Met-Info

IIM
Metallurgy
Materials Engineering

The Indian Institute of Metals
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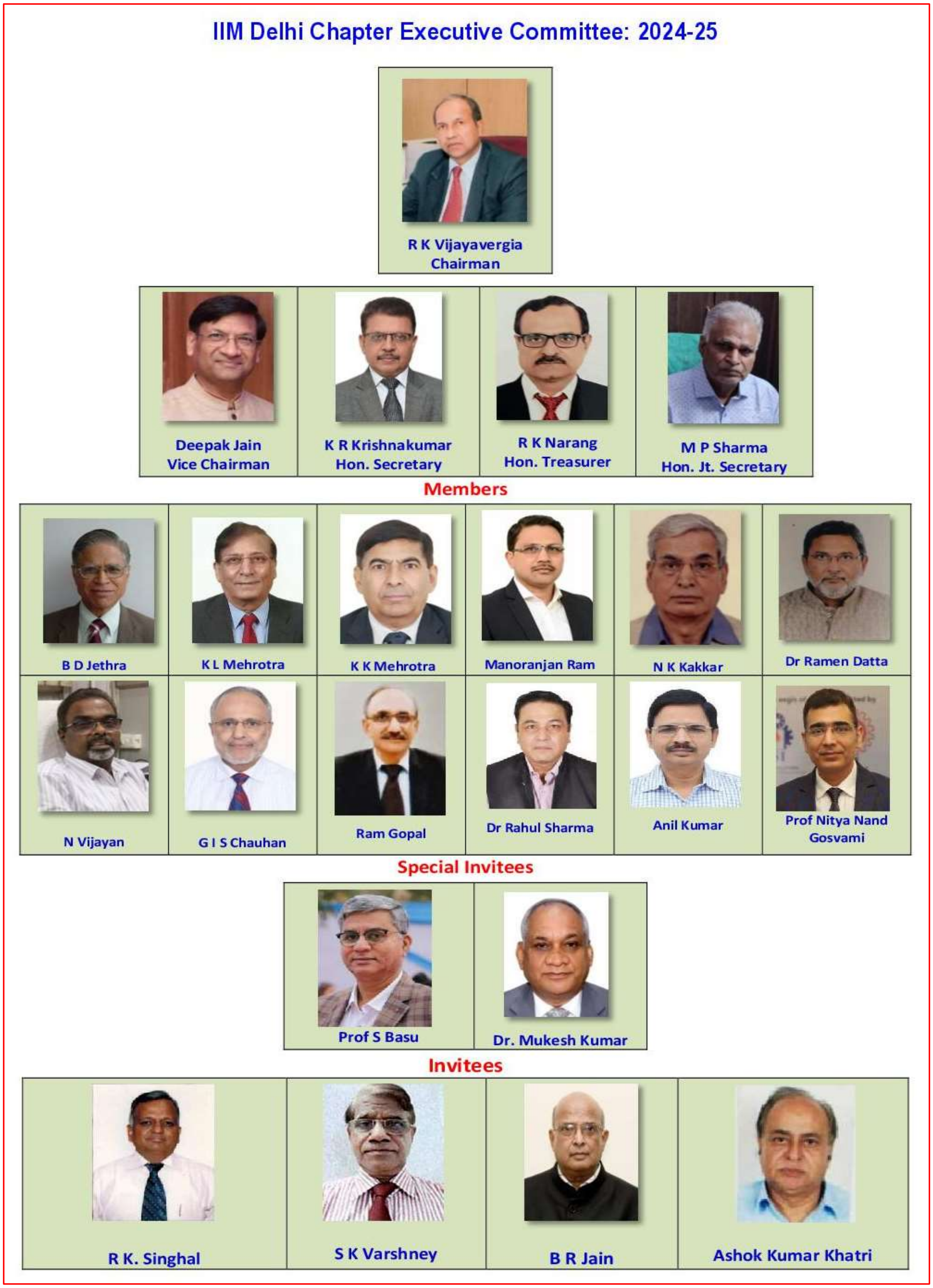
EXECUTIVE COMMITTEE: 2023-24



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Heavy Metals: Types-Properties-Uses

Heavy metals are a group of elements characterized by their high atomic weight and density. These metals possess distinctive properties such as toxicity and corrosion resistance. Their widespread use in various industrial processes, including manufacturing, mining, has led to environmental concerns due to their persistence and potential health hazards.

The term "heavy metal" has been traditionally used in environmental and scientific literature to refer to certain elements, typically transition metals, metalloids, and some non-metals, that are associated with contamination and potential toxicity. Alongside these harmful elements, heavy metals such as: iron, zinc, copper, and manganese are vital for various physiological functions in living organisms, albeit in small quantities. Although excessive exposure to these essential metals can be harmful, they serve crucial roles in cellular processes and enzyme activities.

Properties of Heavy Metals

Heavy metals, traditionally classified based on their density or molar mass, possess various properties. Some of these properties are:

1. Density

Generally, high densities — often greater than 5 g/cm^3 — are what characterize heavy metals. Mercury is an example of a poisonous heavy metal with a high density. It has a density of about 13.53 g/cm^3 at room temperature. This is far higher than the density of lighter metals, such as lithium, which is just 0.534 g/cm^3. Mercury is toxic and can cause serious health issues if not managed properly.

2. Electro-negativity

Electronegativity describes how strongly atoms attract electrons to themselves, and heavy metals exhibit a wide range of electronegativity. For instance, radium has an electronegativity of 0.9, while that of gold is 2.54. These values can influence how heavy metals form compounds and interact with other elements.

3. Toxicity

Heavy metals can be highly toxic to biological systems. Metals like: mercury, lead, cadmium, and arsenic are particularly notorious for their potential to cause heavy metal poisoning when they accumulate in the body in excessive amounts. This may result in harm to the neurological system and other important organs. The well-established toxicity of lead affects several bodily systems, most notably the nervous system. It harms adults as well as has the potential to create serious developmental problems in children. Lead is no longer widely used in paint, plumbing, or gasoline products because of the health dangers involved.

4. Solubility

The potential toxicity of heavy metals such as lead (Pb), nickel (Ni), thorium (Tl), chromium (Cr), cadmium (Cd), mercury (Hg), and thallium (Tl) poses serious threats to the environment health. Living organisms can easily absorb them due to their high solubility in watery conditions. After being taken, these metals have the potential to build up in bodily tissues and bio-magnify via food chains, endangering both human health and ecosystems. Thus, it is essential to regulate heavy metal pollution effectively to lessen its negative effects.

