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The Indian Institute of Metals – Delhi Chapter

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Dr Sanak Mishra Conferred Prestigious "Life Time Achievement Award for Engineering Contribution" by INAE

Dr. Sanak Mishra, former Managing Director of SAIL, Rourkela Steel Plant, and former President of The Indian Institute of Metals, was conferred the **"INAE Lifetime Achievement Award in Engineering – 2025"** in recognition of his *"Outstanding Contributions in the field of Metallurgical Engineering and Leadership Role in the Growth of the Steel Industry in the Country"* by the ***Indian National Academy of Engineering (INAE)***, in Bengaluru, on 19th December, 2025. Notably, the previous recipient of the prestigious awards includes the likes of Dr. APJ Abdul Kalam, Rata Tata, Narayana Murthy (Infosys) and Azim Premji (WIPRO).

Dr. Sanak Mishra obtained MS and PhD in Metallurgical Engineering from University of Illinois at Urbana-Champaign in USA. A founder member of SAIL's R&D Centre for Iron & Steel at Ranchi, he later shifted to SAIL Corporate Office and was Head of Technology Planning, Business Restructuring and e-Commerce. He was subsequently Managing Director of Rourkela Steel Plant and Board Member of SAIL from 2002 to 2005, where he engineered a dramatic turnaround. He moved, in 2006, as Vice President of ArceloreMittal Corporate Group and CEO of India Projects. He also served as the first Chief Executive of Indian Steel Association.

Dr. Mishra has received numerous accolades such as *National Metallurgist Award* and *Life Time Achievement Award* of the Ministry of Steel; *JRD Tata Award of Excellence in Corporate Leadership*; *Distinguished Alumnus Award* of Indian Institute of Science, *Distinguished Alumni Award* from Dept. of Material Science & Engineering at the University of Illinois - Urbana Champaign, which has also recently named him as a *Legendary Alumni*.

Dr Mishra has been President of Indian National Academy of Engineering and also President of The Indian Institute of Metals.

IIM Delhi Chapter is proud of its association with Dr. Sanak Mishra and conveys our heartiest congratulations and best wishes.

India's 2050 Aluminium Prospect

By mid-century, aluminium is set to become one of the defining industrial commodities of the energy transition. Global aluminium demand could grow by around 80 per cent by 2050 compared with 2020. According to World Economic Forum reports, one recent macro-model of primary aluminium fundamentals suggests that demand for primary metal alone could approach 110 million tonnes by 2050, even as a rising share of total use is met by recycled metal.

Where India stands in 2025

India is the world's second-largest producer of primary aluminium, accounting for roughly 6 per cent of global output in 2023, and has seen production capacity more than double over the past two decades from about 1.7 million tonnes in 2003 to just over 4.17 million tonnes in FY2024. However, the same period has also seen a sharp rise in imports of metal and scrap.

India's share of world primary production was about 5.7 per cent in FY2024-25. On those numbers, India is a serious global producer, but not yet a dominant one.

India's aluminium consumption in 2023-24 was around 4.9 million tonnes, with demand projected to reach about 8.3 million tonnes by 2030, implying a CAGR of 8 per cent per annum. Other market assessments point to a similar trajectory, with some placing expected demand near 9-10 million tonnes by the early 2030s.

Over the past 14 years, the Aluminium Association of India (AAI) has estimated that domestic aluminium consumption has increased by about 160 per cent, while imports of aluminium products have risen by around 250 per cent and scrap imports by roughly 285 per cent.

Power sector accounts for roughly 48 per cent of India's aluminium use, followed by transport at around 15 per cent and building and construction at about 13 per cent, with consumer durables, machinery and packaging making up most of the balance. Per capita consumption remains low by global standards. AL Circle estimates for 2025 put India's per capita aluminium use in the 3.9-kilogram range, compared with a global average near 11 kilograms.

Long-term demand

Analysis by the International Aluminium Institute (IAI) and other industry platforms suggests that, under scenarios consistent with stated climate and development policies, total global aluminium demand could reach the equivalent of 335 million tonnes a year by 2050, counting both primary and recycled metal. The bulk of that growth is expected to come from transport (particularly electric vehicles and light-weighting), construction (especially in rapidly urbanising Asia and Africa), packaging and electrical infrastructure.

Primary aluminium demand continues to grow into the 2040s and, around mid-century, reaching the order of 110 million tonnes per year, even as recycled metal takes a larger share of total use.

Energy and carbon

Aluminium is a power-hungry metal. Globally, the aluminium sector consumed about 7 exajoules, or roughly 1,944 terawatt hours, of energy in 2023, making it the fourth-largest industrial energy consumer worldwide. While the sector's overall energy intensity has improved by around 15 per cent since 2010, most primary smelters are already relatively close to best-available technology, meaning future gains will depend increasingly on decarbonising the power supply rather than dramatic efficiency breakthroughs.

India's aluminium producers are at the sharp end of that reality. The country's grid remains heavily coal-based. Captive coal-fired power plants are still the backbone of most large smelter complexes. This makes Indian primary aluminium particularly exposed to carbon-related trade measures.

The European Union's Carbon Border Adjustment Mechanism (CBAM), now in a transitional phase and scheduled for full implementation from 2026, will gradually impose a carbon price on imports of aluminium and other energy-intensive goods to mirror the EU Emissions Trading System.

The European Commission has recently confirmed that while indirect emissions for metals will not be included initially, pre-consumer scrap will be treated as a separate product category, a nuance that still leaves Indian producers with significant exposure, given the direct emissions profile of coal-based smelting.

Benchmark emission intensities for aluminium electrolysis under CBAM rules point to a figure of about 1.55 tonnes of CO_2 equivalent per tonne of aluminium from 2026 as a reference point. Many Indian smelters, depending on their power mix, sit above that threshold.

In April 2025, Rio Tinto signed a MoU with India-based AMG Metals & Materials to explore a low-carbon aluminium project in India, with a concept of up to 1 million tonnes per year of primary aluminium and 2 million tonnes of alumina powered by a combination of wind, solar and pumped hydro storage.

But one project cannot, on its own, rewrite the sector's emissions profile. For India to remain competitive in a 2050 world where buyers and regulators will scrutinise embedded carbon, a broader shift in energy sourcing for smelters – through renewable power purchase agreements, hybrid grid-captive models and potentially dedicated green energy corridors – will be necessary rather than optional.

Recycling and circularity's ability to absorb the shock

The second structural lever available to India is secondary, or recycled, aluminium. India has made some progress in increasing the share of secondary metal in its consumption mix. India's 'Vision Document 2047' on the aluminium sector notes that the share of secondary aluminium in total consumption has risen over the past decade, even as primary continues to dominate. At the same time, it flags the difficulty of sourcing enough domestic scrap and the challenges associated with importing scrap at scale.

AAI's own analysis, highlighting a near-threefold surge in scrap imports over 14 years, emphasises how dependent India has become on external scrap flows.

The problem is that India's scrap ecosystem remains fragmented and largely informal. Collection rates for post-consumer aluminium in building materials, vehicles and consumer durables lag global benchmarks; formal segregation and tracking at end of life are the exception rather than the rule.

Without a concerted strategy that links urban mining, formal scrap collection, modern sorting and high-efficiency secondary smelting, India risks being squeezed in both directions, paying high prices for imported primary metal in a tight market, and high prices for imported scrap in a world where circularity becomes a key source of comparative advantage.

What a realistic 2050 strategy looks like for India

Put together, the contours of a realistic 2050 strategy for India's aluminium sector are becoming visible.

