**	0.5 Million Ton	0.46 Million ton	OSIL & LURGI
2	**DRI Joda Plant**	0.46 Million Ton	0.44 Million ton	LURGI
3	**DRI Meeramandali**	1.5 Million Ton	1.18 Million ton	LURGI

Note:- Total India's Capacity of DRI is 39.04 MT Vs Tata Group capacity is 2.46 Million Ton

Growth Projection of Steel: Ambitious target for steel production in India

The Indian steel sector has grown rapidly over the past few years and has already emerged as the second largest steel producer in the world, contributing to about 2% of the country's GDP

India Sector-wise Steel Demand

Sector	Demand in 2023 (mn t)	% share in 2023	Demand in 2030 (mn t)	% share in 2030
Construction	37	31%	63	33%
Infrastructure	34	28%	55	29%
Automobile	13	11%	23	12%
Gen. Engg.	14	12%	17	9%
Capital Goods	11	9%	17	9%
Consumer Durable	6	5%	8	4%
Railway	4	3%	6	3%
Consumer Non-Durable	1	1%	2	1%
Total	120	100%	190	100%

Source: Steelmint

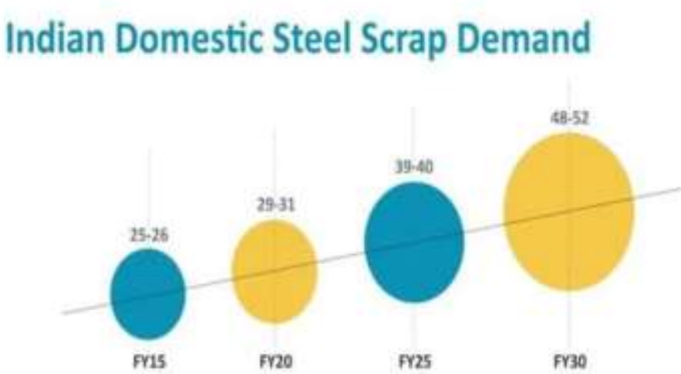
India's steel demand is projected to rise from the present 120 MT to 190 MT by 2030. However, on the higher side this demand could also be closer to 230 MT.

Key influencers include government initiatives, population growth, urbanization trends, and advancements in the auto and engineering sectors

The National steel policy seeks to increase consumption of steel and major segments are infrastructure, automobiles and housing. New Steel Policy seeks to increase per capita steel consumption to the level of 160 Kgs by 2030 from existing level of around 78 Kg

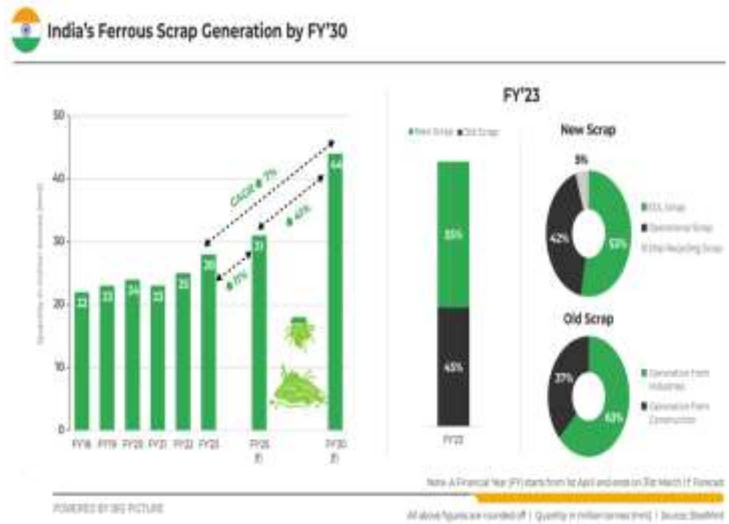
Challenges in availability of raw materials for Secondary steel Producers

India's target to double its steel production capacity to 300 million tons by 2030 may face difficulties due to non - availability of steel scrap. The country hasn't developed a strong recycling industry and relies heavily on imported scrap steel for production.



In 2022 alone, India spent over 12 billion USD on importing metal scrap, and within the next 5 to 6 years, India is expected to become the world's largest importer of scrap steel, with imports reaching approximately 20 million tons by 2030. There is going to be a deficit of nearly 30 MT of scrap by the year 2030. Currently, India is ranked as the second-largest scrap steel importer in the European Union, as well as in the United States, Asia, and the Middle East

The Indian steel industry is confronted with numerous challenges in addressing the scrap steel supply issue due to strict scrap steel export policies from the European Union India continues to seek new opportunities to expand its steel industry



DRI emerging as substitute to Metallics for steel melting

India's sponge iron industry overview

• Currently, DRI has about 30% share in India's total crude steel- making. With an annual installed capacity of approximately 63 mnt in FY23, India is the world's largest DRI producer.

• Since DRI is gaining prominence as an alternative to melting scrap in India's induction and electric arc furnaces, capacity-building is under way.

• Based on the monthly steel capacity expansion data, till October 2023, a total of 31 sponge iron plants received approval for EC/CTE. Among these, 5 mnt of capacity obtained EC approval, and 12.5 mnt received Consent to Establish (CTE) approval.

CY /Sponge Iron Production in India	Production	Coal Based	Gas Based	% Gas Based
2019	36.8	30.1	6.7	18%
2020	33.6	27.5	6.1	18%
2021	37.1	29.1	8.0	22%
2022	41.4	33.4	8.0	19%
2023	48.5	39.3	9.2	19%

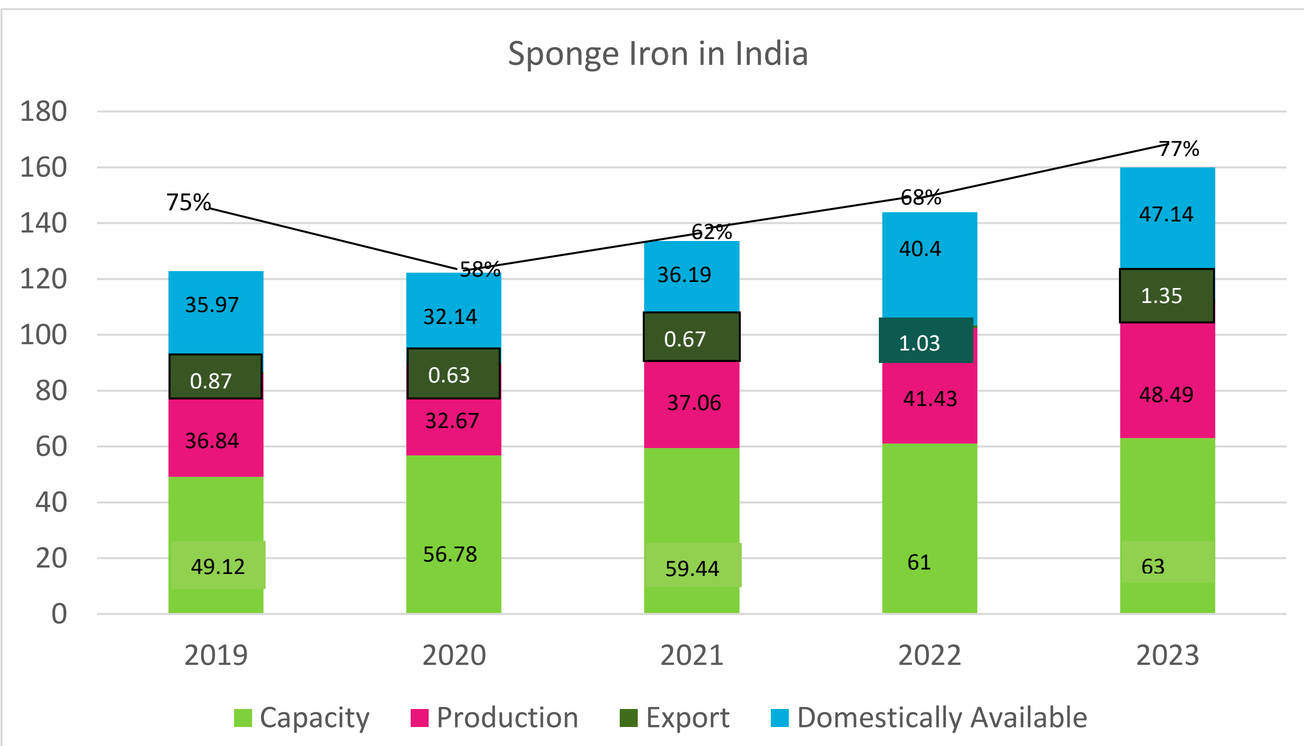
What does the sponge iron's future look like in India?

• India's sponge iron production is projected to increase by around 12% to 48 mnt by FY2024-25 (FY25), as per SteelMint's estimates.

• This will be supported by the expected increase in crude steel production to around 145 mnt by this period. The government's steady infra push is creating a case for additional demand.

• The red flag, however, is the intense coal usage in making sponge iron when emission is a dirty word globally. There is no place for smaller 100-tpd capacities but only the 600-900 tpd or even 1,200-tpd plants.

• But India's future lies in the 600-tpd, because the 900-1,200 tpd category has challenges in the form of imported coal dependency.



___ %Capacity Utilization

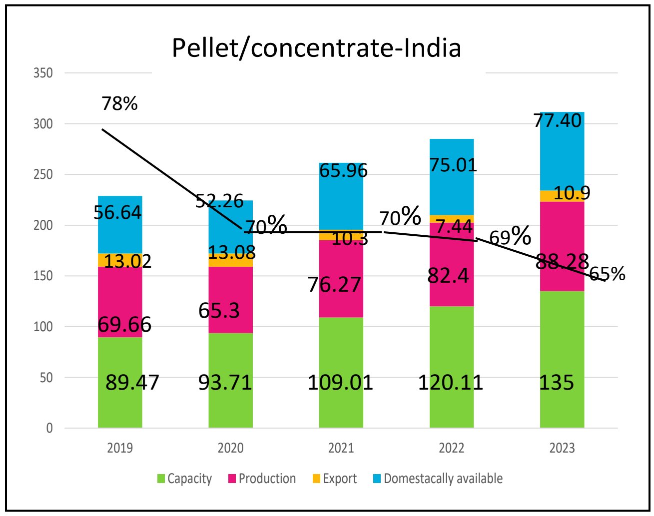
Pellet DRI creating its own space

Market to Expand Nearly 2.1X through 2033

The global iron ore pellet market is predicted to expand over 2.1X through 2033, amid a 4.4% increase in expected CAGR compared to the historical one.

This is due to the growing demand for steel from several end-use industries like construction and automotive.

- DRI grade iron ore pellets, are gaining more preference in countries like India and Iran, are anticipated to witness a higher demand, rising at 9.0% CAGR.
- Key advantage of DRI grade pellets is their suitability for direct reduction processes. Direct reduction processes often result in lower greenhouse gas emissions as compared to Blast Furnace route, making them more environmentally friendly.
- Current pellet are being used for Iron & Steel making is at 30:70 % ratio but in future steel making trough DRI route will be increased than BF rout. This versatility allows steel producers to adapt to changing market conditions, energy costs, and environmental regulations.
- Demand for materials like DRI grade iron ore pellets will increase significantly as the steel industry explores and implements new technologies to reduce carbon emissions(lower fines generation and sp. Coal consumption and higher productivity).