5. Bioaccumulation

Heavy metals exhibit a characteristic known as bioaccumulation, which is the accumulation of these substances in larger creatures as a result of their consumption of smaller ones higher up the food chain. This causes higher trophic levels to accumulate heavy metals over time. As an example, fish that are at the top of the ocean food chain and are predators, such as tuna, can collect large amounts of mercury. This event highlights the widespread threats that heavy metal contamination poses to human health and the ecosystem.

6. Oxidation States

The oxidation state of heavy metals significantly influences their toxicity and usefulness. For instance, hexavalent chromium (Cr^+6) is known for its extreme toxicity, posing serious environmental and health risks. It can cause damage to the liver, lungs, and stomach upon intake. On the other hand, trivalent chromium (Cr^+3) is much less toxic and is even an essential nutrient in small amounts. The difference in toxicity between various oxidation states is due to the way they interact with biological systems. For example, different oxidation states can affect the ability of metals to form complexes with organic molecules within living organisms, influencing their mobility, bioavailability, and the way they are processed by the body.

7. Catalytic Activity

The diverse oxidation states and complex formation capabilities of transition metals make them highly effective catalysts. By offering different paths and surfaces for reactions, they enable them to promote chemical reactions. In certain applications, arsenic compounds — while not elements — also function as catalysts by their distinct chemical characteristics.

8. Chemical Reactivity

Heavy metals exhibit varied chemical reactivity based on several factors. Transition metals, for instance, have partially filled '*d*' orbitals, allowing them to form positive ions during reactions. Their electron configurations are stable, which is crucial for their reactivity; typically, *'s'* electrons are removed before *'d'* or '*f*' electrons. The size of the nucleus also plays a role, affecting the metal's ability to attract and retain electrons, thus influencing reactivity. Generally, the more reactive a metal is, the easier it loses electrons to form cations. These properties are essential in understanding the behaviour of heavy metals in different chemical contexts.

9. Metallic Properties

Heavy metals exhibit various metallic properties, including: conductivity, malleability, and ductility. These metals typically conduct electricity and heat due to the presence of delocalized electrons in their structure. Additionally, they possess the ability to be hammered into thin sheets (malleability) and stretched into wires (ductility), making them valuable in various industrial applications. However, their toxicity and environmental impact underscore the importance of responsible handling and disposal practices.

10. High Melting and Boiling Points

Heavy metals typically have high melting and boiling points due to strong metallic bonds and stable crystal structures.

11. Environmental Persistence

Environmental persistence is the tendency of a chemical substance to remain in the soil or water for a long time without being broken down or made unavailable to living organisms. Heavy metals do not break down into other, less harmful elements over time, so their potential hazards continue to pose risks for a long period until they can be sequestered or perhaps leached away. The long-term contamination of ecosystems and resulting bioaccumulation of heavy metals is what makes this group of elements such a problem.

Is the Toxicity of Heavy Metals a Universal Property Among All Type Heavy Metals?

No, toxicity is not a universal property of all heavy metals. While many, such as mercury and lead, are toxic, others, like zinc and iron, are essential nutrients in small amounts. Toxicity varies with dose, exposure, and metal type.

Uses of Heavy Metals

Heavy metals find extensive use across various industries due to their unique properties. For instance, lead is utilized in: batteries, radiation shielding, and ammunition. Mercury is employed in: thermometers, fluorescent lights, and dental amalgams. Tungsten is valued in: electrical contacts, X-ray tubes, and high-speed tool steels. Additionally, heavy metals like platinum, palladium, and rhodium serve as catalysts in chemical reactions.

TYPE OF HEAVY METALS

1. Aluminium

Aluminium can be considered a heavy metal because it exhibits several properties characteristic of heavy metals, despite its relatively low density compared to other heavy metals. It forms cations (Al^3+) in solution and can exhibit similar chemical reactivity to heavy metals in certain contexts, qualifying it as a heavy metal despite its lightweight nature. Aluminium is a lightweight, silvery-white metal that resists corrosion and has good electrical and heat conductivity. It finds extensive use in: packaging, building, and transportation, among other areas. The strength-to-weight ratio of aluminium makes it a valuable material for use in vehicle and aircraft construction. But compared to some other metals, it is not as strong and can be costly to produce. Cans made of aluminium are one example of a final product made from aluminium.

2. Bismuth

Bismuth, with its distinctive rhombohedral crystal structure and reddish hue, is valued for its low toxicity. It's utilized in medicine and cosmetics, and as a safer alternative to lead in free-machining alloys for plumbing. Notably, bismuth is the key ingredient in Pepto-Bismol®, offering relief for digestive issues. Its unique properties also make it suitable for various industrial applications, contributing to its versatility and safety in use.

3. Zinc

Zinc is a silvery-white metal that is often used as an alloying element — for example by combining it with copper to make brass. It is also used to coat (galvanize) steel to stop it from rusting. It is a trace dietary element that is vital to human health. Zinc can corrode in some situations, and is not as durable as other metals. Zinc is a metal with tensile strength that is less than half of mild carbon steel, making it unsuitable for load-bearing applications. Coins and batteries often contain zinc.

4. Lead

Lead is a greyish or silvery-white soft, dense metal with a low melting point. It is used in batteries, radiation shielding, and as an additive in paints. Despite its usefulness, lead is toxic, and its use is being reduced for health reasons.

5. Mercury

Mercury is used in thermometers, barometers, and other scientific equipment. At room temperature, mercury is a liquid. Other applications of mercury include fluorescent lighting and dental amalgam. Mercury's use is strictly regulated due to its extreme toxicity. It is used in the process of producing caustic soda and chlorine gas.

6. Copper

Copper is known for its excellent electrical and thermal conductivity. It is widely used in electrical wiring, plumbing, and the production of electronics. Copper is also antimicrobial and doesn’t corrode easily, making it ideal for use in marine environments. However, it is relatively expensive and can be replaced by cheaper alternatives in some applications.

7. Arsenic

Arsenic, a metalloid, has some properties of heavy metals. It finds application in pesticides, semiconductors, and wood preservatives. Steels are alloyed with it as well. Arsenic is extremely poisonous, and is dangerous for the environment and human health.

8. Chromium

Chromium is a shiny metal used for its high corrosion resistance and hardness. It is used as an alloying element in stainless steel, chrome-plated metals, and in dyes and pigments. Chromium is toxic in its hexavalent form and is a subject of environmental regulations. It's introduced into alloys either as pure chromium or recycled from steel scraps.