First, the country has to assume that its domestic demand will grow faster than the global average for at least the next 10-15 years. With consumption growing at roughly 8 per cent annually in recent years and per capita use far below global norms, projections of demand doubling from about 4.5 million tonnes in the early 2020s to around 9 million tonnes by the early 2030s are not speculative; they are consistent with current trajectories and existing policy commitments in infrastructure, manufacturing and energy.

Second, India cannot plan for that demand on the assumption that global markets will always provide cheap, carbon-blind metal and scrap. Long-term industry outlooks suggest that total aluminium demand, primary plus recycled, could exceed 300 million tonnes a year by 2050, with primary demand alone still rising.

Third, the policy levers available are concrete rather than rhetorical. Green power procurement for smelters is one of them; the Rio Tinto–AMG M&M proposal is an early test case of whether India can host large-scale, renewable-powered primary aluminium capacity at competitive cost. A second lever is a serious national circularity programme for aluminium, anchored in formalising scrap flows, incentivising high-efficiency secondary smelting and aligning quality standards for imports with domestic sustainability objectives.

Source: AL CIRCLE, 03 December 2025

India's Steel Sectoral Performance in Nov.'25

India's produced 13.841 million tons of crude steel in Nov'25 registering 11.8% gains over year and 2.1% gain on month. With this, cumulative crude steel output for Apr–Nov '25 crossed the 100-million-ton milestone, reaching 109.49 million tons, which is higher by 11.3% on year.

(in MnT)	November 2025	Y-o-Y Change (%)	M-o-M Change (%)
Crude Steel Prod.	13.841	11.8%	2.1%
Finished Steel Prod.	13.242	13.5%	0.6%
Consumption	12.968	7.1%	-3%
Imports	0.387	-52.5%	-15.7%
Exports	0.733	83%	14.6%

Source: JPC

Finished steel production also trends higher with production for Nov'25 pegged at 13.24 million tons, up by 13.5% on y-o-y basis but showing moderate growth of 0.6% on month. Cumulative finished steel production also breached 100 million tons mark with production for Apr-Nov'26 at 104.834 million tons, up by 10.8% on year.

On the consumption front, the market consolidated on a sequential basis, with finished steel consumption in Nov'25 standing at 12.968 million tons—down 3% m-o-m but up 7.1% y-o-y.

The country remained net steel exporter for the second consecutive month by exporting 0.73 million tons of finished steel in Nov'25, up by 83% on year, and 14.6% on month.

Source: JPC- Provisional Data

Recycling and Green Steel

Green Steel and the decarbonisation of steel have become an increasingly prominent topics for global steel industry. It is an issue on which the recycling industry has a pivotal role.

Some 630 million tonnes of recycled steel are used each year in global steel production, thereby preventing almost 950 million tonnes of CO_2 emissions. Looking to the future, recycled steel will continue to enjoy great demand.

Rapid material analysis and sorting are very crucial to recycling business. Generative AI is being adopted faster and recyclers must either embrace the AI revolution or get left behind. This could mean computer vision systems identifying and sorting electronic components, robotic arms dismantling devices and automated robots extracting lithium batteries.

The recycling industry has a well-earned reputation for demonstrating innovation and resilience in an ever-changing world.

Important Facts

Ferrous metals have magnetic properties. Steel, an iron alloy containing carbon, is by far the most recycled material in the world. As per 2018 figures, total crude steel production was 1.8 billion tonnes, with verified data for 81% of global steelmaking, indicating an associated steel scrap use of just under 470 million tonnes. A further 70 million tonnes of scrap is consumed by the world's iron and steel foundries each year. Global external steel scrap trading - including internal EU-28 trade - amounted to 105.4 million tonnes in 2018 for an increase of 2.6% over 2017.

The most commonly recycled items are scrap from industrial processes, and also end-of-life products such as containers, vehicles, appliances, industrial machinery and construction materials.

Proportion of steel scrap used in domestic steel production (2018):

China	*20.2%*
EU-28	*55.9%*
USA	*69.4%*
Japan	*35%*
Russia	*42.5%*
Turkey	*80.7%*
Republic of Korea	*41.4%*

Throughout the world, use of scrap metal is an integral part of the modern steelmaking sector, improving the industry's economic viability and reducing its environmental impact. Compared to ore extraction, the use of secondary ferrous metals significantly reduces CO_2 emissions, energy/water consumption and air pollution. At the same time, the recycling of steel makes more efficient use of the Earth's natural resources.

Recycling Process

In general, metal recycling is a pyramid industry with many small companies at the bottom feeding scrap to large multi-nationals at the top. Steel recycling involves some, or all, of the following steps:

Sorting: Magnets attract steel and so, through the use of magnetic belts, this metal can be easily separated from other recyclables such as paper in a recycling facility. Different kinds of steel do not need to be separated always.

Shredding: Shredders incorporate rotating magnetic drums to extract iron and steel from the mixture of metals and other materials.

Media separation: Further separation is achieved using electrical currents, high-pressure air flows and liquid flotation systems.

Shearing: Hydraulic machinery capable of exerting enormous pressure is used to cut thick, heavy steel recovered from, for example, railways and ships. Other cutting techniques, such as the use of gas and plasma arc torches, are sometimes employed.

Baling: Iron and steel products are compacted into large blocks to facilitate handling and transportation.

Recycling Facts

- Recycling one tonne of steel saves 1100 kg of iron ore, 630 kg of coal and 55 kg of limestone.
- Recycling one tonne of steel saves 642 kWh of energy, 1.8 barrels (287 litres) of oil and 2.3 cubic metres of landfill space.
- Steel recycling uses 74% less energy, 90% less virgin material and 40% less water; it also produces 76% fewer water pollutants, 86% fewer air pollutants and 97% less mining waste.
- A BIR-commissioned study conducted by Imperial College London has concluded that CO_2 emissions are reduced by 58% when using ferrous scrap in steelmaking rather than virgin ore.

Source: Extract from BIR Annual Report 2024

Global Recycled Steel Use Reaches 630 mt in 2025

Global crude steel production totalled 934.3 million tonnes in the first half of this year for a decrease of 2.2 percent over the corresponding period in 2024, according to *worldsteel*. From the regional perspective, the only year-on-year increase in crude steel production was recorded by Africa. The biggest producer in the first six months of this year was Asia/Oceania at 693.9 million tonnes (down 1.9 percent from January to June 2024). Also registering lower totals were: the EU-27 (-3.3 percent to 65.4 million tonnes); Other Europe (-7.1 percent to 20.8 million tonnes); the Middle East (-5.4 percent to 27.5 million tonnes); North America (-0.6 percent to 53.2 million tonnes); the CIS (-5.4 percent to 41.6 million tonnes); and South America (-0.4 percent to 20.5 million tonnes).

Bureo of International Recycling (BIR) - Ferrous Division is now using the term "recycled steel" rather than "steel scrap" in order to resonate more effectively when highlighting the importance of the material for global steelmaking.

Around 630 million tonnes of recycled steel is used each year in global steel production, thereby preventing almost 950 million tonnes of CO_2 emissions while also saving energy and conserving natural resources. The term "recycled steel" also reinforces the importance of the material for "green" steelmaking.

Recycled steel usage

Recycled steel usage lowered in China, the EU-27, the U.S., Japan, and South Korea in the first half of 2025 whereas increases were registered in India and Turkey. China's crude steel production fell by 3 percent in the first six months of this year to 514.8 million tonnes but its recycled steel usage tumbled a significantly steeper 11.4 percent to 109.01 million tonnes. However, the nation retained its position as the world's largest consumer of recycled steel.