Source: fmi – Future Market Insights

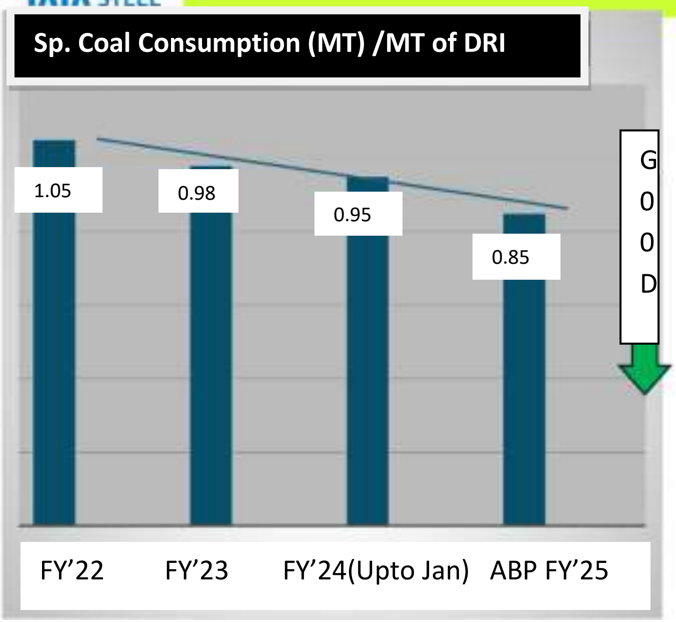
Focus Points for CO_2 Reduction

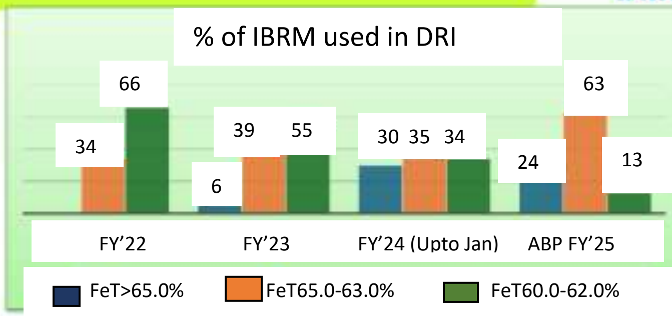
- Smart sourcing of coal & Iron Ore- Spec vs Price.
- Utilization of Waste gases in power generation
- CO_2 reduction in power generation – Char utilization
- Operational efficiency using IT tools – Digi Twin.
- New Project – short term Use of NG / SYN gas in kiln to reduce carbon
- New Project – Long term – Capex – Vertical Kiln (Hydrogen Based / NG based)

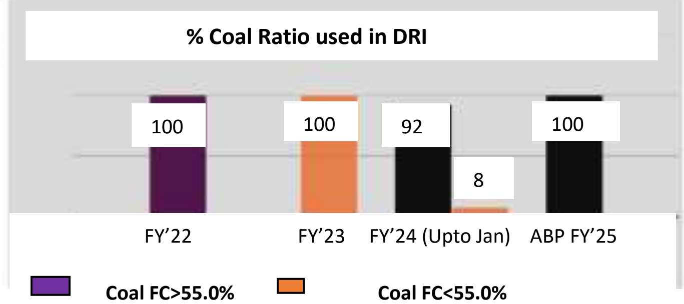
Challenges and way forward:

- Commercial viability of Gas usage in production of DRI
- New technology cost & ROI
- Cost of procuring DRI / HBI from Middle east region /Gulf countries

Impact of Raw Material on CO Abetment



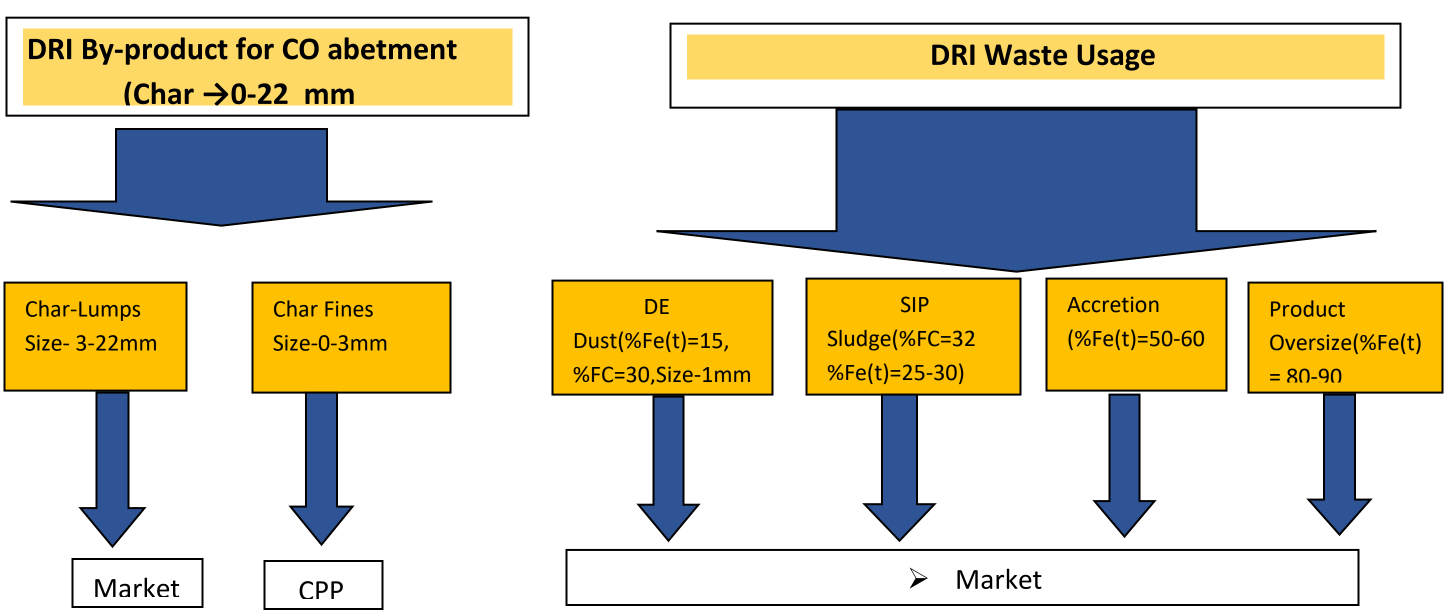




Observations

- ➢ Continuous decrease in specific coal consumption / MT of DRI production.
- ➢ Good quality of iron ore contribute to increase production rate as well as reduction in sp. Coal consumption.
- ➢ Consistency of RB-1 coal has good impact to maintain product quality as well as sp. Coal consumption

Use of By product for CO2 abetment & waste usage



Initiatives Taken/Implemented to Reduce CO2 Abetment

1. Installed 20000 MT coal shed to reduced ground loss for contamination.

2. 100 sq. meter ground concreting done for temporary coal storage.

3. 100% char fines used by power plant with coal blending.

4. 5% char lumps re-cycling inhouse (DRI process) with coal.

5. 95% char lumps sell to market (plan to use inhouse in future).

6. ESP carbon always maintained below 6-7%.

7. Alignment of slip Seals arrangement & Gland rope maintenance in every shutdown to eliminate flue gas loss.

8. Many kaizens implemented to control spillage in circuit.

Opportunities to Reduce CO2 abetment

1.Use of pellet as IBRM.

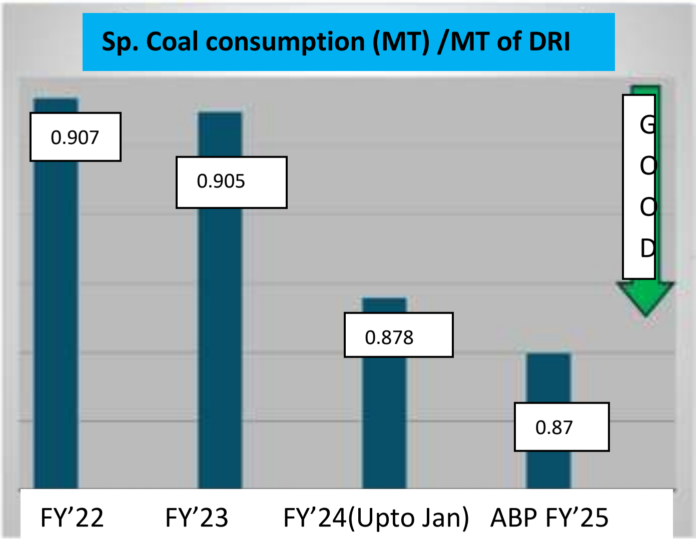
2.Installation of drier for raw material dry.

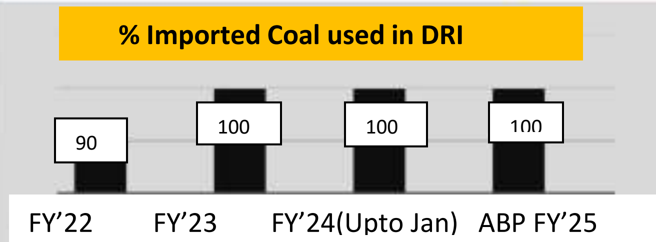
3.Explore possibility to use Natural Gas for OSIL design kilns.

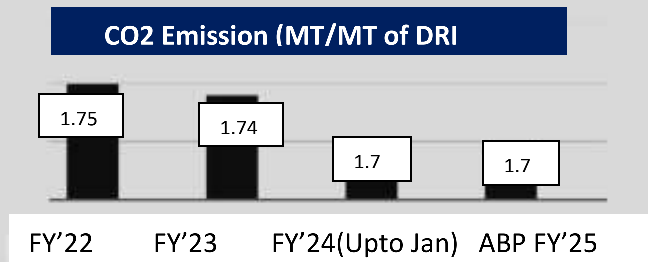
4.Use of natural gas for initial start up of cold kilns in place of LDO.

5.100% char lumps used in Power Plant after crushing circuit installation.

Impact of Raw material on CO abetment(Joda)







Observations

- Continuous decrease in specific coal consumption / MT of DRI production.
- Good quality of iron ore(FeT>65.5%) contribute to increase production rate as well as reduction in sp. Coal consumption.
- Consistency of low ash (<18%) and high carbon(>56%) coal has good impact to maintain product quality as well as sp. Coal consumption.
- Microporous board in refractory installation to reduce radiation loss(kiln1) .
- Coal % charged at injection side increased from 50% to 58% it helps to reduce carbon loss in ESP Dust.

Initiatives Taken/Implemented to Reduce CO2 Abetment (Joda)

1. Digital twin thermodynamic Model development for quality consistency and productivity.

2. Incorporation of Microporous board in refractory installation to reduce radiation loss.

3. Dry coal (<7% moisture) use in DRI process it helps to reduced carbon consumption.

4. 100% use of Good quality iron ore (FeT>65.8%).

5. Air to carbon ratio to be optimised by Digital twin model

6. (-3mm) fraction size coal discarded from feed end side.

7. Auto control of kiln pressure and maintained within 3-4mmwc 8. Online coal moisture analyser.

9. 100% low ash and high carbon coal (RB1) used in DRI process.

10.Carbon content in charcoal should be minimized for the optimum utilization during DRI process and it signifies in energy consumption in DRI making.

11.Reduction in thermal energy consumption by injecting coal Briquette.

12.Best quality of Dolomite in terms MgO Content to be used in DRI process so that processing would be reduced of steel making while usage at SMS in down stream.