9. Nickel

Nickel is a strong, ductile metal used to make some grades of stainless steel, coins, and rechargeable batteries. It's valued for its resistance to corrosion and ability to withstand high temperatures. Some people may experience allergic reactions to nickel.

10. Cadmium

Cadmium is a soft, malleable, ductile, silvery-white metal that is resistant to corrosion and is used as protective plating on other metals. It is also used in nickel-cadmium batteries. In addition, it can be added to paints and coatings as a pigment due to its vibrant colours. Cadmium exposure can cause detrimental effects on the body, such as cancer and harm to the neurological, reproductive, gastrointestinal, cardiovascular, and respiratory systems. As a result, its use is strictly restricted on goods meant for children, who might consume it by teething on toys or other objects. U.S. Consumer Product Safety Commission forbids selling of toys that have concentrations of heavy metals, such as cadmium, exceeding certain levels.

11. Thallium

Thallium, with its silvery-white appearance, is prone to tarnishing yet finds diverse applications despite its toxicity. While historically utilized as a pesticide and rodenticide, its high density renders it invaluable in: optical lenses, infrared detectors, electronic devices, and pharmaceuticals. However, its toxic nature necessitates stringent management to mitigate environmental and health hazards. Proper handling and disposal protocols are crucial to prevent contamination and ensure safe utilization of thallium-based products.

How To Choose Which Type of Heavy Metal To Use?

Choosing the right type of heavy metal for a specific application involves considering several factors. Here is a list of considerations to guide you through the selection process:

1. Assess the environmental conditions the metal will be exposed to, such as temperature extremes, corrosive substances, or other elements.
2. Decide whether the metal needs to be strong, flexible, or have other specific mechanical properties.
3. Evaluate how much you are willing to spend, as some metals may be more expensive than others.
4. Estimate the amount of metal required.
5. Look at the melting point, ease of machining, safety factors, space constraints, coefficient of thermal expansion, thermal and electrical conductivity, and density.
6. Verify compatibility with other materials it will interact with.
7. Ensure compliance with required regulatory standards.
8. Check the availability of the metal. Some metals might be readily available, while others could have a limited supply.
9. Consider the metal's recyclability and its overall environmental impact.

Heavy Metals Used in Metal 3D Printing

Heavy metals commonly used for 3D printing include: copper, cadmium, and chromium. These materials are chosen for their strength and resistance to corrosion.

Heavy Metals Used in Embossing

Heavy metals such as: platinum, copper, and gold are appropriate for embossing. These metals are perfect for crafting intricate, raised motifs because of their malleability.

Heavy Metals Used in Laser Engraving

In laser engraving, certain heavy metals are preferred due to their ability to absorb the laser light efficiently. For instance, lead is known to be easy to mark at high speed because it absorbs fibre laser light very efficiently.

Advantage of Using Heavy Metals

Heavy metals like cadmium, lead, mercury, arsenic, and chromium are often viewed negatively due to their toxicity, but they do have some advantages when used responsibly. For instance, cadmium can be used in batteries, pigments, and coatings due to its resistance to corrosion. Lead has applications in batteries, radiation shielding, and sometimes in construction. Mercury's unique properties make it useful in thermometers and dental amalgam. Arsenic is used in semiconductors and wood preservatives. Chromium is valued for its hardness and corrosion resistance, often used in stainless steel and metal plating.

Disadvantage of Using Heavy Metals

Even though high density or atomic weight are common characteristics of heavy metals, not all of them are intrinsically hazardous. Still, some metals are known to pose a risk to human health and the environment, such as arsenic and mercury. Serious health problems can arise from exposure to heavy metals, such as lead, mercury, and cadmium. These could include organ failure, neurological deficits, and environmental deterioration that would jeopardize ecosystems and public health as a whole. It's critical to understand these dangers and exercise extreme caution when using and being exposed to heavy metals.

Do All Heavy Metals Pose a Significant Threat to Human Health?

No, not all heavy metals pose a significant threat to human health. Certain heavy metals, such as arsenic, hexavalent chromium, lead, mercury, and cadmium are well-known for their toxicity and health hazards, but other heavy metals, like iron, zinc, and copper, are necessary micronutrients that are safe in the right amounts for a variety of physiological processes.

Are Heavy Metals Naturally Occurring in the Environment?

Heavy metals are elements that occur naturally within the Earth's crust, presenting in diverse forms and concentrations, typically within minerals or bonded with other elements. They can also be artificially produced in laboratories.

Natural phenomena like erosion, volcanic activity, and the weathering of minerals release these metals into the environment, making them bioavailable. Yet, human actions such as mining, industrial processes, and the utilization of metal-based products have markedly amplified their presence, resulting in heightened environmental pollution and greater exposure to these elements among humans.

What Distinguishes Heavy Metals From Other Types of Metals?

Heavy metals are distinguished from other types of metals primarily by their high atomic mass and densities. Additionally, they often exhibit unique properties such as toxicity and corrosion resistance, setting them apart from lighter metals like magnesium.

What Is the Difference Between a Transition Metal and a Heavy Metal?

The difference between transition metals and heavy metals lies in their position on the periodic table, their properties, and their uses. Transition metals are found in the d-block of the periodic table and include elements from groups 3 to 12. They are characterized by their ability to form compounds with variable oxidation states and their use as catalysts. Transition metals are generally hard and have high melting points, also known for forming coloured compounds. The term heavy metal generally refers to metals with a high atomic weight or density. Heavy metals can include both transition metals (like mercury and lead) and non-transition metals (like arsenic). The term often carries negative connotations due to the environmental and health risks associated with some heavy metals.

Source: Xometry

Coke Oven Gas Injection Technology in Blast Furnaces

Tata Steel plant at Meramandali, Odisha has placed an order with SMS group for the implementation of Paul Wurth Coke Oven Gas (COG) Injection Technology at their Blast Furnace (BF) #1. Coke oven gas is a byproduct that forms during the production of coke from coal in coke ovens. This order marks a significant milestone, setting a precedent for the industry’s move towards sustainable steel production.