The following also recorded larger declines in recycled steel usage when compared to crude steel production during the first half of this year:

- EU-27 (-4.2 percent to 39.403 million tonnes for recycled steel consumption versus -3.3 percent to 65.4 million tonnes for steel production);
- U.S. (-9.1 percent to 26.71 million tonnes for recycled steel consumption versus an unchanged steel production of 39.9 million tonnes);
- Japan (-6.7 percent to 14.894 million tonnes of recycled steel usage as against a 5 percent drop in steel production to 40.6 million tonnes); and
- South Korea (an 11.3 percent slump in recycled steel usage to 10.242 million tonnes compared to a dip of 2.8 percent in steel production to 30.6 million tonnes).

On the positive side,

- India reported a 15.3 percent leap in its recycled steel usage in this year's January to June period to 19.65 million tonnes as against an increase of 9.2 percent in its crude steel production to 80.9 million tonnes.
- Turkey was increasing its recycled steel usage by 2.2 percent to 16.051 million tonnes despite a 1.7 percent dip in its steel production to 18.3 million tonnes.

In total, during the first half of 2025, recycled steel usage in key countries and regions was 6.9 percent lower year on year at 235.96 million tonnes; this usage figure represents data for 76 percent of global steelmaking.

The respective shares of recycled steel usage in crude steel production were

- 21.2 percent for China,
- 24.5 percent for India,
- 33.4 percent for South Korea,
- 36.7 percent for Japan,
- 60.2 percent for the EU-27, and
- 66.4 percent for the U.S.
- Worthy of particular note was recycled steel's 87.7 percent share of crude steel production in Turkey.

India remained the world's second-largest recycled steel importer in the first six months of 2025 (+18 percent to 4.580 million tonnes), with its list of suppliers headed by the U.S. (+30 percent to 0.92 million tonnes) and the U.K. (+7 percent to 0.47 million tonnes).

Source: MRAI News Updates: 30 October, 2025

World's Largest Steel Plant Coming at Gadchiroli

Gadchiroli, which has mammoth reserves of superior quality iron ore, may house the World's Largest Steel Plant — with a capacity of 25 million tonne per annum, entailing an investment of Rs 1 lakh crore. The entire plant will be built in seven years and the first phase is expected to be ready in four years. The proposed plant will nearly double JSW's own steel-making capacity, which currently stands at 28 million tonne, as per the company website.

Gadchiroli has the best grade of iron ore with a realisation of nearly 64%, which prompted steel companies to start ventures here. The district has the best grade iron ore in the world. Lloyds Metals & Energy Limited (LMEL) launched the first iron ore mine over five years ago. LMEL alone is sitting on a 1 billion tonne reserve. Iron ore in Gadchiroli was first discovered by Jamshedji Tata in the 1900s.

The state govt plans to develop this district of Vidarbha as a steel hub. If it works out, JSW Group will be the third steel venture in the district. The earlier two units have been planned by LMEL and Surjagad Ispat Private Limited. With all three clubbed, Gadchiroli is expected to have an installed capacity of 33 million tonne after all plants are built. LMEL has plans to set up a capacity of 6 million tonne and Surjagad's projections are at 2 million tonne. The biggest will be JSW with 25 million tonne.

📌**Key Highlights:**

- Over 9,100 acres acquired in Chamorshi taluka for the project.
- Capacity triple the size of SAIL Bhilai Steel Plant.
- Expected creation of 20,000+ jobs, driving regional economic uplift
- Features India's first 10 million tonne iron ore slurry pipeline & green steel initiatives.

Source: TOI

India Needs Targeted Public Finance to Scale Green Steel

India's planned steel capacity expansion presents an opportunity to adopt cleaner technologies if supported by the right financing pathways.

India needs to deploy public capital strategically to bridge the financing gap for green steel projects — which are technically proven but still considered risky for private finance — and to avoid carbon lock-in from its planned capacity expansion.

With planned steel capacity expansion to 300 mt, technology choices made now will influence emissions for 30–40 years. Steel plants typically operate for decades once constructed, making early public finance intervention important.

Carbon lock-in will occur if steel plants with 30–40-year lifespans are built with conventional technology, locking in emissions until 2060–70. This could affect India's net-zero goals.

Beyond climate implications, traditional blast furnaces use metallurgical coal as a primary energy source, largely imported from Australia. As India adds more BF-BOF capacity, the country's met coal imports are expected to nearly double by 2035, posing an energy security challenge.

While venture capital and private equity typically fund emerging technologies, these sources may not be well-suited for green steel given its low technology readiness level, massive capital requirements, and extended payback periods.

Nearly $24billion has been injected into steel decarbonisation projects globally. Virtually every major green steel initiative globally has relied on substantial public finance to reach viability. The Indian government is also formulating a National

Mission for Sustainable Steel with an estimated 5,000 crore Indian rupees ($600 million) outlay aimed at decarbonising steel production. The programme is likely to offer production-linked incentives, concessional loans, or risk guarantees to steelmakers, with up to 80% of funds expected to support secondary steel mills.

Another key pillar under development is Green Public Procurement (GPP). A draft GPP policy would mandate that 25–37% of steel used in public projects be low-carbon, creating an assured domestic market for green steel. However, implementing GPP has been challenging — a proposal to establish a centralised agency for bulk procurement of green steel was rejected by the Ministry of Finance in 2024. Under the Carbon Credit Trading Scheme, set to begin trading in October 2026, emissions intensity targets will be imposed across nine industrial sectors, including steel. While this could reward cleaner steel production, its impact will depend on carbon pricing levels which will be driven by target stringency.

These measures signal government intent, but the scale of proposed funding remains modest.

Markets differentiate between green steel types. Gas-based Direct Reduced Iron projects like Cleveland-Cliffs in the US and ArcelorMittal in Germany failed to secure buyer premiums and were cancelled despite grants, while integrated hydrogen-based projects like Sweden's Stegra secured long-term offtakes with 20–30% premiums.

The market data shows buyers will pay premiums for steel with end-to-end green credentials spanning renewable energy, hydrogen production, and steelmaking.

India's approach will differ from the West — focusing on maximising impact through instrument design rather than large direct subsidies. Ultimately, India's green steel transition demands strategic public capital deployment that ensures judicious use of taxpayers' money, while spurring innovation and investment from industry, global financiers, and technology providers.

Source: The Institute for Energy Economics and Financial Analysis (IEEFA), 01 Dec.2025

Helios' Solution for Decarbonizing Steelmaking

Inspired by work on lunar resource extraction, the *Helios Cycle* claims to create zero direct emissions and uses 30% less energy than traditional methods of extracting iron — offering transformational potential for the heavy-emitting steel industry.

The steel industry, a cornerstone of modern civilization, faces significant challenges. As one of our most used materials, steel, and its production, is a massive global enterprise — with over 1.8 billion metric tons produced annually. However, this industry is also a massive polluter — responsible for approximately 11 percent of the world's total greenhouse gas output. Traditional steelmaking processes, which rely heavily on carbon-intensive equipment such as blast furnaces, on an average, emit around 1.8 tons of CO_2 for every ton of steel produced. Additionally, the quality of iron ore — a primary raw material — is declining globally, leading to more energy-intensive and costly extraction and refinement processes.

Israeli startup *Helios*, originally set out to solve the challenges associated with space exploration, found itself with a solution to address Earth's pressing environmental issues — particularly, in the steel industry.