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6th India International DRI Summit 2024
Multi Pathways for mitigation of carbon footprints

tenova

Ministry of Steel
SIMA Sponge Iron Manufacturers Association
Indian voice for the ore based metallic & steel industry

6th India International DRI Summit 2024
Multi Pathways for Mitigation of Carbon Footprints

Tenova's Approach Towards Green Pig Iron Production Through Direct Reduction Technology

Tenova iBlue®

Praveen Chaturvedi
TENOVA

11th March 2024, Hotel Le Meridien, New Delhi

Techint Group

tenova

OUR FAMILY

USD **33.6** billion
Annual Revenues

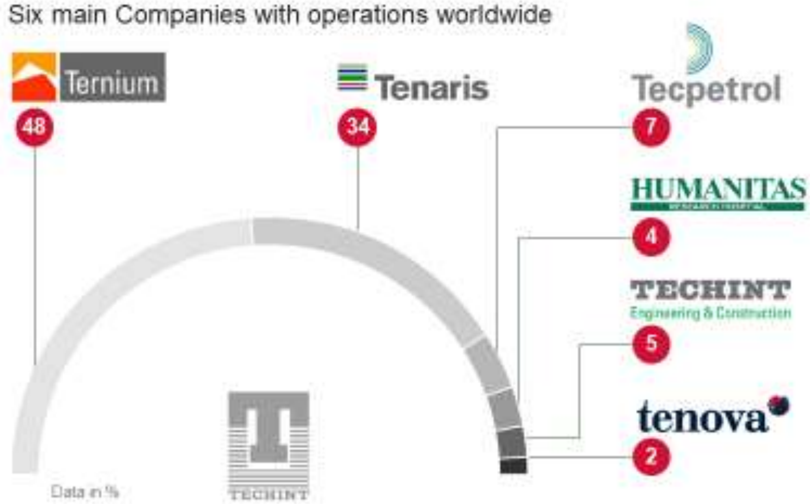
60,000
Permanent Employees

79,300
Total Employees

5
Continents

Revenues as of December 31, 2022

Six main Companies with operations worldwide



Sustenovability

tenova

OUR APPROACH

Sustenovability is a neologism that embodies the perfect blend between the Tenova Brand, its eco-friendly values and its capacity to **deliver sustainable solutions**

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sustenovability.tenova.com
is a new web platform featuring stories, best practices and case studies that highlight how Tenova is living up to its commitment towards sustainability

Tenova Group Company Profile 2

tenova

THE ENERGIRON PROCESS

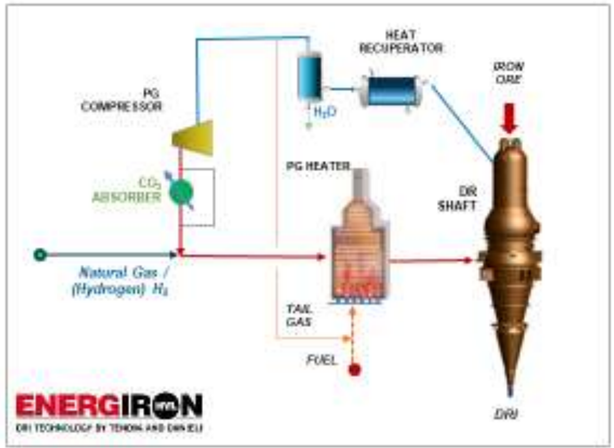
The unique features that make **ENERGIRON®** the preferred **DRI technology** towards **sustainability**

DRI Technology Characteristics for Green Steel

tenova

BASIC REQUIREMENTS FOR DECARBONIZING IRONMAKING/STEELMAKING INDUSTRY

- ✓ Possibility for inherent **CCU/CCS.**
  ENERGIRON DR technology has an inherent selective CO_2 removal as part of its standard and unique scheme.
- ✓ **Hydrogen Ready!** Flexibility to operate with NG/H_2 from 0-100%:
  ENERGIRON is the only DR technology available capable to operate from 100%NG - 100%H_2 in **reversible operating mode** at any moment with no need to modify the process configuration.
- ✓ Flexibility for **high %C DRI** for HM production
  ENERGIRON is the only proven technology to produce >4%C DRI with 100%NG. Even with 30%H_2 (energy), %C >3.3% can be achieved.

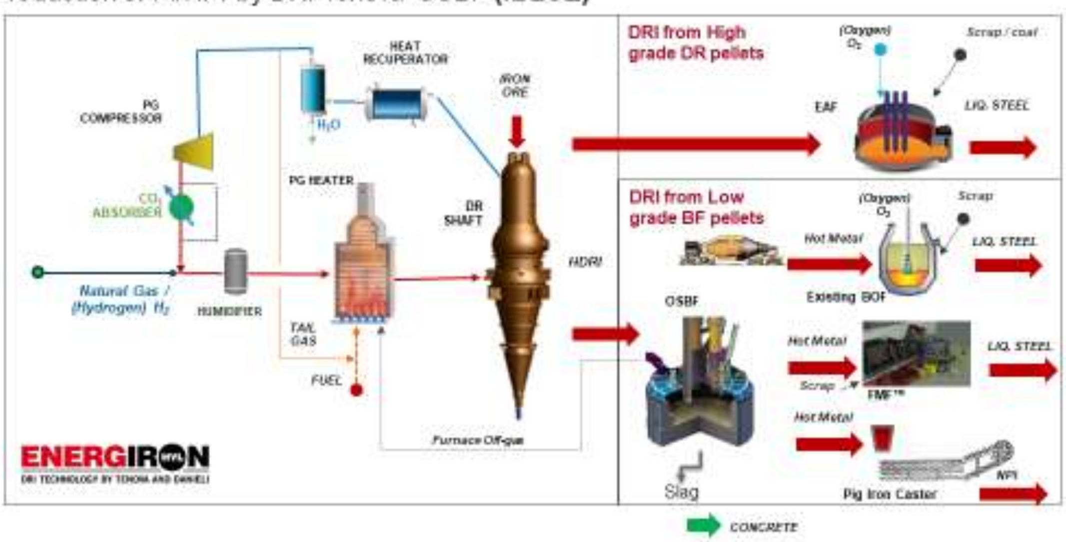


ENERGIRON® DRI Standard ZR Process Scheme

Routes for low-C footprint steelmaking

tenova

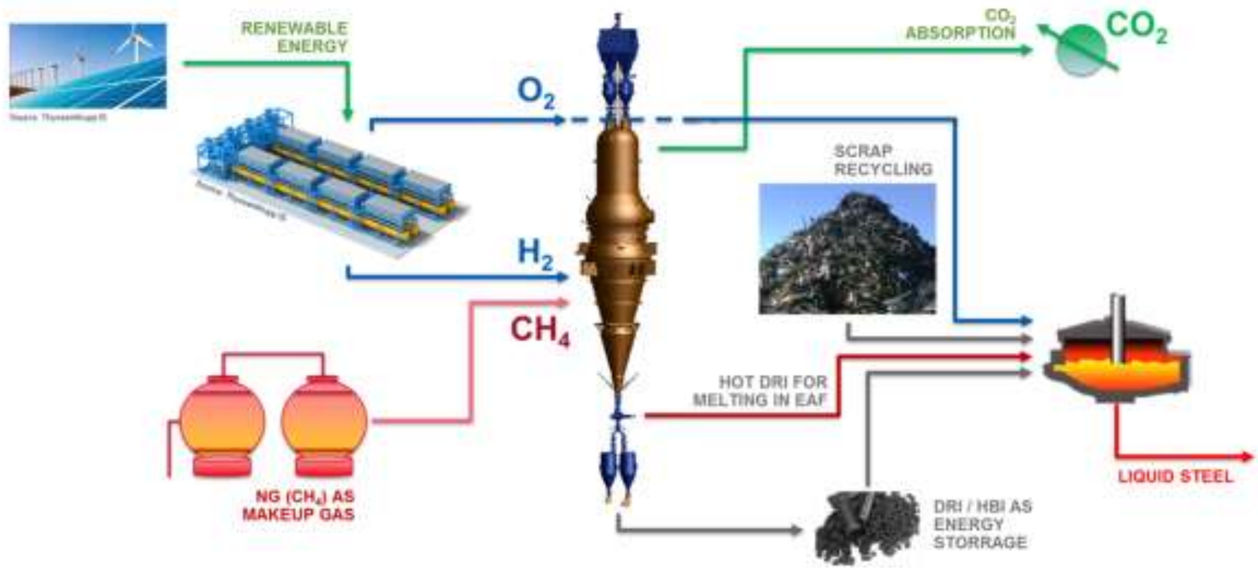
1. Steel production by DRI-EAF
2. Replacement of BF by ENERGIRON DRI-Tenova OSBF **(iBLUE)** for Hot Metal production to existing BOF-downstream facilities
3. Production of PI/NPI by DRI-Tenova OSBF **(iBLUE)**



Ironmaking via Direct Reduction

tenova

TENOVA HYDROGEN-BASED DIRECT REDUCTION



Sustainable decarbonization of steel industry

Carbon Capture & Utilization (CCU)

tenova

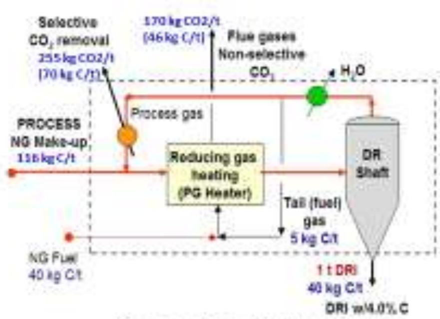
CO_2 ABSORPTION SYSTEM

<u>In ENERGIRON ZR</u>:

From total Carbon input:

- ~ 45% of total carbon (as CO_2) is selectively removed.
- ~30% through flue gases and
- ~ 25% as C in the DRI

Selective CO_2	255 kg/t	60%
Non-Selective CO_2	170 kg/t	40%
Total CO_2	425 kg/t	



Carbon balance for Nucor Plant

<u>Selective CO_2: What to do with it?</u>:

Since 1998, CO_2 gas, from the CO_2 absorption system of ENERGIRON plants has been used as byproducts by different off-takers

HyL/ENERGIRON DR Plant	Off-taking company	Use
Ternium; Monterrey, Mexico	Praxair	Food and beverages industries
Ternium; Puebla, Mexico	Infra	Beverages industries
PTKS; Indonesia	Janator	Food industry
PSSB; Malaysia	Air Liquid/MOQ	Food industry
JSW Salav, India	Air Liquid	Dry Ice
Emirates Steel; UAE[1]	Masdar/ADNOC	Enhanced Oil Recovery (EOR)

ENERGIRON: DR MODULES SIZES

ENERGIRON

0,20 MTPY CDRI
Carbon 3.0% - 4%
Metallization 94%

2,5 MTPY
Carbon 3.0% - 4.5%
Metallization 95% - 96.5%

2.5 – 5 million tpa Blast Furnace

PROVEN EXPERIENCE FROM THE SMALLEST TO THE LARGEST DR MODULES WORLDWIDE

30

tenova

iBlue: HM via Open Slag Bath Furnace

Oct 2, 2023

Tenova vision for the decarburization transition

TENOVA VISION FOR THE DECARBURIZATION TRANSITION

The TENOVA Approach to support the industry to reach the carbon footprint reduction:

ENERGIRON DRI Technology, jointly developed by Tenova and Danieli, to produce high quality reduced iron

+

a) An **Electric Arc Furnace (EAF)** for liquid steel production, and/or,

b) An **Open Bath Slag Furnace (OSBF)** for hot metal production

Is this transition enough for the long term objective?

Yes, but complementing, **Hydrogen** needs to be used

SOME FACTS

Many technologies are being studied for the decarburization of the industry.

So far only gas based direct reduction has been proven and readily available at industrial scale as a reliable vehicle to industry decarburization.