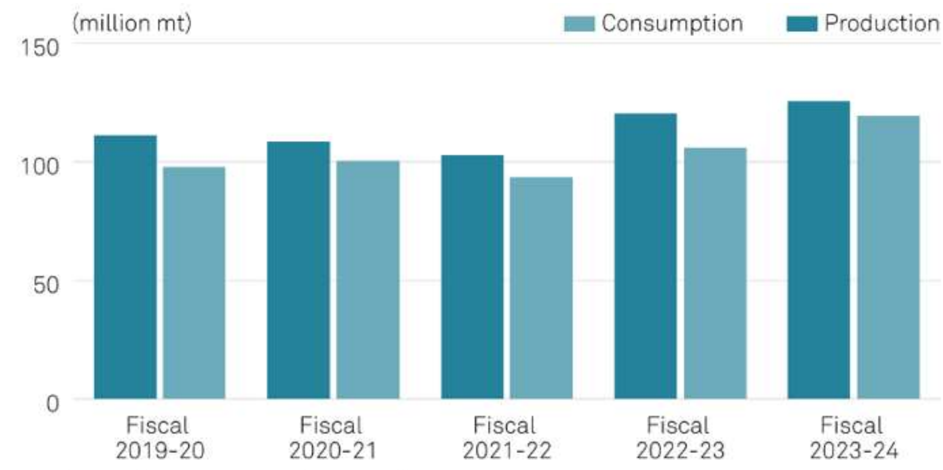
Paul Wurth COG Injection Technology is a breakthrough innovation that aims to reduce the coke rate and consequently the carbon footprint of the blast furnace operation. By utilizing the chemical potential of COG, the process can save around 0.65 kilogram of coke for each kilogram of COG injected, which considerably reduces the OPEX cost and significantly improves the CO_2 footprint. Paul Wurth's COG injection technology is designed to ensure the safe and reliable injection of the highly toxic and explosive COG into the blast furnace through the tuyeres using specialized lances.

The comprehensive scope of supply for this project includes plant engineering, supply of all process equipment including compressor station, electrics and automation ensuring an integrated approach to the implementation of this technology.

To optimize the supply of gas to the blast furnace, selection of adequate compressor technology as well as the control of the temperature range are crucial success factors to guarantee smooth operation of the plant. The advanced Paul Wurth automation system assures this smooth operation and at the same time, guarantees plant safety implementing for each injection line fully automatic flushing, flow monitoring and lance cooling.

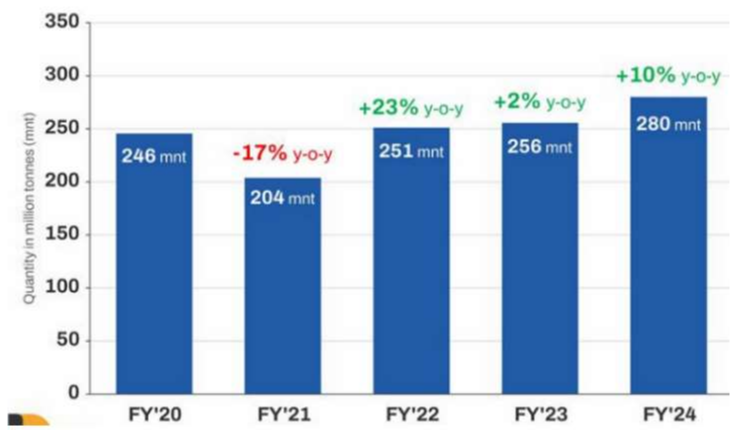
The project is expected to be commissioned by Q1 2026 and will be completed within 25 months.

India’s Steel Production and Consumption

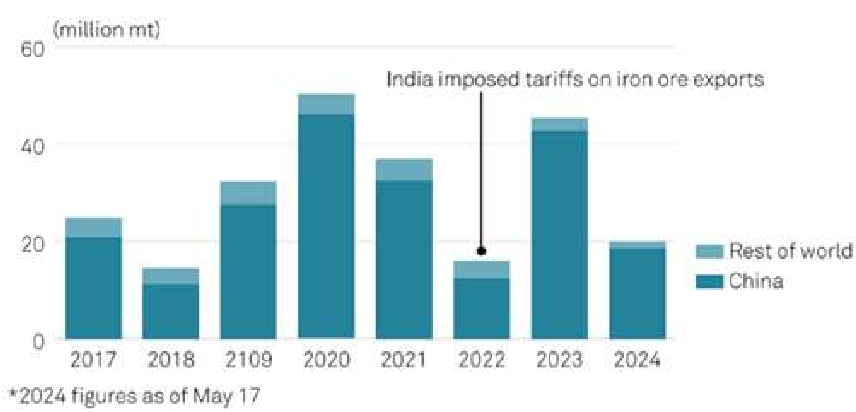


Source: Energy Transition, Metals, 27 May 2024

India’s Iron Ore Production (FY20-FY24)