A journey from space to Earth

Helios initially focused on lunar resource extraction. The promoter, a space geek, wanted to know why we haven't done more since astronauts last landed on the moon in 1972. What's happened since then? Why haven't we been back? Why are there no bases on the moon? Is it just funding? Geopolitics? Lack of technology?"

He found that the answer was multifaceted — there were significant technical and logistical challenges that had hindered progress. One issue was the sheer complexity and cost of sending essential resources, such as oxygen, from Earth to sustain lunar missions. Therefore, producing oxygen directly from lunar regolith (the Moon's surface material) could drastically cut costs and facilitate deeper space exploration. This discovery led him and his team to focus on developing technologies that could leverage lunar resources efficiently.

Oxygen is going to be by far the most needed consumable on the Moon, primarily for burning propellant. Therefore, if you can produce that oxygen on-site — rather than sending everything from Earth — you can save billions of dollars. The most accessible oxygen on site is in the minerals on the ground.

While originally intended to support life and propulsion on the Moon, Helios's technology soon revealed its potential for an application on Earth: the steel industry. The core of its innovation involved a method for extracting oxygen from lunar soil, which could also be used to improve iron production here on Earth. By adapting this lunar technology, Helios discovered a novel way to produce iron without the high carbon emissions typical of traditional steelmaking processes. This breakthrough led

Helios to pivot its focus to explore how its technology could transform iron production to address environmental challenges in the steel industry.

Reinventing iron production

Iron production has remained largely unchanged for millennia, relying heavily on carbon to extract iron from its ore. This method, while effective, releases vast amounts of carbon dioxide into the atmosphere.

Traditional steelmaking process starts with iron ore, which is essentially iron chemically bound to oxygen. This iron ore is then fed into a blast furnace, where it is subjected to extremely high temperatures. To separate the oxygen from the iron, carbon is added/injected into the furnace. The carbon reacts with the oxygen in the ore, effectively pulling the oxygen away from the iron. What you're left with is liquid iron (with some impurities) — which is then used to produce steel — and carbon dioxide, which is released into the atmosphere as a byproduct.

Helios has developed a process that substitutes carbon with sodium, a common and abundant element found in table salt. This approach, called the *Helios Cycle*™, operates at significantly lower temperatures — 250-350°C, similar to typical kitchen oven temperatures — compared to the 1,200-2,000°C required by traditional steelmaking methods.

By replacing the carbon with sodium to extract oxygen from iron ore, the Helios Cycle eliminates CO_2 emissions and operates more efficiently — reducing both energy use and production costs by 30 percent — making it a more sustainable and cost-effective alternative to conventional steel production.

The steel industry's challenge isn't just emissions — it's also the declining quality of iron ore. Mining industry uses a costly, carbon- and energy-intensive process called beneficiation to upgrade ore quality.

Helios' technology allows for the processing of lower-quality ores — those typically considered unsuitable for use in traditional methods, due to their lower iron content or higher impurity levels. In conventional steelmaking, these ores would need to undergo a beneficiation process. By using Helios' process, these lower quality ores can be used directly, bypassing the need for such energy-intensive beneficiation steps.

Compared to hydrogen-based methods, which also hold great promise for decarbonizing steel production, Helios' approach also has advantages. Hydrogen technologies struggle with high production costs, complex storage and infrastructure needs, and can still be carbon intensive. In contrast, Helios' use of sodium is more energy-efficient, sidesteps these hydrogen-related challenges, and benefits from sodium's wide availability and low cost — making it a more practical and scalable solution.

Scaling for impact

Helios plans to build its first pilot plant next year, capable of producing several thousand tons of iron annually, to demonstrate the technology's viability and set the stage for commercial production. After the pilot, Helios plans to start building its first commercial units — with the first expected around 2028.

In the meantime, Helios' potential for impact continues to grow — the startup has attracted over $6M in seed funding; and just last month, the company forged a partnership with Australian steel manufacturer BlueScopeX and was named a winner in the World Economic Forum's UpLink Sustainable Mining Challenge. Helios also recently secured its membership in the World Steel Association (WSA) — an exclusive network of the largest and most established steelmakers in the world, representing nearly 90 percent of global steel production. Membership is a mark of credibility and influence within the industry. Helios is the first and only technology company accepted as a member that is not a steelmaker — they acknowledge that The Helios Cycle aims to be the technology that not only decarbonizes but can commercially compete with current iron production methods.

The global steel industry is on the brink of unprecedented transformation over the coming decades, necessitating a diverse portfolio of technologies to achieve a smooth transition to a low-emission future.

In the medium term, the emergence of technologies such as carbon capture, storage and hydrogen will be pivotal - and innovative and radically new technologies show significant promise. These include direct electrolysis and the Helios cycle, with sodium reduction being an exciting innovation with an incredible story that could potentially revolutionize steel production. Having multiple viable technologies will greatly ease the industry's transition toward sustainability, as their success will broaden the technological options available to the industry. The more options we have, the more likely a successful transformation will be — ultimately, paving the way for a more sustainable steel industry.

Thus, *Helios Green Iron* (HGI™), produced using the Helios' ironmaking technology – the "Helios Cycle™", stands at the forefront of a transformative era in the iron and steel industry.

The Helios Cycle™ emits zero direct emissions, offering superior advantages not only compared to traditional methods but also compared to other innovative low-emission iron technologies.

If HGI™ production takes place in proximity to iron ore mines, a significant reduction of transport-related emissions can be achieved, constituting a further reduction in scope 3 emissions.

Conclusion

HGI™ represents a transformative leap forward for the iron and steel industry, offering a blend of environmental responsibility and economic opportunity. By utilizing HGI™ as feedstock, or adopting the Helios Cycle™ in internal production processes, not only can iron and steel manufacturers face the current regulatory challenges and capitalize on the existing market opportunities, but also prepare for the challenges and opportunities of tomorrow, while leading the transition towards a decarbonized economy.

Source: https://heliosmatters.com

Electra's New Demonstration Facility for Clean Iron

Electra, the US-based clean iron company, unveiled the site of its new demonstration facility in Jefferson County, Colorado. The 130,000 sq. foot facility will produce up to 500 metric tons of Electra's low-carbon, high-purity iron annually.

Steel is a crucial building material and accounts for 7% of global carbon-dioxide emissions each year—more than the impact of shipping and aviation combined. Electra, the Colorado-based startup showcased a technology that pushed the boundaries of known electrochemistry.

Steel production is one of the largest sources of emissions, driven primarily by the energy-intensive step of refining iron. Electra claims to reimagining the fundamentals of ironmaking, enabling a scalable, cost-effective pathway to low-carbon steel.

Steel production is a two-step process. The first one involves taking iron ore, which contains compounds of iron and oxygen, and treating it with something—typically coal—that can remove the oxygen, leaving behind iron with some impurities. More than 90% of carbon-dioxide emissions of steelmaking come from this first step. Then that iron is refined by oxidizing impurities, and mixed with small amounts of other metals to make different types of steels.

There are three main ways to make emissions-free steel:

- Capture emissions from conventional steelmaking and bury it deep underground, which has been deployed at a plant in the United Arab Emirates;
- Replace coal with a carbon-free fuel, such as renewables-powered hydrogen, which is what H2 Green Steel does; and
- Use carbon-free electricity to go from iron ore to iron, which is what Electra does, and then convert that into steel in existing electric-arc furnaces.

Carbon capture has failed to take off, with no further construction happening at large steel plants. H2 Green Steel expects to complete its 2.5-million ton plant in 2026, but its process is only price competitive with high-grade iron ore and thus limits its applicability to replacing all steel production. And, so far, none of the startups wanting to use only electricity for steel production have reached the commercial stage.