The use of high percentages of hydrogen (up to 100%) as reduction gas allow a terrific abatement of CO emissions

Direct reduction iron needs to be molten in an electric arc furnace.

iBLUE® TECHNOLOGY

DECARBONIZATION STRATEGIES

Reinventing Integrated Steelmaking

Natural gas–based Pig Iron production

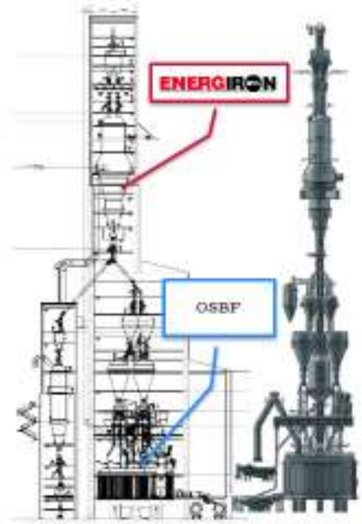
MERGING TWO PROVEN TECHNOLOGIES OF TENOVA

tenova

IRONMAKING REINVENTED

Valuable production of **Hot Metal / Pig Iron** thanks to:

- ✓ ENERGIRON High-C DRI + Reducing Arc Furnace
- ✓ DRI C content > 4.0%
- ✓ More than 90% of Carbon bonded as Fe_3C
- ✓ Maintaining downstream BOF facilities, just replacing the BF
- ✓ **Use of conventional BF-grade pellets**
- ✓ BF-like slag by product for the concrete industry
- ✓ Optimized Capex for the lowest possible CO_2 footprint



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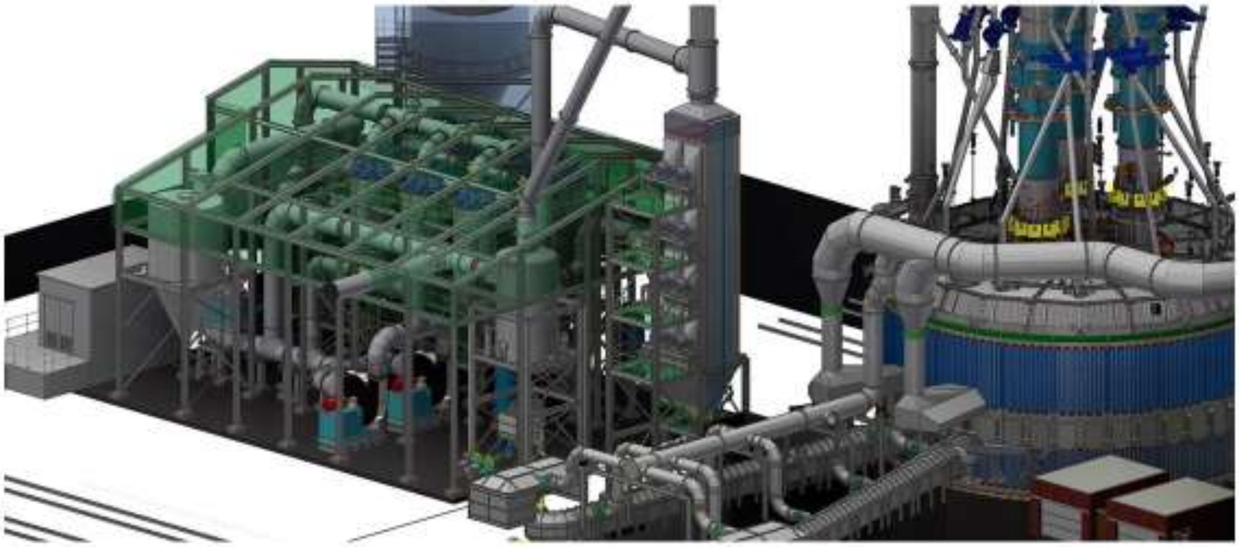
Features of the OSBF

tenova

Gas cleaning technology

tenova

PATENTED DRY GAS CLEANING SYSTEM – 90% REDUCTION IN WATER CONSUMPTION

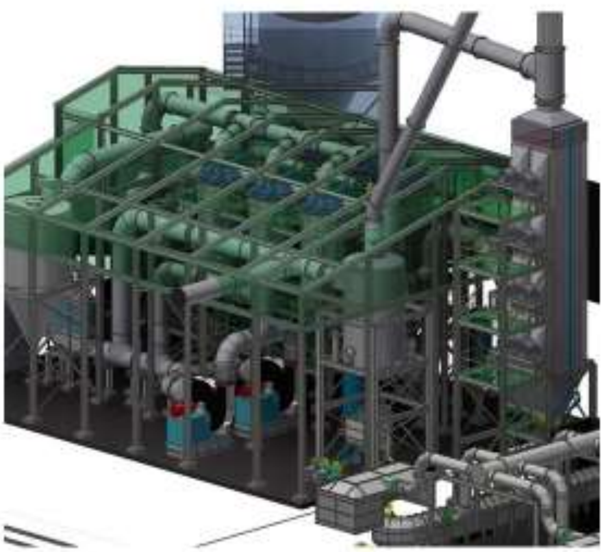


Oct 2, 2023

Minimize CO_2 emissions

tenova

MAXIMISE THE POTENTIAL OF iBLUE FLOW SHEET



Sending clean CO-rich gas to the ENERGIRON® Process Gas Heater:

- **Reducing Natural Gas consumption**: OSBF gas is a 'free' substitute to fuel
- The Combusted OSBF gas is absorbed in existing DRP gas handling system, meaning no dedicated equipment is needed for the gas sequestration

Can such gas can be used otherwise?

- Yes, it can be combusted, heat can be recovered in a Waste Heat Recovery System, and CO_2 shall be captured: its more expensive and less efficient

Oct 2, 2023

A mix of proven Tenova proprietary technologies

tenova

TENOVA masters all technologies involved with a 50 years experience

DRP

HyL started first pilot in 1984. HyL is THE world recognized brand for Direct reduction.

2006: strategic alliance "ENERGIRON" with Danieli.

21 DR Plants worldwide

40+ years of experience in DRP

OSBF

Tenova Pyromet is the result of the successful merger between the submerged arc furnace division of Techint Technologies (Tagliaferri) and Pyromet Technologies.

First furnace in 1968 and today counts 300+ references in the world

 17 1 April 2022

iBLUE® as future proof technology

tenova

ADDING A FMF® DOWNSTREAM ALLOWS INCREASE OF SCRAP UTILIZATION AND substitutes BOF

Tenova FMF® furnace melting hot metal and scrap to produce steel

Increasing the hydrogen utilization requires a flexible handling of the metal in a way to follow the process as hydrogen becomes more available.

FMF® (Flexible modular furnace) concept allows to charge high percentage of HOT METAL (80-90%) into a furnace with continuous feed of scrap via CONSTEEL®.

The possibility to add electrical power can increase the % of scrap added to the mix

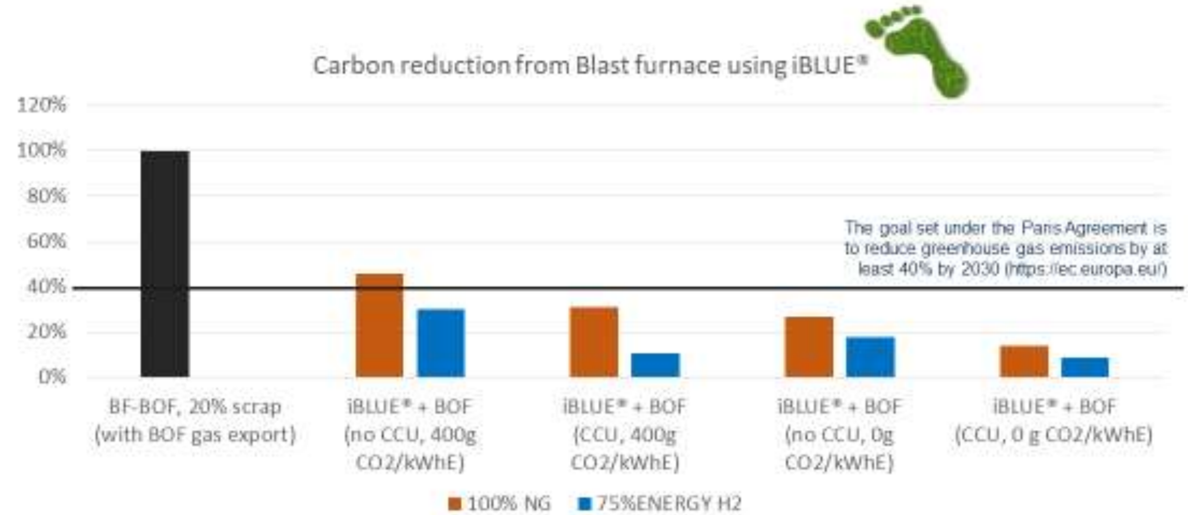
Tenova has 40+ references of these solutions around the world.

 18 1 April 2022

CO_2 Emissions reduction with iBLUE®

tenova

IT IS ALREADY POSSIBLE TO MEET THE PARIS AGREEMENT WITHOUT HYDROGEN



Conclusions

tenova

- The way to decarbonization goes through Direct Reduction
- DRP + EAF route has a number of advantages, it is a very well proven technology, but **works only with high grades pellets**
- The increase of DRI production will lead to a **shortage of DR grade pellets** and it is a question if the supply will be able to match the demand
- Tenova iBLUE® offers a proven way to produce steel from **low grade Blast Furnace pellets**
- iBLUE ® can count on high Carbon DRI produced via the ENERGIRON™ process and can supply green hot metal to the traditional steelmaking route (i.e. BOF) or to other advanced technologies (i.e. Tenova FMF™) able to take advantage of an increased scrap addition to the metal.
- iBLUE ® can also be coupled to EAF /FMF® technology to enhance production flexibility.

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Leading the change to Green Steel future

Naveen Ahlawat, Head-
Power to X
Jindal Steel & Power Ltd.

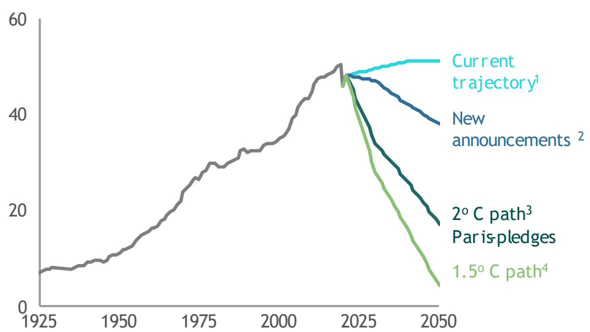
MAR 2024

6th India International DRI Summit 2024

The fight against climate change calls for immediate coordinated action

Global temperatures have been rising fast and not in track with the Paris pledges…

Global net CO_2 emissions & pathways (Gt per year)



…The window to limit severe impact due to warming is closing and the time to act is now

Global warming by 2100 — Cost of inaction

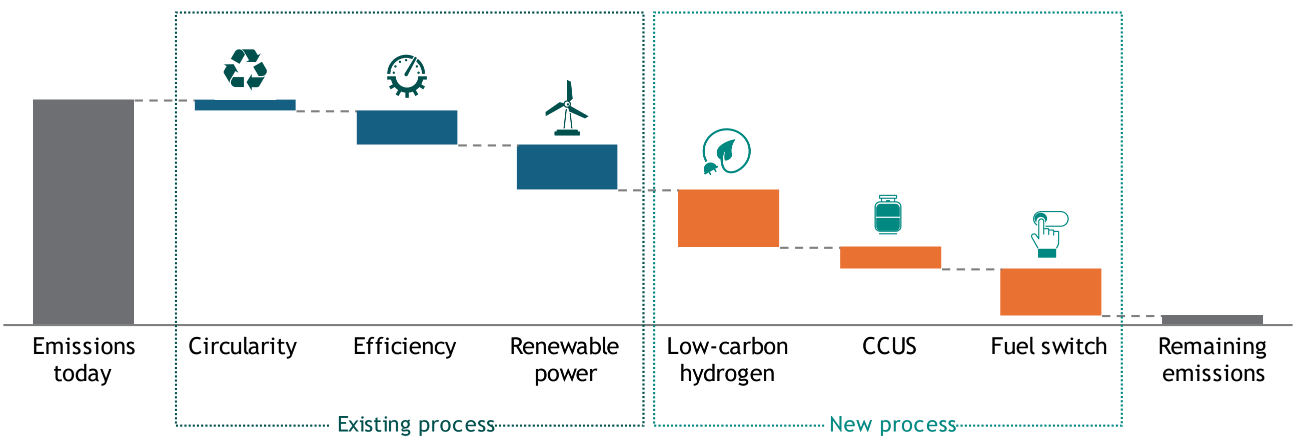
- >+4°C | *GDP[4] shrinks by >25%*
- +2°C | *GDP[4] shrinks by ~13%*
- +1.5°C | *GDP[4] shrinks by 8%*