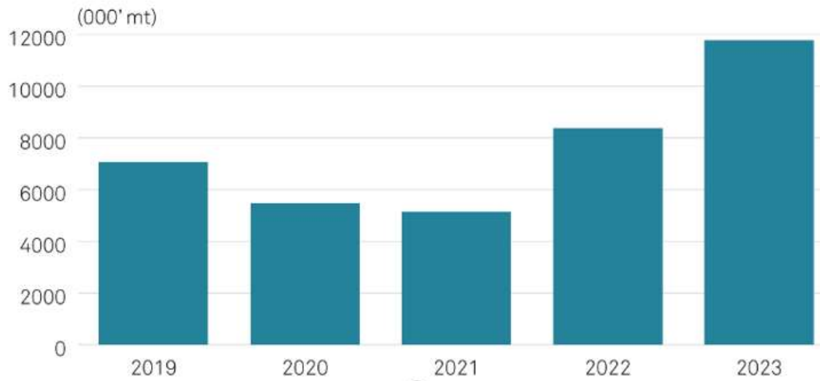


India’s Iron Ore Export



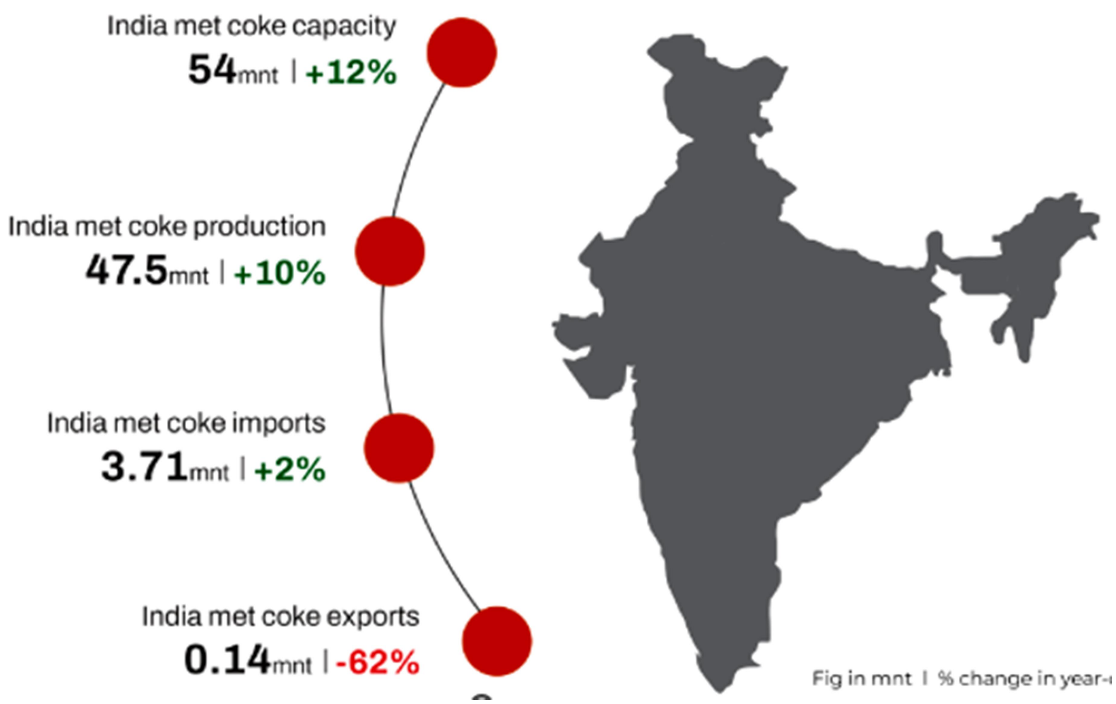
Source: Energy Transition, Metals, 27 May 2024

India's Ferrous Scrap Imports



Source: Energy Transition, Metals, 27 May 2024

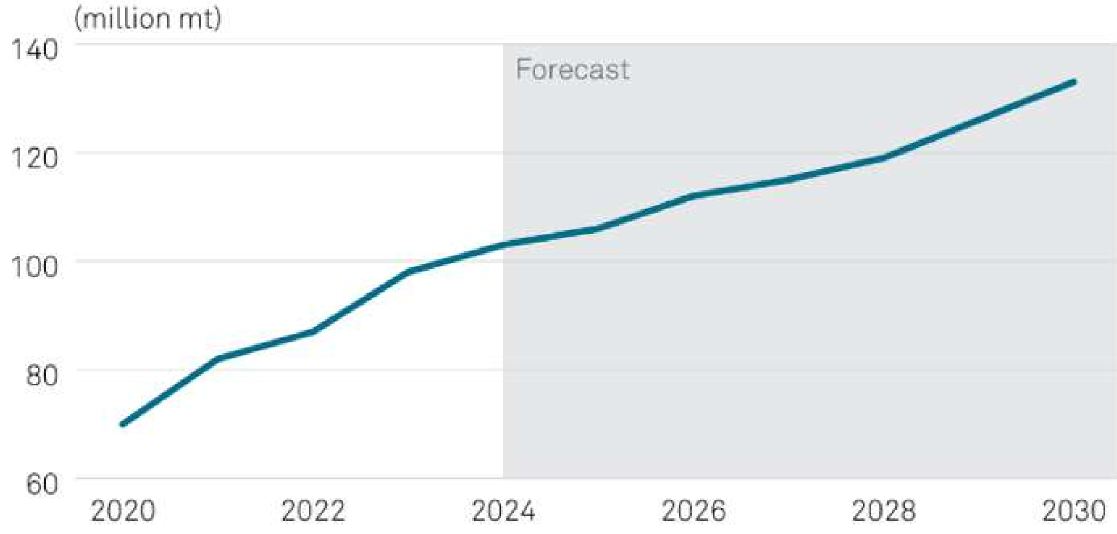
India's Met Coke Industry Performance in FY24



Figures in million tonnes; % Change -in year on year (y-o-y)

Source: BigMint Alert: Met Coke-30 May 2024

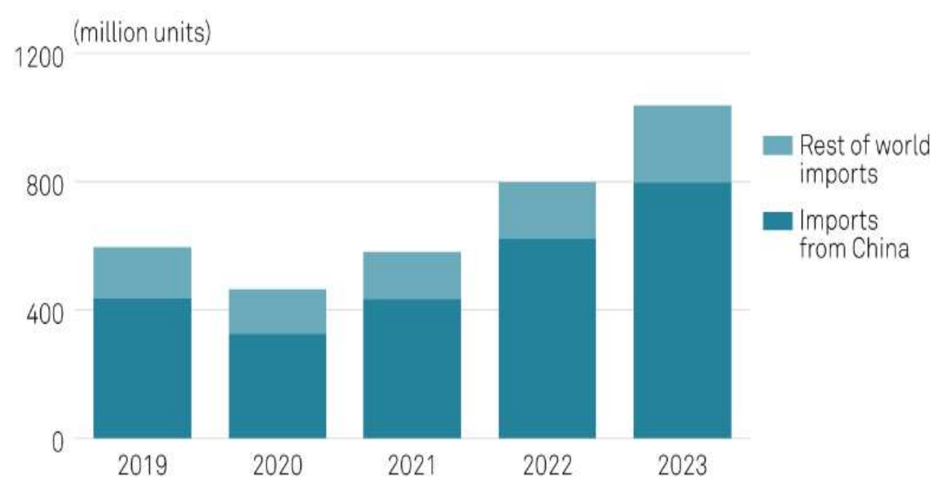
India's Met Coal Demand by 2023



Source: Energy Transition, Metals, 27 May 2024

Lithium Supply

India has been making a strategic push towards securing vital resources for its burgeoning clean energy ambitions. This includes mineral lithium, which has been included under the critical minerals list of at least eight major global economies, including India.



Imports represent lithium ion

Lithium is used to build electric vehicles and energy storage systems, making it a key mineral in energy transition efforts.

India in 2023 discovered about 5.9 million mt of lithium ore in the Jammu and Kashmir union territory. But as most of those deposits are clay deposits, their processing is seen as more challenging than the deposits found in brine or hard rock deposits. As commercial solutions to extract lithium from clay deposits emerge in a few years, India will begin real mining. Until then, India has to explore partnerships for securing lithium supplies.

India in January signed a lithium mining agreement with Argentina, the world's leading holder of lithium-based resources, in a move that will play a crucial role in driving energy transition efforts and ensure a resilient and diversified supply chain for critical and strategic minerals essential for various domestic industries.

India is expected to continue developing its critical mineral supply chain and fueling its economy through capital spending, a trend that will further bolster India's influence in global metals and minerals sectors over the coming years

Circular Pelletizing Technology

Indian iron ore mining company Essel Mining and Industries Limited (EMIL) recently granted the final acceptance certificate (FAC) to Primetals Technologies for its Circular Pelletizing Technology (CPT) plant located at its facilities in Basantpur, Odisha state, India. CPT is the world's most compact pelletizing plant for the production of high-quality pellets, featuring an indurating furnace with unique circular design.