Electra is reinventing this age-old process with our patented low-temperature electrochemical-hydrometallurgical system to refine ore into high-purity clean iron.

Electra is developing an emissions-free iron without melting ore. Technology promises a step-change in the race to produce steel without a massive carbon footprint. Electra's goal is to have a 50,000-ton plant built by 2027 and the same site will be expanded to million-ton scale by 2029.

Electra claims it is reinventing iron production to tackle the nearly 10% of global carbon dioxide emissions produced from iron and steelmaking. Its patented technology uses chemistry and clean energy to transform a broad range of iron ore into responsible, resourceful, pure iron at scale.

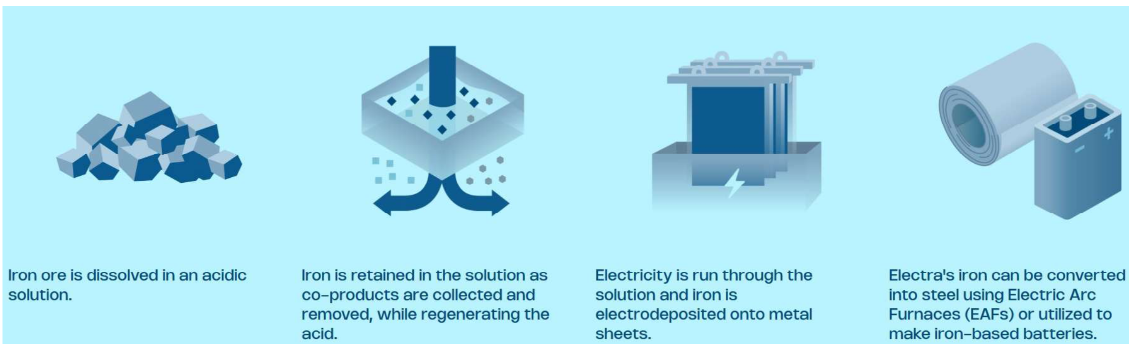
The facility is expected to begin operations in mid-2026 and will deploy the company's technology to convert iron ore into 99% pure iron using its proprietary low-temperature process powered by chemistry and clean energy.

The facility is supported by a new $50 million grant from Breakthrough Energy Catalyst, a programme within Breakthrough Energy that funds and helps scale early commercial clean energy projects, and an $8 million dollar tax credit from the

Colorado Industrial Tax Credit Offering (CITCO) along with $186 million in Series B funding announced earlier this year.

Electra's Process

Electra's process involves taking iron ore and heating it up to 400 deg C (752°F) with hydrogen. Then dissolving the ore in acid, which also separates out any sand. Running electricity through the iron ore-acid mixture at temperatures of about 60 deg C—cooler than coffee—which is enough to separate oxygen from iron oxide and leave behind silvery-gray plates of emissions-free iron. The whole process takes between three and five days.



Electra's process

Process Features

Flexible Inputs

Compatible with intermittent renewable energy: Low-temperature process allows to synchronize production with the availability of cost-effective intermittent renewable energy.

Uses the widest range of iron ores: Traditional ironmaking uses the highest grades of ore as feedstock. Electra process unlocks new types of ores including previously mined, unused materials.

Valuable Outputs

Produces 99% pure iron: High-purity iron provides the highest economic value for EAF steelmakers and battery manufacturers.

Extracts co-products to maximize value: Full value refining process removes co-products like silica and alumina, reducing waste and preserving critical minerals.

Modular Design

Electra system is built in a network of connected cells — similar to stackable blocks — that can be replicated and combined to rapidly increase production.

Each repeatable, modular unit is built using readily available equipment and materials available at scale. This nimble, cost-effective approach is engineered for global scalability and commercial viability.

Electra's other competitors

US-based *Boston Metal* founded in 2012, which also like Electra, relies on electricity to make green iron, but still hasn't built a commercial scale plant.

Australia-based *Element Zero* says it can convert iron ore to iron using only electricity at less than 400 deg C. So far, it's only shown to work at small scale and doesn't expect to have a commercial scale plant until 2030.

The advantage that Electra and Element Zero have with their lower temperature process is that it allows them to start and stop the conversion of iron ore to iron without hassle. That's important, if the goal is to use solar and wind power when it's available. Boston Metal can't do that without molten metal solidifying and destroying their reactor.

All three startups aim to supply the carbon-free iron to a steelmaker that uses a mixture of scrap steel and virgin iron in an electric-arc furnace to make steel. And if that process is powered by renewables, the entire cycle from iron ore to steel can be emissions-free.

In 2022, Electra's 20 or so workers were able to make iron plates the size of office paper that weighed few kilograms. The company shared its space with a bakery. Electra then took over the bakery, has about 100 people working and produces carbon-free iron plates of more than 100 kilograms. A million-ton iron plant will contain hundreds or thousands of the kinds of plates.

One thing that gives electricity-driven iron production an advantage is that it can use any type of iron ore. There are billions of tons of such raw material sitting in dumps around the world, making it very cheap to acquire. The company claims that it can even separate out useful raw material, such as alumina which is used to make aluminum, from low-grade ores and create an additional source of revenue.

Currently, Electra consumes about the same amount of energy as a conventional iron-making process does. Electricity is more expensive than burning coal, and so lowering energy use is key to being price competitive. Ideally electrochemical iron-making processes should use a lot less energy than conventional methods.

Challenges ahead

There are a lot of challenges ahead.

Even if a technology problem is solved, there will be whole lot of logistical challenges that will have to be conquered.

Companies relying on either hydrogen or only electricity will need to secure huge amounts of green power which can be tough, with governments around the world struggling to build enough solar and wind energy.

And while hydrogen can be retrofit into existing steel plants, the companies relying on electricity-powered iron production will have to build new plants from scratch. It's a bigger economic hill to climb.

Funding

Electra has forged partnerships with some of the world's largest iron-ore producers (including BHP), steelmakers (including Nucor), and equipment manufacturers. Electra has raised $85 million from investors including Bill Gates-backed Breakthrough Energy Ventures, Capricorn Investment Group, Singapore's Temasek and Amazon's Climate Pledge Fund.

The next round of funding worth $150 million will enable it to acquire land for the commercial plant and fund the engineering design. After that, a million-ton plant would cost about $1.6 billion, which means that they will have to raise a lot more money.

Electra's other competitors Boston Metal, like Electra, which also relies on electricity to make green iron, and has raised $262 million. Founded in 2012, it still hasn't built a commercial scale plant.

H2 Green Steel was able to raise billions of dollars because it lined up an order book of about 1.2 million tons of emissions-free steel at a higher cost than conventional steel.

With new funding from Breakthrough Catalyst and purchase agreements from industry leaders for the demonstration facility, Electra is on track to reach commercial scale clean-iron production by the end of the decade.

Potential customers

The driver of the momentum is automakers, electrical-appliance brands, and equipment manufacturers willing to pay a premium price for emissions-free steel in a bid to meet their climate commitments. Without customer demand, it's hard to get investors. Big brand names are willing to pay up to 50% price premium for low-carbon steel.

Many of the startups have secured blockbuster investments. Sweden-based startup H2 Green Steel raised $1.6 billion in equity, one of the biggest funding rounds for startups in 2023. Electra plans to supply its green iron to steelmakers to turn it into green steel, while H2 Green Steel is planning a large-scale plant that will be up and running by 2026.

Electra aims to emulate the Swedish startup and is working to secure orders from automakers and electrical-appliance makers.