1. Current pledges assume countries decarbonize further at same annual rate required to achieve NDCs between 2020 and 2030 2. Newly announced path reflects high-level net-zero ambitions announced by China, EU, Japan, South Korea, Argentina (July 2021) 3. 2° path and 3° path based on emission reductions required by respective 2018 IPCC scenarios
4. Global GDP per capita, relative to no additional warming. According to Burke et al. (2018)
Source: EEA, EDGAR 5.0, EC, IEA, FAO, PRIMAP-hist v2.1, Global Carbon Project, IPCC, UNEP Emissions Gap Report, WRI, Nature (May 2020), BCG analysis

True steel decarbonization requires implementation of multiple green measures from mines to metal (1/2)

Emission reduction potential

Illustrative



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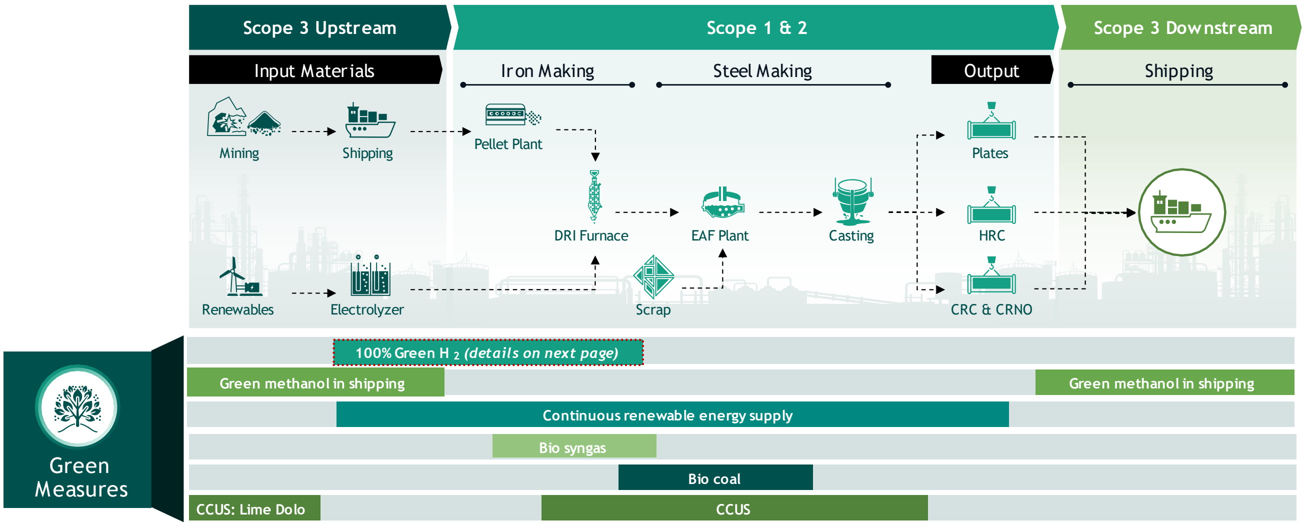
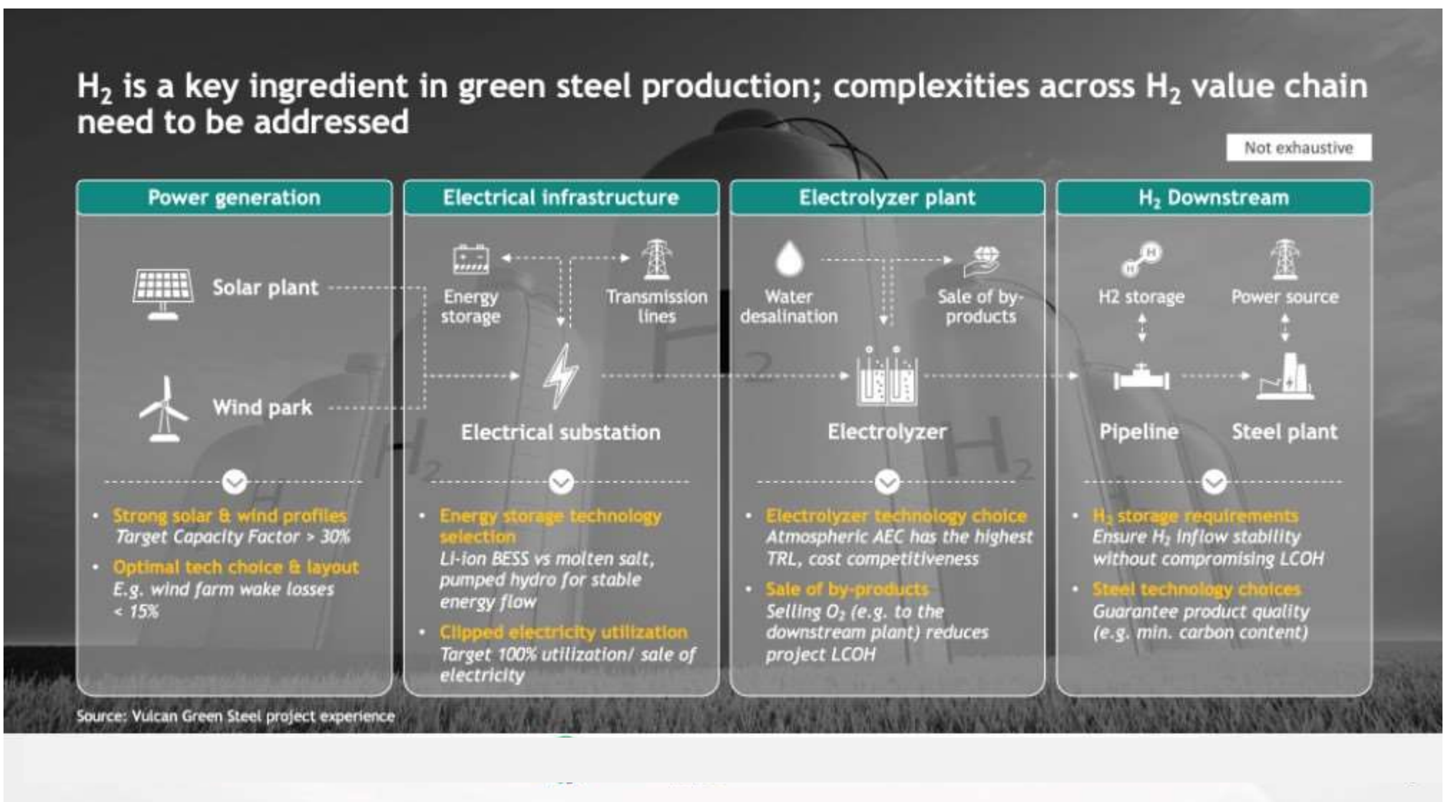
True steel decarbonization requires implementation of multiple green measures from mines to metal (2/2)



Source: Vulcan Green Steel project experience

5



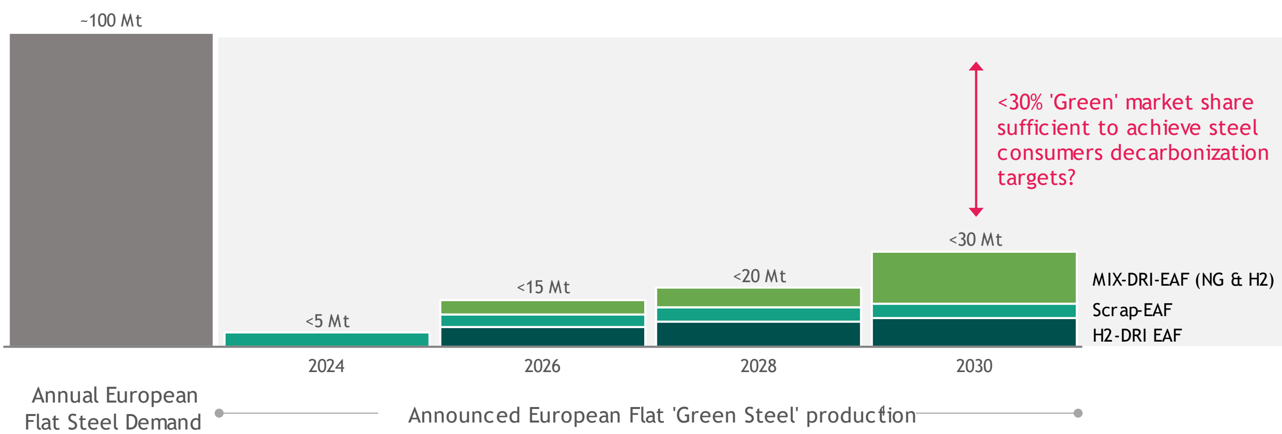
Significant progress made in solving for green steel production

	Green 'low-carbon' **Hydrogen & Power**	High-grade **iron ore pellets**	**DRI-EAF plant** construction
Constraint	Vast amounts of Green H_2 is required to reduce Iron Ore to Iron	Scarce Ion Ore with >67% Fe-content is required for the DRI-EAF process	Number & capacity of DRI-EAF plant construction companies is limited
Enabler	Partnership for H_2 procurement & 24/7 access to low-cost renewables	Access to iron ore & palletization capacity via MoUs & own mines	Partnership with plant construction companies

7

Supply gap expected | <30 Mt 'Green steel' announced for 2030

European Flat Steel Demand & announced 'Green Steel' Production



1. Publicly announced production volumes by Arcelor Mittal, Thyssenkrupp, TATA Steel, Salzgitter, SSAB, H2GreenSteel, Arvedi, Dillinger
Source: BCG analysis

8

Transitioning to green steel to have minimal cost impact across industries

Details	Wind[1]	Automotive[2]	Appliances[3]
Steel consumption per unit (t)	210-230	~1	~0.05
Premium for Green Steel[4] (€/t)	250-300	250-300	250-300
Additional cost (€)	53k-69k	250-300	12-15
Incremental cost due to green steel (€) (Add. green cost; Base cost)	Grey steel: €40-50/MWH[5]; Green steel: €40-50/MWH[5] (€0.4-0.8); +1%	Grey steel: 30k; Green steel: ~30.3k (250-300); +1%	Grey steel: 330; Green steel: 342-345 (12-15); +4%

1. Steel cost is ~5 -10% cost of setting up offshore wind farm based on discussions with multiple wind suppliers; 2. Steel cost is ~3-5% cost of a car; 3. Steel cost is ~15% cost in a washing machine; 4. Premium for green steel in range of € 250 -300/t; 5. Levelized cost of electricity
Source: 2025 estimate for large scale projects, Wood Mackenzie, Europa, Bank of America Merill Lynch "Who Makes The Car" 2020 Report, World steel association "Eco -Efficiency Analysis of Washing machines" Öko- Institute, Secondary research, Vulcan Green Steel project experience, BCG analysis