The CPT plant – the first of its kind – was successfully put into operation in October 2020, in midst of the pandemic. Since then, there has been an ongoing ramp-up of the production capacity.

With a design capacity of 1 million tons per year, the CPT plant processes local iron ores to produce pellets for both the export and domestic market.

A CPT plant ensures that space requirements for the induration furnace are reduced by 50 percent compared to conventional pelletizing plants. As a result, the weight of the equipment and the building structure are significantly lower. The pelletizing process required less energy, as the CPT process is designed to optimize the thermal efficiency of the recycled hot process gas. This leads to lower operational expenses (OPEX).

Source: Primetals Press Release

BioIron – A Possible Solution to Decarbonise Steelmaking

Making steel – the process of converting iron ore into iron and iron into steel – uses a lot of energy. Because of this steelmaking is responsible for around 8% of all global CO_2 emissions and 69% of Rio Tinto's Scope 3 emissions in 2023. Most of these emissions are created during the process of transforming iron ore – the raw material – into metal. Decarbonising the way iron (and therefore steel) is made could make a significant contribution to reducing global CO_2 emissions**.** A new process, BioIron™, could offer a solution to reducing carbon emissions in iron and steelmaking.It avoids the direct use of fossil fuel.

In this new process, iron ore fines are mixed with raw biomass material (like agricultural waste) and heated using a combination of gas released by the biomass and high-efficiency microwaves powered by renewable energy, turning the iron ore into metallic iron. One main attraction of the BioIron™ process is that, as studies have demonstrated, it uses less than a third of the electricity needed by other new technologies currently being trialed such as those using hydrogen.

Rio Tinto worked with experts from the University of Nottingham, England and Metso Corporation (formerly known as Metso Outotec), a specialist in sustainable technologies, to prove BioIron™ works on a small batch scale, and now at new facility it is planned to produce one tonne of iron per hour.

BioIron™ uses raw biomass and microwave energy instead of coal to convert Pilbara iron ore to iron and has the potential to support low carbon dioxide (CO_2) steelmaking. Modelling shows that when combined with renewable energy and carbon-circulation by fast-growing biomass, BioIron™ has the potential to reduce CO_2 emissions by up to 95% compared with the current blast furnace method.

The process worked well at a small-scale pilot plant, and now it is planned to test it on a larger scale at new BioIron™ Research & Development Facility.

The plant has been designed in collaboration with University of Nottingham, Metso Corporation and Western Australian engineering company Sedgman Onyx. Fabrication of the equipment will begin this year, with commissioning expected in 2026.

The research and development facility will employ around 30 full-time employees and include space for equipment testing to support further scaling up of the

BioIron technology, while developing a workforce highly skilled in steel decarbonisation and supporting WA universities and research organisations.

BioIron™ still releases CO_2, however by using fast-growing plants, these emissions are offset by the CO_2 absorbed during photosynthesis when the plants regrow. If you just used plants and didn't regrow them, or if the plants grew slowly – like trees in old growth forests – the CO_2 would stay in the atmosphere. So, using a fast-growing biomass source is important.

The biomass used in this process doesn't include food sources. The process doesn't, and can't, use food such as sugar and corn. The parts one can't eat – the straw, stalks and leaves – contain material called lignocellulose which has the type of carbon the process needs.

If it's done right, it could be a truly sustainable solution. One should not want to solve one problem and cause another. Environmental groups can specify that what kind of biomass need to be considered and how it's to be produced and transported. This is also a part of the research and a benchmarking study of biomass certification processes is needed. Rio Tinto is aware of the complexities around the use of biomass supply and is working to ensure only sustainable sources of biomass are used. Through discussions with environmental groups, as the first step it has ruled out sources that support the logging of old growth and High Conservation Value forests.

To produce iron and steel with a smaller carbon footprint, many technological breakthroughs are needed. But there's no single and obvious pathway to producing steel with low or no emissions. BioIron™ is one of the promising solutions and it works well with the Pilbara iron ores, the world's largest iron ore region.

Theoretically there are other ways one can produce iron from iron ore without using coal. One is to use hydrogen to react with the oxygen. Another way is using electricity like in aluminium production. But variety of solutions are needed to support sustainable steelmaking, and biomass could be a good option. BioIron offers process with fewer emissions, which can contribute to an industry-wide challenge and help steelmakers to reduce their emissions, too.

BioIron was invented by Rio Tinto's steel decarbonisation team after a decade of extensive research. Electricity consumption in the BioIron process is about one-third of the electricity required by other steelmaking processes that rely on renewable hydrogen.

BioIron uses raw biomass such as agricultural by-products like wheat straw, barley straw, sugarcane bagasse, rice stalks, and canola straw, instead of coal as the reducing agent.

Rio Tinto is aware of the complexities around the use of biomass supply and is working to ensure only sustainable sources of biomass are used. Through discussions with environmental groups, as a first step Rio Tinto has ruled outsources that support the logging of old growth and High Conservation Value forests.

Rio Tinto will invest $143 million in iron ore R&D facility in Western Australia to assess the effectiveness of BioIron, to support decarbonising the global steel value chain.

The BioIron facility will include a pilot plant that will be test the innovative steelmaking process at a semi-industrial scale, capable of producing one tonne of direct reduced iron per hour. It will provide the required data to assess further scaling of the technology to a larger demonstration plant. Pilot plant to be capable of producing 1 mt/hour of DRI is expected to be commissioned in 2026.

Source: Rio Tinto, Press Release 4 June 2024

Trials on Carbon Capture Unit

ArcelorMittal and partners Mitsubishi Heavy Industries Ltd. (MHI), BHP and Mitsubishi Development Pty. Ltd. claim a successful start with a trial pilot carbon capture unit on the blast furnace off-gas at ArcelorMittal Gent in Belgium. It is claimed that the carbon capture unit is successfully capturing blast furnace emissions at the steelmaker's mill in Gent, Belgium.

The pilot carbon capture unit will operate for one to two years at Gent to test the feasibility of progressing to full-scale deployment of the technology. The company says it should capture a sizeable portion of the Gent site's emissions, if successful. Engineers have been working on-site since January to assemble and commission the unit. The trial at Gent consists of two phases, where the first phase separates and captures the CO_2 from the top gas from the blast furnace at a rate of around

300 kilograms of CO_2 per day. This brings a technical challenge given the differing levels of contaminants in the top gas. The second phase tests separation and capture of CO_2 in the off-gases in the hot strip mill reheating furnace, which burns a mixture of industrial gases, including coke oven gas, blast furnace gases and natural gas.