Clean iron produced at Electra’s demonstration facility is already contracted for delivery to several strategic partners to qualify the material for use in steel applications. Signed purchase orders include Nucor, the largest steelmaker in the United States and early investor of Electra, Toyota Tsusho, the global steel trading company, and INTERFER Edelstahl Group, the European steel and metals distributor.

Nucor will use Electra’s clean iron in its electric arc furnace (EAF) steelmaking at their sheet mills.

The advanced purchase commitments with Electra are a clear demonstration of Nucor’s belief in their clean iron technology and its dedication to accelerating the adoption of sustainable steelmaking. This facility lays the groundwork for a new era of low-carbon materials.

Once qualified, Toyota Tsusho America plans to sell Electra’s clean iron to steelmakers and distribute green steel to automakers, creating a closed-loop system that supports widespread adoption of low-carbon materials.

INTERFER Edelstahl Group will use Electra’s clean iron, following qualification, in specialty steel applications to help customers meet their decarbonisation goals.

As part of the unveiling, Electra announced its first Environmental Attribute Credit (EAC) purchases from Meta. Under the agreement, Meta will purchase verified

EACs linked to the reduced emissions from Electra's clean iron. The contract with Electra is part of Meta's goal to reach net zero emissions in 2030 by addressing emissions sources throughout its supply chain, including the steel used to build and operate its infrastructure. Meta will also have the option to purchase EACs for CO_2 reduction from future Electra commercial facilities.

Meta's early-commitment to Electra's clean iron production helps advance low-carbon industrial materials and support the addition of new domestically-produced iron supply.

Meta is to collaborate with Electra to advance low-carbon iron and steel – critical data centre building solutions – made here in the US. Through this partnership and Meta aims to demonstrate a pathway for these innovative materials.

Source: Weekly news from Steel Times International, 19 November 2025

How Vietnam can Ensure Greener Steel

Vietnam's pledge to achieve net-zero carbon emissions by 2050 will require key reforms in many sectors, including in steel.

Decarbonising steel production will be critical in view of the industry's rapid growth in recent years. According to the World Steel Association, Vietnam surpassed Italy in 2024 with its production of 22 million tonnes, becoming the 11th largest steel producer globally.

In the first half of this year, finished steel output rose 9.7 per cent from the previous year to 16 million tonnes, suggesting that annual production may significantly exceed the previous year's level. This sustained growth consolidates Vietnam's position as one of ASEAN's leading steel producers.

The steel industry is an important pillar of Vietnam's economic development. It provides input for the country's rapid infrastructure expansion, it supports key manufacturing sectors such as construction and shipbuilding, and it contributes to export revenues and industrial employment.

The industry is led by privately owned *Hoa Phat Group*, which accounts for 40 per cent of national crude steel output. *Formosa Ha Tinh Steel,* a Taiwanese Vietnamese joint venture, is the second-largest producer, operating a major blast-furnace complex in central Vietnam. *Vietnam Steel Corporation* is an important state-linked holding company, *Hoa Sen Group* dominates coated and galvanised steel, and *Pomina Steel* and *Vina Kyoei* serve construction markets.

The sector is concentrated, energy-intensive, and a major source of industrial emissions. In 2023, Vietnam's steel industry emitted approximately 32 million tonnes of CO_2. This corresponds to about 8-9 per cent of Vietnam's national greenhouse gas emissions. With its fast growth, the sector is on a path to emit close to 40 million tonnes of CO_2 in the near future.

Vietnam's steel exports flow mainly to ASEAN countries, China, and increasingly to the EU, which will require a growing share of steel with lower carbon content. The EU Carbon Border Adjustment Mechanism (CBAM) will impose carbon tariffs from 2026, making decarbonisation an economic necessity.

With growing global demand for low-carbon steel from automotive, construction, and manufacturing industries, Vietnam has an opportunity to position itself as a competitive green steel producer in Asia.

The hopes of green steel

Vietnam's steel sector emits carbon dioxide mainly because it depends on coal-based blast furnace-basic oxygen furnace technology, where coke serves both as fuel and as a chemical agent to reduce iron ore, releasing CO_2 in the process.

About 70 per cent of emissions come from this type of tech using imported coking coal, and 30 per cent from electric arc furnaces using scrap. All this makes steel one of the country's most carbon-intensive industries.

Emissions from steel production can be reduced in the near term. According to the International Energy Agency, improving material efficiency, such as reducing scrap losses through better collection and sorting, could cut industrial CO_2 emissions by more than 40 per cent by 2050, while deploying the best available technologies and energy-efficient upgrades can reduce energy use in existing plants by up to 20 per cent.

In the long term, green steel produced using green hydrogen, renewable electricity, or other low-carbon technologies instead of coal offers a pathway to decarbonise this hard-to-abate sector.

Transition strategies such as hydrogen blending and carbon capture, utilisation, and storage (CCUS) retrofits can help reduce emissions. The optimal pathway depends on regional conditions but scaling low-cost options now while preparing for CCUS and low-carbon hydrogen is essential for a resilient net-zero transition.

A number of countries are making notable strides in green steel production, offering valuable lessons for Vietnam's development strategy.

India, the world's second-largest steel producer, has begun a phased shift towards low-carbon steelmaking. Major companies such as Tata Steel, JSW Steel and ArcelorMittal Nippon Steel India are investing in scrap-based electric arc furnaces, hydrogen-ready direct reduced iron technology, and carbon-capture pilots.

Tata Steel has tested hydrogen injection in blast furnaces, JSW plans up to $13 billion in decarbonisation projects and renewable integration; and AM/NS India is investing about $7 billion to make much of its Hazira output green steel. National policies, such as the steel scrap recycling policy, PLI scheme for speciality steel, and the national green hydrogen mission, are aligning incentives and pilot funding.

India's gradual, policy-supported transition offers a pragmatic model for emerging economies like Vietnam.

Oman provides another instructive example of how an emerging economy can leverage its natural advantages to attract green-steel investment.

The country is developing the Vulcan Green Steel project in Duqm, led by Jindal Steel Group, which will use aforementioned tech powered by solar and wind energy. Backed by government incentives such as long-term land leases, reduced fees, and streamlined approvals, the project positions Oman as a regional green-industry hub connecting Asia, Europe, and Africa.

Although Oman lacks domestic iron ore, its renewable potential, hydrogen strategy, and proactive investment climate illustrate how clear policy direction and infrastructure planning can draw large-scale private investment, offering useful lessons for Vietnam as it pursues industrial growth within a low-carbon framework.

Costs and constraints

Vietnam's steel industry faces mounting pressure to decarbonise, but also confronts structural constraints. The country imports most of its iron ore and scrap steel, and local ore quality is low, a significant limitation for direct reduced iron production.

This reliance on imports means that Vietnam's competitiveness in green steel will depend heavily on processing efficiency and access to clean energy rather than raw material advantages.

At the same time, the country has several strengths to build upon. Vietnam's expanding renewable power capacity, particularly solar and wind, provides a foundation for decarbonisation.

The Power Development Plan VIII envisions substantial renewable energy zones. However, it remains to be seen if Vietnam's green hydrogen strategy can benefit steel and other challenging sectors to reduce emissions.

In the near term, expanding electric arc furnace capacity using scrap represents the most practical decarbonisation pathway. With 30 per cent of production already using this less emissions-intensive method, Vietnam has a foundation to build upon.

Increasing scrap collection and recycling infrastructure could enable a relatively quick shift away from coal-intensive blast furnaces. Natural gas-based direct reduced iron, using liquefied natural gas from Vietnam's expanding import infrastructure, offers a transitional route before green hydrogen becomes commercially viable.