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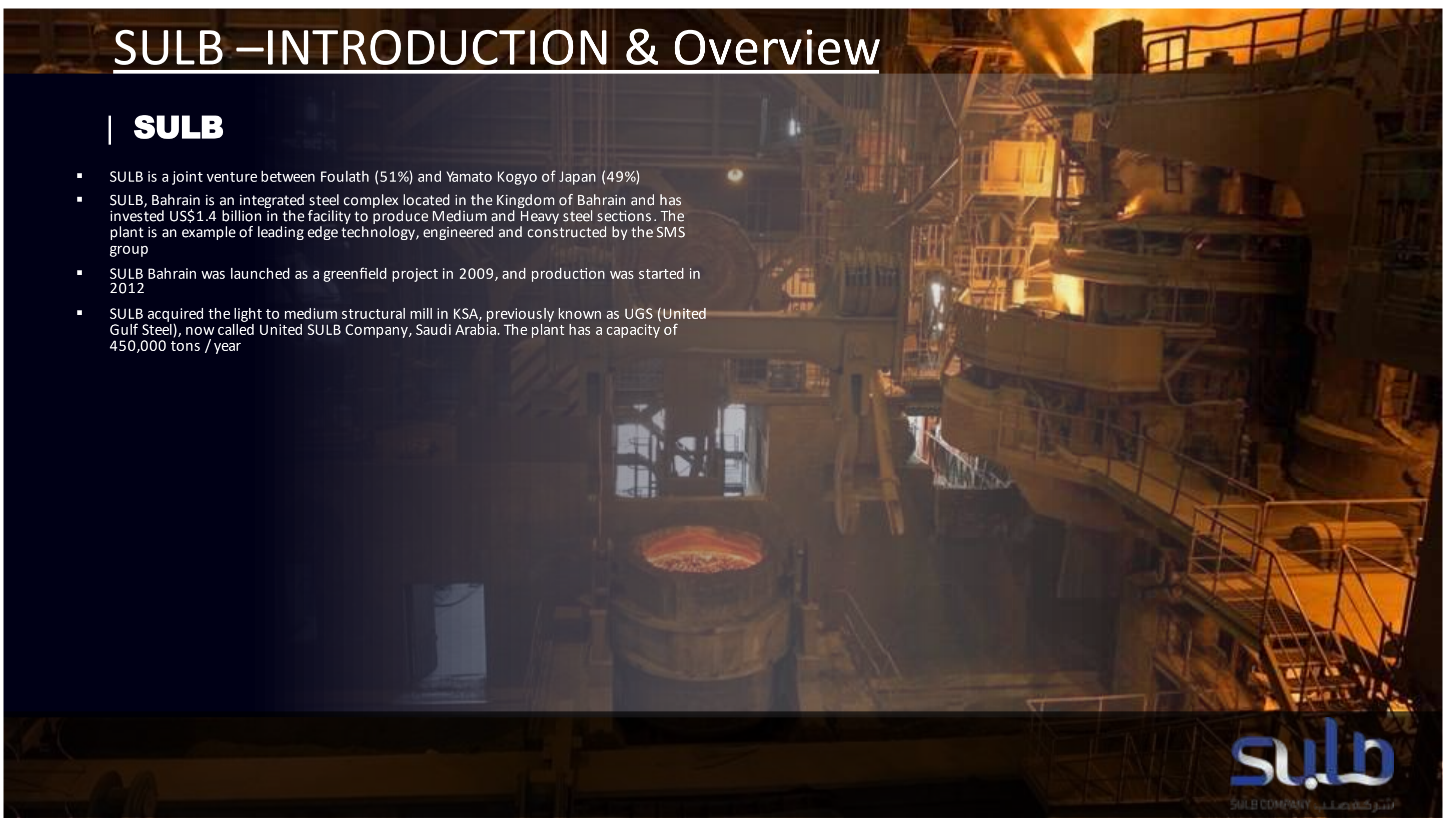
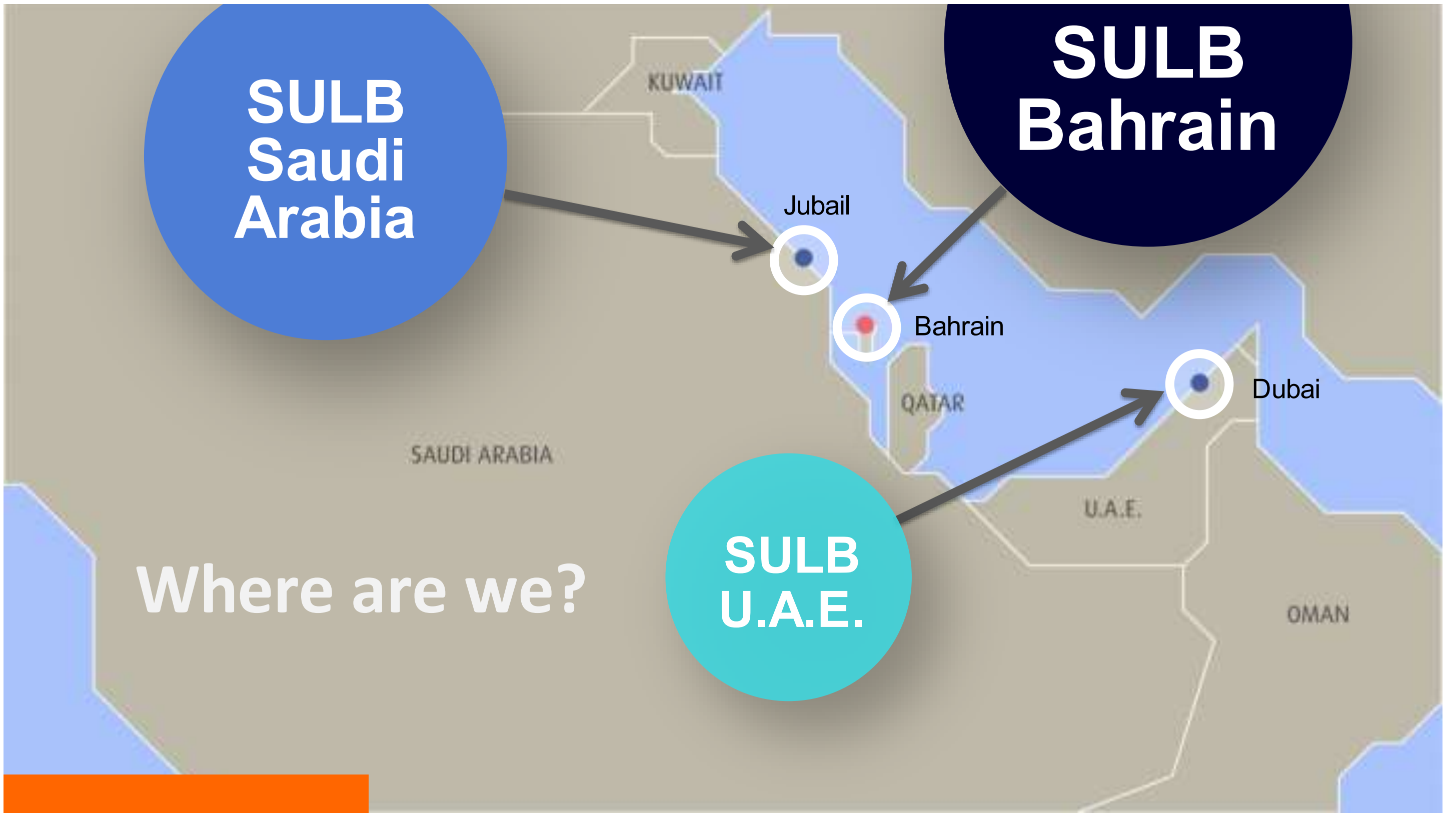
6th INDIA INTERNATIONAL DRI SUMMIT 2024

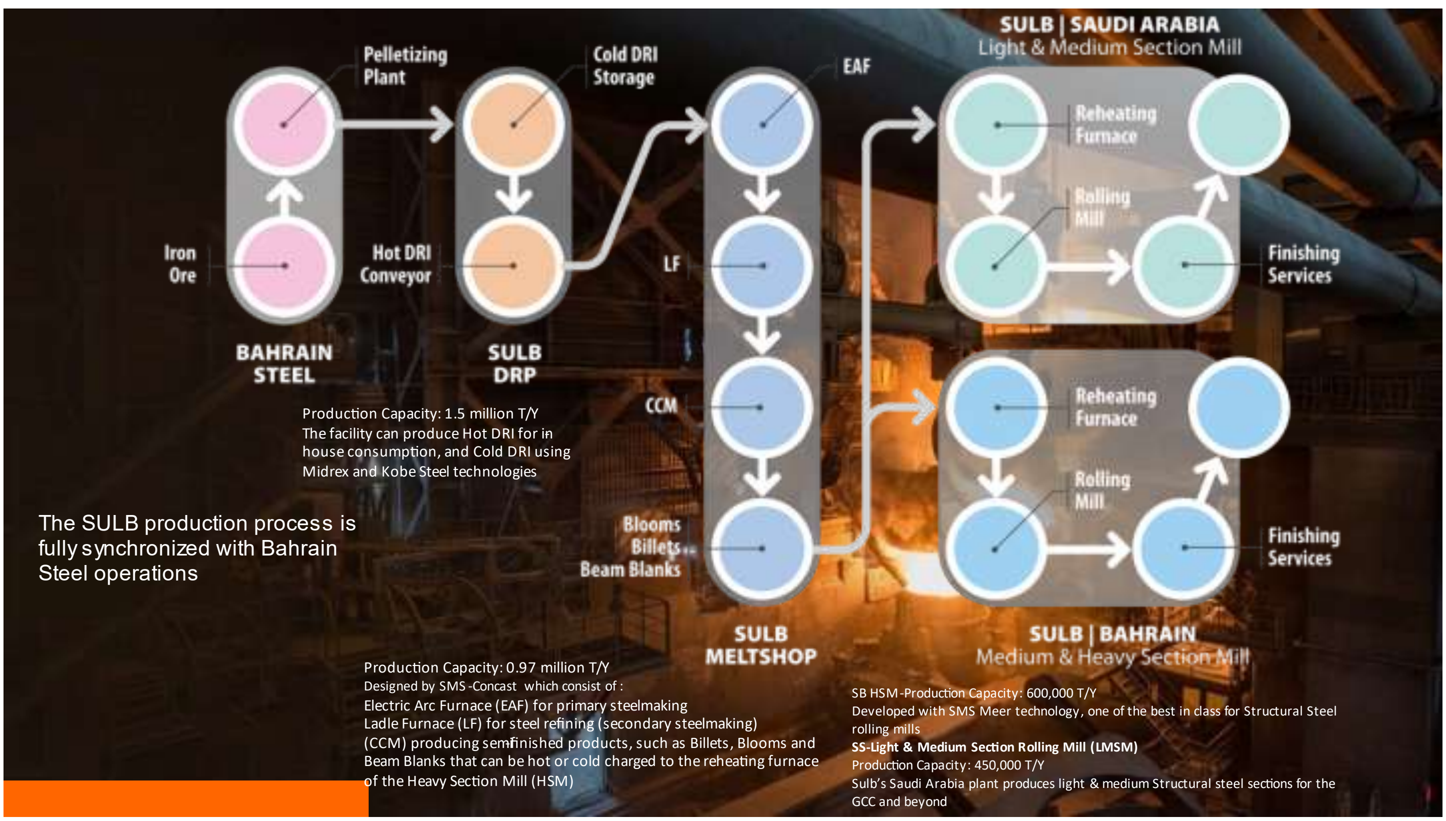
Ravi Singh
CEO-Sulb Company
Kingdom of Bahrain