In October 2022, the four companies announced a joint collaboration on a multiyear trial of MHI's carbon capture technology at multiple carbon dioxide-emission points, starting at the Gent steelmaking site. The pilot carbon capture unit is being tested with blast furnace and reheating furnace gas. Collaborators believe it has the potential to capture steelmaking gases such as reformer flue gas from a direct reduced iron plant.

ArcelorMittal and partners say the development of the carbon capture solution at Gent could feed into multiple CO_2 transport and storage projects under development in the North Sea region. They hope it contributes to global technological solutions required to decarbonize steel production.

Proposed under the Net-Zero Industry Act, the European Union's objective is to achieve an annual CO_2 storage capacity of 50 million metric tons by 2030. Moreover, the International Energy Agency (IEA) estimates carbon capture, utilization and storage, or CCUS, technology must apply to more than 37 percent of primary steel production by 2050. ArcelorMittal is facilitating the trial in Gent, with MHI supplying its proprietary carbon capture technology and supporting the engineering studies. BHP and Mitsubishi Development, as key suppliers of high-quality steelmaking raw materials to ArcelorMittal's European operations, are supporting trial funding.

ArcelorMittal Belgium's decarbonization efforts can be summarized in three axes. The first axis focuses on energy efficiency: reuse of waste heat and renewable energy. In our second axis, replacing coal with a combination of gas and electrification. And finally, the third axis is based on circular use of carbon — CCU and CCS. Here, the installation of the carbon capture unit on our Gent blast furnace is a great example. The main ambition is to achieve completely carbon-free processes. A radical change is difficult, so every step is embraced that takes towards our goal.

Source: Recycling Today, May 27, 2024

Global DRI Production Increased by 7% in 2023

Global direct reduced iron (DRI) production in 2023 increased by 7.4% compared to 2022 – to 135.51 million tonnes from 126.16 million tonnes a year earlier. (data from the WorldSteel Association). India accounted for over 36% of the total DRI production. During the year, Indian companies produced 49.33 million tons of the product, which is 16.7% more than in 2022. Iran, the second largest DRI producer, increased its output by 1.7% y/y – to 33.45 million tons. The share of Iranian DRI in global production was 24.7%. Together, these countries account for about 61.1% of global DRI production.

The Russian Federation, Egypt and Saudi Arabia had a share of 5.7%, 5.3% and 5%, respectively, in global DRI production. Over the past year, Russia produced 7.78 million tons (+0.9% y/y) of direct reduced iron, Egypt – 7.22 million tons (+19.9%), and Saudi Arabia – 6.81 million tons (+1.5%).

In 2023, the United States reduced DRI production by 0.8% y/y – to 5.24 million tons, Mexico – by 11.6% y/y, to 5.16 million tons, Algeria – increased by 3.1% y/y, to 4 million tons, the UAE – also increased by 4.2% y/y, to 3.59 million tons.

In 2022, global direct reduced iron production increased by 6.9% – to 127.36 million tons. In 2021, these volumes amounted to 119.2 million tons. Midrex plants are the world's largest supplier of DRI, accounting for almost 80% of global annual production in 2022.

Global DRI production is expected to grow by 56.2% by 2030 compared to the base year of 2019 and by 40% compared to 2022, to 175 million tons. The largest growth in DRI production is expected in the European Union and MENA countries.

Hydrogen's Role in Producing Lower – Carbon Materials

There is a lot of hype about green hydrogen. It's certainly one solution that can help decarbonise some hard-to-abate industry sectors. Steelmakers expect to use it as a reductant for zero-carbon steel making and iron and titanium production, and for calcining in alumina refineries. In all these cases, hydrogen's unique chemical properties are used for processing minerals and metals, rather than using hydrogen as an energy carrier. There are still some challenges we need to overcome before green hydrogen can play a major role in decarbonising our operations.

Supply chains needed to support hydrogen

Hydrogen is a very energy-intensive material to produce – approximately four times more per tonne than aluminium. It will take some time to establish the electrolyser supply chain that's needed to deliver green hydrogen at the scale needed for industry.

Affordability

For hydrogen to be widely adopted, it also needs to be a cost-efficient solution. One of the ways we can make it more affordable for wider industrial use is by developing technologies that can be built into existing infrastructure, avoiding the need to build new equipment or making large-scale (expensive) modifications. Electric Hydrogen is a start-up that has reduced capital intensity by a factor of three relative to competitor options through combining better process design and system engineering with a scientific breakthrough.

Storage and transport

Hydrogen is prone to leakage from storage and transport facilities – an estimated 1% per day can be lost when stored in liquid form. It has a global warming potential of 5–16 times that of carbon dioxide over 100 years, making it potentially more damaging to use than burning natural gas. Given this, it is advisable to consume hydrogen close to its point of generation to avoid supply chain leakage and energy transformation losses.