Costs remain a challenge. A recent analysis suggests that green steel using hydrogen-based direct reduced iron costs approximately $600-800 per tonne, compared to $400-500 for conventional blast furnace steel.

While more costly, green steel will be able to access the EU markets without paying the CBAM's carbon tariff. This could make government support for green steel worthwhile, as it would allow access to EU markets.

To get a competitive edge, many countries are now supporting green steel with fiscal incentives either to support green hydrogen or CCUS. For instance, the US 45V clean hydrogen production tax credit indirectly supports steel decarbonisation by reducing the cost of green hydrogen inputs. This incentive can lower the cost of hydrogen-based steelmaking close to the cost of conventional coal-based steel.

Canada's refundable CCUS tax credit, in place from 2022 to 2040, covers 37.5–60 per cent of eligible costs, including geological storage, offering long-term certainty for steel and other industrial emitters.

In Asia, Malaysia provides a 10-year investment allowance and 70 per cent income tax reduction for CCUS service providers, creating one of the region's most proactive industrial carbon management frameworks.

As of now, Vietnam does not provide subsidies or tax credits to support green steel. Its fiscal constraints limit the government's ability to provide large-scale, long-term subsidies comparable to those in wealthier nations.

The steel industry's capital-intensive nature means that retrofitting existing facilities or building new green steel plants requires significant investment, often billions of dollars per facility.

In private steel mills, the government cannot subsidise the costly retrofit of private steel mills, but it could encourage it with incentives that do not strain the public budget, such as accelerated depreciation or research and development tax credits.

Vietnam can also foster a green steel industry despite limited fiscal space by focusing on regulatory and market-based tools. The government can create a predictable carbon-pricing framework through its forthcoming emissions trading system, recycle revenues into targeted incentives, and mandate low-carbon standards in public procurement.

Access to concessional and blended finance from multilateral partners, such as the Just Energy Transition Partnership, World Bank, Asian Development Bank, and decarbonisation funds, can de-risk private investment.

Foreign investment by firms with the technology and experience would be very beneficial. Coupled with long-term renewable power contracts and growing export demand for low-carbon steel under the EU's CBAM, these mechanisms could go a long way to attract private capital without straining the budget.

Source: November 18, 2025, Vietnam Investment Review

Steel Supports the Future of Mobility

How is steel supporting the future of mobility?

Globally, mobility will continue to have an increased focus on sustainability. It is here that steel provides key benefits – on average, it is by far the most sustainable material for automotive Body in White design.

Steelmakers are also engaged in a transition towards the use of more recycled content for automotive and decarbonization of the upstream, which helps maintain their leadership position in this space as steel remains the material of choice for greener mobility.

What role does steel play in enabling EV affordability and accessibility?

Steel solutions remain the most cost-effective option for automakers, without sacrificing performance, which is why it is the preferred material for affordable EV design.

Steel solutions also enable flexibility in production and balance between models, which today are key benefits for EV manufacturers to offer competitive and affordable vehicles.

How does steel help automakers balance strength with lightweight design?

For decades, automotive steel has demonstrated its versatility with solutions that meet stringent crash requirements. Steel has an unmatched set of properties to ease the design and industrialization of vehicles and is a key driver for improving safety.

Vehicles are comprised of various steels that vary in strength in order to keep material part thicknesses to a minimum level. This enables maximizing lightweighting for components with strong crash requirements. Innovations like Laser Welded Blanks allow vehicle designers to tailor the properties and thickness of a unique part to achieve the best compromise for lightweighting.

Source: World Auto Steel Update, 26 October 2025

Geothermal Energy

Geothermal energy is a promising and versatile renewable energy resource with vast untapped potential for electricity generation, heating and cooling. Geothermal energy is the thermal (heat) energy derived from the Earth's subsurface. Part of this energy is residual heat generated during the planet's formation (i.e. from planetary accretion and the decay of short-lived radioactive isotopes) more than 4 billion years ago. The rest originates mostly from the continuous and spontaneous radioactive decay of naturally occurring isotopes (e.g. uranium 238 and 235, thorium 232 and potassium 40) within the Earth's core and mantle, which maintains the core temperature at around 5000°C. This heat from the core and mantle is transferred to the Earth’s surface through conduction (heat passing through materials) as well as convection and advection mechanisms (heat being transported by a moving fluid – e.g. magma), resulting in a continuous heat flow of about 45 TW across the surface of the globe. Another portion of the Earth's thermal energy comes from solar radiation at the surface and from ambient heat absorbed and accumulated over millennia, which influences the temperature of soil, bedrock and water at shallow depths everywhere on Earth. The temperature difference between the Earth’s core and surface induces a temperature gradient in the crust: on average, the temperature increases 25-30°C per kilometre of depth. However, geothermal heat-flows and temperature gradients are unevenly distributed and are strongly linked to tectonic conditions, including volcanic activity at spreading centres, rift zones, subduction zones and hot spots, as well as crustal extension (with thinner crust). These circumstances can lead to regionally elevated temperatures in the crust, and temperatures can also be higher in areas with extensive sediment-covered granitic intrusions, due to heat produced from radioactive decay. Geothermal energy systems harness this heat from the subsurface and transport it to the surface, where it can be used for heating and cooling, electricity generation and energy storage. Geothermal heat can be carried to the surface by fluids naturally occurring in the subsurface in specific geological settings such as aquifers, where water trapped in porous or fractured rock beneath a layer of relatively impermeable caprock forms a reservoir and is heated by the surrounding rock. Temperature, fluid and rock permeability conditions define hydrothermal resources. The systems used to exploit these hydrothermal reservoirs are what is termed as conventional geothermal technologies.

Efforts to overcome dependency on location-specific hydrothermal resources have led to the development of new approaches that harvest heat at greater depths by circulating a fluid from the surface through engineered systems, either through fractured rock or in closed-loops circuits, sometimes in areas that have no preexisting hydrothermal reservoir. These approaches, also termed reservoir-independent, are more recent and generally less mature, and are therefore referred as next-generation geothermal technologies. Overall, they include enhanced geothermal systems (EGSs) and closed-loop geothermal systems (CLGSs), with the latter sometimes also referred to as advanced geothermal systems (AGSs).

In addition, low-temperature heat can be transferred from and to the near-surface (<100m of depth) using **ground-source heat pumps** – also called **geothermal heat pumps** – to supply a variety of applications with low- and medium temperature heat (generally below 200°C) or cooling.

Unlike for other renewable energy sources such as wind, solar and hydro, geothermal energy production does not depend on climatic conditions or seasonality. It can be used in direct applications (for space and water heating and cooling, or for industrial processes) or for electricity generation, with different technologies (e.g. binary, flash and dry steam plants) depending on the geothermal resource conditions (temperature, pressure of the reservoir) and properties (e.g. reservoir geology, permeability/porosity, heat transfer conditions); the chemical properties of the fluid; and whether the fluid is in vapor or liquid phase in the system. However, several challenges must be addressed to successfully scale up geothermal energy development.

Geothermal power plants use heat from the geothermal fluid to power a turbine that turns a generator to produce electricity. The heat-depleted geothermal fluid is then reinjected into the reservoir, where it collects heat again. Binary-cycle power plants circulate the geothermal fluid through a heat exchanger to heat and vaporise a second fluid that flows through the turbine to produce electricity (generally using a closed-loop Rankine cycle). Flash steam power plants process the geothermal fluid to separate steam from water, before flowing the steam through the turbine to generate electricity. Dry steam power plants inject geothermal steam that is above the saturation point of water directly into the turbine to generate electricity, without needing to separate water from steam. Binary plants can operate with fluids at lower temperatures than flash and dry steam plants (from ~95°C versus more than ~180°C), but they also have lower conversion efficiencies and generally higher investment costs.