GCC IRON MAKING

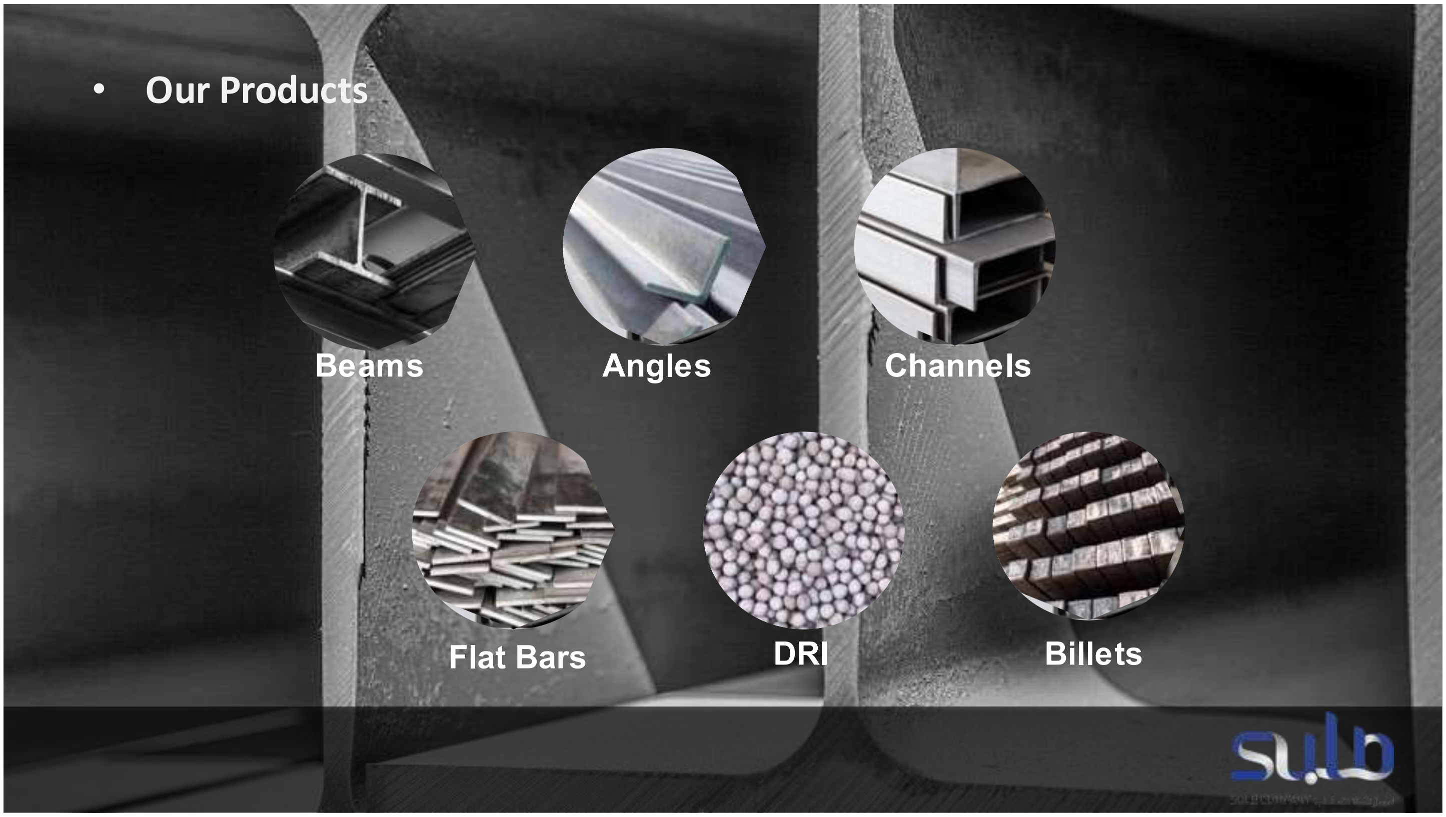




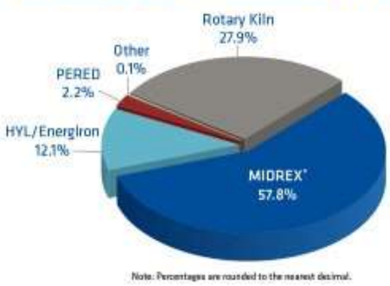
SULB Saudi Arabia
SULB Bahrain
SULB U.A.E.
KUWAIT
Jubail
Bahrain
QATAR
Dubai
SAUDI ARABIA
U.A.E.
OMAN
Where are we?



SULB | SAUDI ARABIA
Light & Medium Section Mill
Pelletizing Plant
Cold DRI Storage
EAF
Reheating Furnace
Rolling Mill
Finishing Services
Iron Ore
Hot DRI Conveyor
LF
BAHRAIN STEEL
SULB DRP
CCM
Production Capacity: 1.5 million T/Y
The facility can produce Hot DRI for in house consumption, and Cold DRI using Midrex and Kobe Steel technologies
Reheating Furnace
Rolling Mill
Finishing Services
The SULB production process is fully synchronized with Bahrain Steel operations
Blooms
Billets
Beam Blanks
SULB MELTSHOP
SULB | BAHRAIN
Medium & Heavy Section Mill
Production Capacity: 0.97 million T/Y
Designed by SMS-Concast which consist of :
Electric Arc Furnace (EAF) for primary steelmaking
Ladle Furnace (LF) for steel refining (secondary steelmaking)
(CCM) producing semifinished products, such as Billets, Blooms and Beam Blanks that can be hot or cold charged to the reheating furnace of the Heavy Section Mill (HSM)
SB HSM-Production Capacity: 600,000 T/Y
Developed with SMS Meer technology, one of the best in class for Structural Steel rolling mills
SS-Light & Medium Section Rolling Mill (LMSM)
Production Capacity: 450,000 T/Y
Sulb's Saudi Arabia plant produces light & medium Structural steel sections for the GCC and beyond



2022 World DRI Production by Process

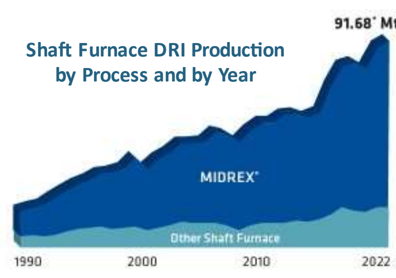


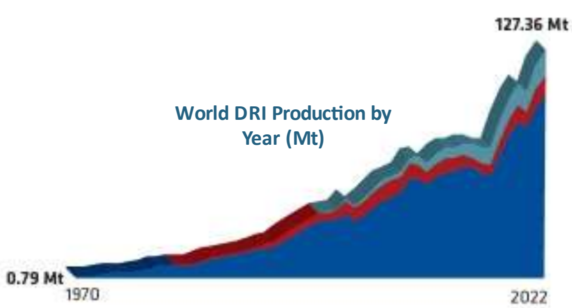
Total World Production: 127.36 Mt

	2020	2021	2022
MIDREX®	60.2%	59.5%	57.8%
HYL/Energiron	12.4%	12.7%	12.1%
PERED	2.9%(e)	2.2%(e)	2.2%(e)
Other	0.2%	0.1%	0.1%
Rotary Kiln	24.3%	25.4%	27.9%

(e) estimated

Source: Midrex Technologies, Inc.

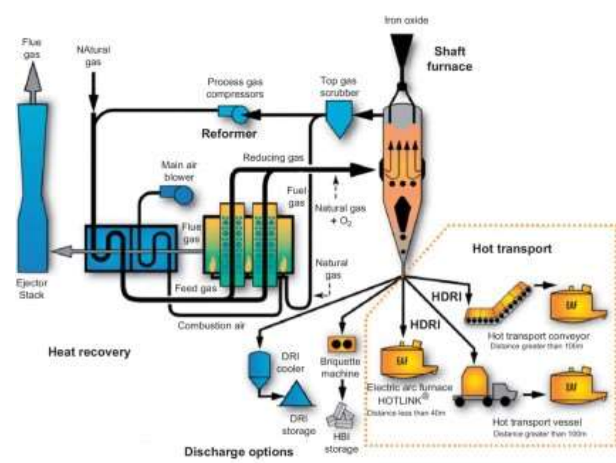




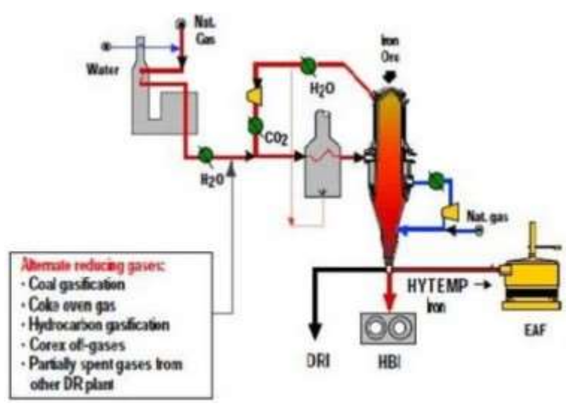
NAME	'12	'13	'14	'15	'16	'17	'18	'19	'20	'21	'22
Middle East/N. Africa											
ALGERIA	-	-	-	-	-	-	0.11	1.54	2.23	3.08	3.88
BAHRAIN	-	0.78	1.44	1.23	1.26	1.26	1.60	1.45	1.38	1.51	1.42
EGYPT	2.84	3.43	2.88	2.73	2.82	4.67	5.22e	4.05	4.71	5.23	5.82
IRAN	11.58	14.46	14.55	14.55	16.01	20.55	25.75	28.52	30.21	31.85	32.90
LIBYA	0.51	0.95	1.00	0.45	0.69	0.56	0.61	0.87	0.83	0.88	1.10
OMAN	1.46	1.47	1.45	1.48	1.46	1.51	1.50	1.75	1.73	1.70	1.82
QATAR	2.42	2.39	2.64	2.71	2.58	2.63	2.63	2.49	0.78	0.79	1.62
SAUDI ARABIA	5.66	6.07	6.46	5.80	5.89	5.74	6.00	5.79	5.19	6.13	6.48
UAE	2.72	3.07	2.41	3.19	3.48	3.61	3.78	3.67	2.96	3.66	3.45

Direct Reduction Major Processes

•**Gas-based shaft furnace processes**(Midrex® and Energiron being the main ones)- accounting for 70% of total DRI production



MIDREX



Energiron/HYL

Iron making opportunity in the Middle East and North Africa

The global steel industry is eyeing a switch to direct reduced iron (DRI) using green hydrogen to reduce emissions.

Unlike the blast furnace-basic oxygen furnace (BF-BOF) process that uses coal to make iron, the direct reduced iron-electric arc furnace (DRI-EAF) route predominantly uses natural gas, which produces lower carbon emissions. The direct reduction of iron ore is the process of oxygen removal from ore without melting, usually using a mixture of carbon monoxide and hydrogen derived from natural gas.

About 55% of the current reduction gases in DR facilities (i.e., Midrex shafts) is hydrogen. By using pure green hydrogen, it is possible to produce carbon-neutral steel.

The Middle East and North Africa (MENA) region is potentially in a good position to begin producing carbon-neutral or green steel, as it has particular advantages over other areas in the world.

Its steel sector is already dominated by DRI with an established supply of DR-grade iron ore. Technical barriers may make it difficult to ramp up DR-grade iron ore production to supply other regions.

The region produced just 3% of global crude steel in 2021 but it accounted for nearly 46% (55 Mt) of the world's DRI production. Further, some of the largest iron ore pelletizing plants in the world are in MENA and supply of DR-grade pellets is not a hurdle, in contrast with other areas. The International Energy Agency (IEA) in its Net Zero Emissions scenario models the global share of hydrogen-based (H2) DRI-EAF production reaching 29% of primary steelmaking by 2050. Bloomberg NEF estimates that 56% (840 Mt) of primary steel production will come from H2DRI-EAF by 2050 in a net zero emissions scenario.

MENA's transition to H2DRI-EAF could commence immediately due to the region having more DRI plants than anywhere else globally. Initially, it would be possible to replace 30% of natural gas with hydrogen in the incumbent fleet of DR plants without any major equipment modifications. The region could then move towards 100% green hydrogen to produce carbon-free steel.

Iron making opportunity in the Middle East and North Africa

MENA has excellent solar resources to aid in the production of green hydrogen via renewable electricity. The World Bank found MENA has the highest photovoltaic power potential capacity globally

IHS Markit forecasts that the region will add 83 gigawatts (GW) of wind and 334GW of solar by 2050, which will increase the respective share of power generation from the current 1% and 2% to 9% and 24%.

The cost of hydrogen production via electrolysis is currently lower than that for blue hydrogen in Middle Eastern countries.
According to IEA, with MENA's available capacity, producing green hydrogen below US$1/kg is achievable by 2050.

The process of switching MENA's DRI capacity to use green hydrogen instead of natural gas is simpler and cheaper when compared to switching from BF-BOF to DRI-EAF in other regions. Challenges for those areas include new investment costs in shifting from BF-BOF to DRI-EAF, management of the value chain including producing DR-grade iron ore pellets, and procurement of green hydrogen.