Technology breakthroughs are unlocking huge potential for geothermal energy, promising to make it an attractive option for countries and companies all around the world. These techniques include horizontal drilling and hydraulic fracturing honed through oil and gas developments.

If geothermal can follow in the footsteps of innovation success stories such as solar PV, wind, EVs and batteries, it can become a cornerstone of tomorrow's electricity and heat systems as a dispatchable and clean source of energy. For the moment, geothermal meets less than 1% of global energy demand and its use is concentrated in a few countries with easily accessible and high-quality resources, including the United States, Iceland, Indonesia, Türkiye, Kenya and Italy. With continued technology improvements and reductions in project costs, geothermal could meet up to 15% of global electricity demand growth to 2050. This would mean the cost-effective deployment of as much as 800 GW of geothermal power capacity worldwide, producing almost 6000 terawatt-hours per year, equivalent to the current electricity demand today of the United States and India combined.

Geothermal is a versatile, clean and secure energy source. Geothermal can provide around-the-clock electricity generation, heat production and storage. As the energy source is continuous, geothermal power plants can operate at their maximum capacity throughout the day and year.

On average, global geothermal capacity had a utilisation rate over 75% in 2023, compared with less than 30% for wind power and less than 15% for solar PV. In addition, geothermal power plants can operate flexibly in ways that contribute to the stability of electricity grids, ensuring demand can be met at all times and supporting the integration of variable renewables such as solar PV and wind.

The potential for geothermal is now truly global The full technical potential of next-generation geothermal systems to generate electricity is second only to solar PV among renewable technologies and sufficient to meet global electricity demand 140-times over.

Geothermal energy potential increases as developers access higher heat resources at greater depths. New drilling technologies exploring resources at depths beyond 3 km open potential for geothermal in nearly all countries in the world. Using thermal resources at depths below 8km can deliver almost 600 TW of geothermal capacity with an operating lifespan of 25 years.

Geothermal can also provide a continuous source of low- and medium temperature heat for use in buildings, industry and district heating. Global geothermal potential from sedimentary aquifers at depths up to 3 km and temperatures greater than 90°C is estimated around 320 TW. This is consistent with the requirements of existing fossil fuel-fired district heating networks, which could be decarbonised by switching to geothermal heat. For lower temperature requirements, the potential for geothermal increases about tenfold. The technical potential of geothermal would be more than enough to meet all electricity and heat demand in Africa, China, Europe, Southeast Asia and the United States.

Geothermal holds particular promise in markets with rapidly rising electricity demand by complementing output from other low-emissions technologies such as renewables and nuclear power while also bolstering energy security

Source: The Future of Geothermal Energy, IEA Report

ILZDA Conference: Unlocking True Potential of Lead Batteries

At a recent conference on Lead batteries organized by India Lead Zinc Development Association (ILZDA), two hundred delegates from India and overseas took stock of the current situation with regard to Lead batteries and prepared a road map for India to exploit the new opportunities offered by emerging applications like Energy Storage, Electric Mobility and Environment Protection.

The Conference had 32 technical presentations (including some on advanced lead batteries, roles of nano carbon, nano oxide etc.) by Indian and overseas experts in sessions on battery technology, markets, recycling, regulations, sustainability etc. It was also decided to constitute a Technical Committee, consisting of members from Lead Battery Units as well as Lead Recycling Units to ensure energy-efficient and resource-efficient green recycling of used Lead Acid Batteries.

Informal lead recycling units should be phased out and replaced by formal recycling units at the earliest; this calls for firm commitment and active involvement by the battery manufacturers, recyclers and consumers.

The conference was supported by the various stakeholders of the Indian Lead battery industry.

Mr Mark Stevenson, Chairperson, Asian Battery Conference and International Secondary Lead & Battery Conference was recognized and honoured with "Battery Ratna" for his outstanding and significant contributions to the global lead battery industry.

79th Annual Technical Meeting of IIM – Some Glimpses

The 79th ATM of The Indian Institute of Metals took place at IIT Hyderabad during 04 - 06 Dec. 2025, with a focus on *"Critical Minerals and Advanced Materials for Energy Transition"*; the event was organized by IIT Hyderabad as well as the IIM Hyderabad Chapter in association with Warangal, Vizag, Paloncha and Nagpur Chapters. About

1800 delegates took part with a very large number of students i.e., 300. There was also a lively Students Interaction Session with 9 Past Presidents of IIM. Students also interacted with some of the Past Presidents on a one to one basis. I had the pleasure of chairing a Technical Session on Non-ferrous Extractions.

The ATM on 05 December was inaugurated by Dr Samir V Kamat, Secretary, Defence R & D and Chairman, DRDO. In his inaugural address, he appealed to the students to remain focused on Metallurgy and Materials Science, because materials will continue to form the backbone of our future growth engine. There was also a CEO Forum for the benefit of the students' community.

Exhibition, a part of the event, had 40 stalls.

A major highlight of this event was that a large number of students, including high school students, won several prizes for quiz, presentations and technical articles.

It was indeed nice of Prof. B.S Murty, President, IIM who recognized and thanked all the Chairmen and Vice Chairmen of the various Functional Committees during the Valedictory Session on 6 Dec 2025.

Organizing the ATM in educational campuses will certainly motivate many students to pursue their career in industry, research and teaching.

L. Pugazhenthy
Past President
The Indian Institute of Metals

Dr. Sandeep Sahu

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Indian Institute of Technology Mandi, India

Education

- Ph. D. (Materials Science and Engineering), IIT Kanpur
- M. Tech. (Industrial Metallurgy), IIT Roorkee
- B.E. (Mechanical Engineering), MDU Rohtak

Experience and Expertise

Dr. Sandeep Sahu is an Assistant Professor in the School of Mechanical and Materials Engineering at the Indian Institute of Technology (IIT), Mandi. Prior to joining IIT Mandi, he served as a Scientist and Assistant Professor at CSIR–Central Scientific Instruments Organisation (CSIO), Chandigarh, and as a Royal Society Newton International Fellow at the University of Southampton, UK. He has also worked as a Research Associate at DRDO-DMSRDE, Kanpur and IIT Kanpur.

Dr. Sahu has over a decade of research experience in **additive manufacturing, severe plastic deformation (SPD), and grain boundary engineering (GBE)** of advanced structural materials. His work focuses on establishing structure–processing–property relationships in additively manufactured and severely deformed alloys, with particular emphasis on superalloys, stainless steels, aluminium, copper, and magnesium alloys, multi-material systems, and corrosion-resistant materials.

His research integrates advanced processing routes such as laser powder bed fusion, friction-based and deformation-assisted processing, high-pressure torsion, and thermomechanical treatments, combined with state-of-the-art microstructural characterization techniques including EBSD, TEM, SEM, and electrochemical testing. He is actively involved in developing sustainable and high-performance materials for aerospace, energy, and structural applications.

Dr. Sahu has authored **40+ peer-reviewed journal publications** in reputed international journals and has received several prestigious recognitions, including the **Newton International Fellowship (Royal Society, UK)** and **Senior Individual Membership of the Indian National Academy of Engineering (INAE)**. He has successfully secured competitive research funding from national and international agencies and is actively engaged in teaching, laboratory development, and mentoring graduate and undergraduate students.

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