Demand for green steel is rising globally, led by European car manufacturers. With the European Union soon establishing a Carbon Border Adjustment Mechanism, MENA steel exports would have an advantage if they were zero carbon.

As the DRI-EAF route has lower emissions than BF-BOF, MENA's producers are ahead in terms of their market positioning and will remain so if they accelerate the transition to carbon-free steel using the H2DRI-EAF route. If it acts fast, MENA has the potential to lead the world in green steel production.

There is a strong focus on hydrogen – which is the ideal green fuel for DRI modules – in the region and MENA is expected to produce 18.15 million tons of hydrogen by 2030 and 28 million tons by 2040.
Hydrogen-compatible steel plants are being built in Egypt, the UAE, Saudi Arabia, Oman and Algeria. And while those facilities will initially run on gas, they will eventually switch to running on hydrogen.

Carbon capture and storage –in the GCC

- 3 CCS facilitiesin operation in the GCC States, capturing3.7 Mtpa of carbon dioxide, equivalent to 10% global capture capacity.
- Qatar Ras Laffan and UAE Al Riyadh facilitiesare developing expansion plans.
- Bahrain,Qatar,Saudi Arabia and UAE include CCS in their NDCs* under the Paris Agreement .
- Power generation and blue hydrogen are expected to emerge as new CCS drivers in the region.
- The Global CCS Institute is opening its inauguralGCC office in Abu Dhabi.

KEY CCUS DRIVERS	GCC + MENA REGION	EU, NORTH AMERICA, AUSTRALIA
Hydrogen production	Immature, but growing interest	Considered unsustainable if produced from fossil fuels
Industrial capture and use	First commercial-scale industrial application; numerous low-cost sources	Growing interest for hard-to-decarbonise sectors
CO_2 for EOR Potential	Attractive and low cost; increasing use of CO_2 for EOR-IOR	Attractive in North America but economically challenging elsewhere
Terrain suitability	Flat deserts and shallow offshore, straightforward, few local communities	Onshore faces community opposition; offshore often harsh environments
CO_2 Storage Potential	Multiple well-characterised giant storage formations, close to emission sites	Varies, may not be near major emission sites, but generally adequate
Tax incentives	None; strong government + NOC control	Tax credits to boost money for CCUS companies
Energy pricing	Heavily subsidised; no free market in gas	Deregulated markets; limited energy subsidies mostly for renewables
Carbon pricing	None	Rising in Europe; introduced in some US states/Canadian provinces
Societal acceptance	Low public opposition to CCUS; public acceptance of oil industry	Medium-high opposition to CCUS; oil industry regarded as unsustainable

CCUS IN MENA VARIES SIGNIFICANTLY FROM THE WEST

COUNTRY	AREAS OF INTEREST			
	Gas processing CCUS	CCUS for EOR	Gas power CCUS	CCUS for industry
Bahrain	LOW	MODERATE-HIGH	LOW	MODERATE
Kuwait	MODERATE	MODERATE	LOW	MODERATE
Oman	LOW	HIGH	LOW	MODERATE
Qatar	MODERATE	MODERATE	LOW	MODERATE
Saudi Arabia	HIGH	HIGH	LOW	MODERATE
UAE	HIGH	HIGH	MODERATE	HIGH

KEY AREAS OF CCUS INTEREST

Carbon capture and storage – in the GCC

The GCC already has several significantcarbon capture projects in operation, includingQatar's 2.2 Mtpa LNG liquefaction operations in Ras Laffan, Abu Dhabi's800Ktpa Al Riyadh steel project in the UAE and the 800Ktpa Hawiyah NGL CCS project in Saudi Arabia. Those three alone store around 3.7 milliontons of CO2 per year, making up a significantproportion of the world's current storage capacity. There are other facilitiescapturing carbon on a large scaletoo, includingfacilitiesin Kuwait, Qatar and Saudi Arabia which, instead of storing it underground, use it in other processes (including in the food and beverage industry and the production of urea and methanol): this is known as carbon capture and utilization (CCU).

While there is a firm foundation for CCS and CCU in the region, there are plans for millionsof tons of new capacityto be developed. All GCC countries have either included the use of carbon capture in their national determined contributions to meet their Paris Agreement commitments or else included it in their official Net Zero strategies. Some of the region's leading state-owned national oil and gas companies (NOCs) have also made carbon capture a key pillarof their individualsustainabilitystrategies and large projects have been announced in Qatar,Saudi Arabia and the UAE.

This focus on CCS in the GCC is for two main reasons: first, there are clear benefits to developing CCS infrastructurefor the region's hydrocarbon exporting economies and, second, the region is well suited to CCS.

The benefits of carbon capture storage

CCS offers many benefits for GCC countries, includingthe possibilityof reducing emissions from oil and gas production, which are already low compared to other producers, to stay ahead of the competition as customers demand ever cleaner energy and decarbonizing the GCC's 'hard to abate' industries so they can be competitive in increasinglyregulated markets while still allowing exploitation of the region's plentiful and accessiblegas reserves. There is alsothe possibilityof exploiting those gas reserves cleanlyto create low carbon blue hydrogen by applying CCS to existing carbon-intensive H2 production processes. Finally,CCS can form an industry in its own right, allowing GCC countries to develop proprietary technology and specialistskillsand creating employment opportunities for GCC nationals.

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NEWS ITEMS

thyssenkrupp Steel Selects MIDREX Flex™ for Immediate CO2 Emissions Reduction

- Midrex Technologies, Inc. and Paul Wurth will partner to engineer, supply, and construct a **2.5 million tons/year MIDREX Flex™** direct reduction plant for thyssenkrupp Steel Europe AG at its Duisburg, Germany, site. The plant will initially operate on reformed natural gas, which contains 50% or more hydrogen (H_2) at the inlet to the furnace, until sufficient H_2 is available, at which time it will be transitioned to up to 100% H_2 operation. Furthermore, the direct reduction plant will be combined with advanced SMS group melting technology to significantly increase operating efficiency and reduce CO_2 emissions by more than 3.5 million tons per year. Plant start-up is planned for end of 2026.

- **Midrex Technologies, Inc. (Midrex) and Paul Wurth, an SMS Group company, announce a signed agreement with H2 Green Steel to supply the world's first commercial 100 percent hydrogen direct reduced iron (DRI) plant. The 2.1 million tons per year MIDREX H2™ Plant will be located in Boden, northern Sweden**. H2 Green Steel will produce green steel, reducing CO_2 emissions by up to 95 percent compared to traditional steelmaking. By replacing coal with green hydrogen powered by renewable electricity, water and heat become the primary emissions. The plant is expected to begin production in 2025 and ramp up during 2026.

- **A high power delegation from Indo German Energy Forum from Germany visited SIMA office on 15th April,2024 for a discussion on their new project called "Facility Green Hydrogen" to support the decarbonization of emission-intensive industries using GH2.**

❖ KC Woody Named Midrex President & CEO, Stephen Montague Continues on Board Dempsey & Boyle Promoted

K.C. Woody

Charlotte, North Carolina, USA (March 31, 2024) – K.C. Woody has been named President & CEO of Midrex Technologies, Inc. effective immediately and Stephen Montague, former Midrex CEO will continue to serve on the Board of Directors. Concurrently, Will Dempsey was appointed Chief Operating Officer (COO) and Sean Boyle was promoted to Vice President – Commercial.

Woody, a graduate of the U.S. Military Academy at West Point who served on active duty as an officer in the US Army, joined Midrex in 2010 and has held a variety of commercial roles including the first Managing Director of Midrex India Private Limited. He was named Director–Plant Sales in 2014, and was promoted to Vice President–Sales & Marketing in 2016. Woody became Chief Operating Officer (COO) in 2020, responsible for leading all the commercial and operations activities for the company, and in 2023, he was promoted to President of Midrex.

"Our industry has a key role to play in reducing global CO2 emissions, and we are dedicated to creating a sustainable future for iron and steelmaking," Woody said. "We are continually evaluating our capabilities and adding resources that accentuate our culture of innovation, improvement, teamwork, and service.

"People, Growth, and Technology – have been our watchwords since day one and are powering us into our second 50 years of total commitment to bringing value to our customers," Woody added.

Stephen Montague

Will Dempsey

Sean Boyle

Stephen Montague joined Midrex Technologies as a co-op student in 1987 and has served in numerous technical and commercial functions throughout his Midrex career before being appointed President and CEO in 2017.

Will Dempsey was most recently Vice President of Commercial at Midrex, responsible for all commercial activities including plant sales, marketing and communications, and the aftermarket group, Global Solutions. In his 13 years at Midrex, he has developed an extensive background in process engineering including lead design and commissioning roles and held positions as Chief of Process Engineering and Director of Engineering. Will believes the best engineering solutions are ethical, elegant, practical, and completely satisfy our clients' needs.

Dempsey holds a Bachelor of Science degree in Chemical Engineering from North Carolina State University.

Sean Boyle, as Director – Plant Sales, led the Midrex plant sales team through the onset of a transitional time for the international steel industry. Boyle joined Midrex in 2013, and has served in various technical and commercial roles including Key Account Manager – North America and Europe when he was an integral part of the effort to secure the H2 Green Steel project. Other noteworthy assignments have included Global Solutions Mechanical Engineer and Lead Mechanical Engineer for different projects.

Boyle earned a B.S. in Mechanical Engineering from Virginia Tech.

❖ Statistics

Item	Performance of Indian Steel Industry		
	April-March 2023-24* (mt)	April-March 2022-23 (mt)	% Change*
Crude Steel Production	144.043	127.197	13.2
Hot Metal Production	87.019	81.162	7.2
Pig Iron Production	7.317	5.861	24.8
Sponge Iron Production	51.500	43.621	18.1
Total Finished Steel (alloy/Stainless + non alloy)			
Production	138.825	123.196	12.7
Import	8.320	6.022	38.2
Export	7.487	6.716	11.5
Consumption	136.250	119.894	13.6
Source: JPC ; *Provisional; mt = million tonnes			

Overall Production

- **Crude Steel**: Production at 144.043 million tonnes (mt), up by 13.2%.
- **Hot Metal**: Production at 87.019 mt, up by 7.2%.
- **Pig Iron**: Production at 7.317 mt, up by 24.8%.
- **Sponge Iron**: Production at 51.500 mt, up by 18.1%, led by coal-based route (81% share).
- **Total Finished Steel**: Production at 138.825 mt, up by 12.7%.

Contribution of Other Producers

- **Crude Steel**: SAIL, RINL, TSL Group, AM/NS, JSWL Group & JSPL together produced 83.999 mt (58% share) during this period, up by 4.9%. The rest (60.044 mt) came from the Other Producers, up by 27.4%.
- **Hot Metal**: SAIL, RINL, TSL Group, AM/NS, JSWL Group & JSPL together produced 77.772 mt (89% share) up by 2.8%. The rest (9.247 mt) came from the Other Producers, up by 68.3%.
- **Pig Iron**: SAIL, RINL, TSL Group, AM/NS, JSWL Group & JSPL together produced 1.372 mt (19% share) up by 15.8%. The rest (5.945 mt) came from the Other Producers, up by 27.1%.
- **Total Finished Steel**: SAIL, RINL, TSL Group, AM/NS, JSWL Group & JSPL together produced 77.345 mt (56% share) up by 7.0%. The rest (61.480 mt) came from the Other Producers, up by 20.7%.

Glimpses of 6th India International DRI Summit 2024

DG,SIMA

Secretary, Ministry of Steel

Chairman,SIMA addressing inaugural Session

Group photograph of inaugural Session

Vice Chairman,SIMA addressing 2nd Session

Group photograph of 3rd Session

Group photograph of 4th Session

Group photograph of 5th Session

Secretary,Ministry of steel taking round of exhibition

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