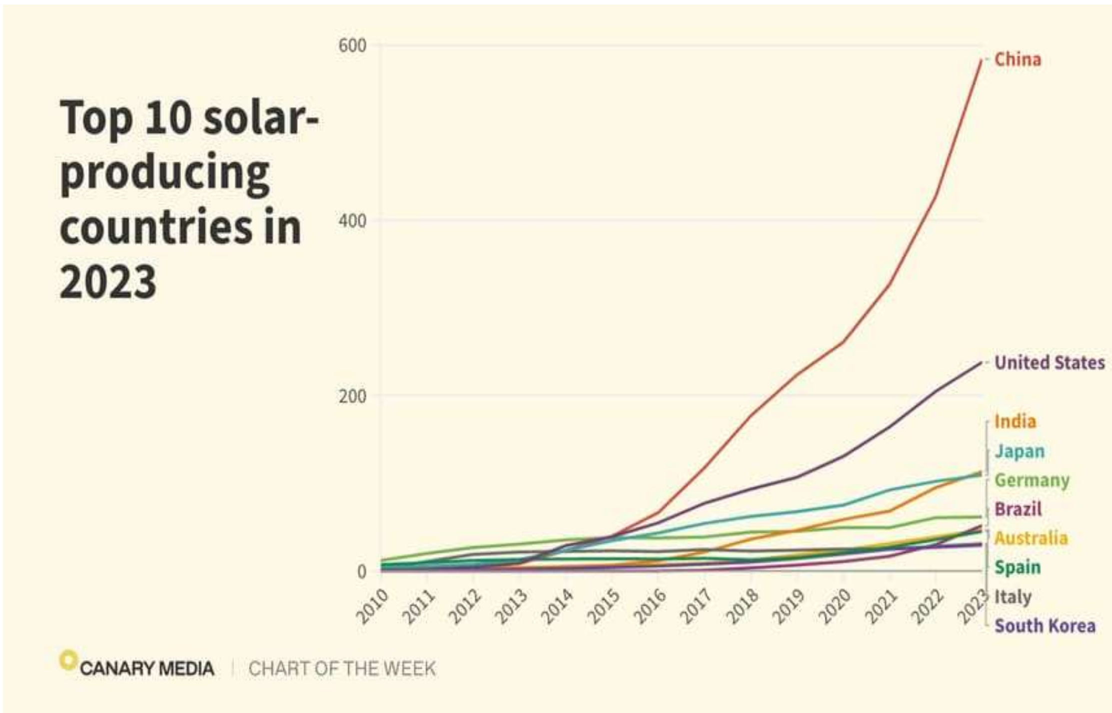
Making the most of renewable resources

Where possible we should seek to electrify our processes as much as possible, for example by using electric boilers to raise steam for mineral refining, rather than using hydrogen as a fuel. That's because we lose energy each time we transform an energy from one source to another, so using renewable energy to generate green hydrogen is less efficient than using that renewable energy to directly electrify an operation. This is what makes direct electrification so capital efficient – it's a far more efficient use of valuable renewable electricity resource. Hydrogen should be used for its chemical properties where electrification cannot play a role.

Source: RioTinto website

Ten Countries which Generated the Most Solar Power in 2023

China was the top solar power producer last year, but it's not the only nation that saw a big leap in solar production.



Solar energy continued to surge and break records across the globe in 2023, generating an estimated 5.5% of global electricity, a total of 1,631 terawatt-hours. According to the latest "Global Electricity Review" from energy research firm Ember, solar has been the fastest-growing source of electricity for 19 consecutive years. In 2023, solar added more than twice as much electricity as coal did worldwide.

China continues to dominate the solar race, single-handedly producing more than 580 TWh of solar electricity in 2023 — more than the next five countries combined. The United States held onto second place with 238 TWh, while India overtook Japan to claim the third spot, generating 113 TWh from the sun last year.

India's solar generation has soared over the past five years, growing more than three-fold since 2018. However, coal continues to meet most of India's demand growth, and makes up 75% of total electric generation. As a result, the country's power-sector emissions continue to rise and have more than tripled since 2000.

Japan is not far behind in fourth place for solar generation, and it gets a higher percentage of its power from the sun than the other leading solar countries. Solar made up 11% of Japan's electricity mix in 2023 — about double the global average. It's now one of 33 countries that get more than 10% of their power from solar, including Chile (20%), Australia (17%), and Spain (17%).

While Germany, in fifth place, has been steadily growing solar generation for the past decade, Brazil — now the world's sixth-largest solar producer — has built up its solar production at breakneck speed. In 2017, the country generated only about 0.8 TWh; last year, that figure was almost 52 TWh. Brazil recorded the third-largest increase in total amount of solar power generated globally in 2023, behind only China and the U.S., making it the largest solar-producing country by far in South America and a formidable solar powerhouse.

Ember expects 2024 to be another record-breaking year for solar worldwide, projecting solar generation to be between 2,150 and 2,350 TWh. That would mark an annual growth rate of at least 32%, higher than the 26% annual growth that will be needed to reach net-zero global emissions by 2050.

Source: Canary Media, 31 May 2024

Europe's Shift from Blast Furnaces to Electric Arc Furnaces

The European steel sector is undergoing a significant transformation in the face of evolving environmental regulations and a need for sustainability. This shift from traditional blast furnace (BF) based operations to electric arc furnace (EAF) method marks a pivotal change in the region's steel production and aligns with the EU's ambitious climate goals.

The driving force

The European Green Deal has a goal for the EU to become carbon neutral by 2050, pushing steelmakers toward more sustainable practices by encouraging the use of scrap. The region eyes an 80 to 95 percent reduction in CO_2 emissions by 2050 compared with 1990 levels. These measures also aim to lower emissions from current levels to between 62 million to 15 million tons in the time frame under consideration.

Alongside the Green Deal, carbon taxes and environmental regulations make emitting carbon more expensive, incentivizing companies to switch to cleaner steelmaking methods. BF technology, which uses coke and coal to smelt iron ore, is energy-intensive and produces significant carbon emissions. EAFs, however, use scrap and electricity, reducing energy consumption and emissions.

The introduction of carbon taxes across Europe adds a financial dimension to the environmental imperative, making the transition to EAF technology not just an environmental decision but an economic one. These taxes are poised to have a profound impact on the steel industry, altering cost structures and influencing production decisions.

EAFs in the making

Steel companies across the EU have embraced these directives, and some are at the forefront of adopting EAF technology and other clean methods to produce low-carbon steel.

ArcelorMittal, based in Luxembourg, and Thyssenkrupp, based in Germany, are among the pioneers in this shift, demonstrating the viability and benefits of EAF use. Their success has set a benchmark, encouraging others to plan for a similar transition, and this widespread movement toward EAF technology highlights the steel industry's collective effort to achieve sustainable production.

By 2030, India-based Tata Steel plans to operate one direct-reduced iron (DRI) unit and one EAF, with a goal to phase out all BF and coke plants by 2037, aiming for carbon neutrality. Tata Steel's strategy includes maintaining its annual 5 million ton production capacity while transitioning to green steel, with an initial goal to shift 40 percent of its production to green steel by 2030 and achieve 100 percent by the end of Phase 2, at Tata Steel Netherlands.

The company also aims to boost its use of scrap from 15 percent to 30 percent post transition, enhancing its circularity and integration within the local economy by sourcing from regional suppliers.

Tata Steel UK also has plans to decommission its BFs and transition to an EAF that is expected to start production in 2027. It also plans to replace its two BFs at Port

Talbot with an EAF, which will have annual crude capacity of 3 million metric tons. This change is expected to cut the facility's listed crude capacity by 40 percent. The blast furnaces at Port Talbot currently produce about 4.8 million metric tons of pig iron and have two basic oxygen furnaces (BOFs) with an annual capacity of 5 million metric tons of crude steel. This move is part of a broader strategy to cut CO_2 emissions and achieve net-zero steel production by 2045. The new EAF will notably reduce carbon emissions by using local scrap.

Salzgitter's SALCOS project in Germany focuses on replacing BFs with DRI plants, marking a major investment toward green steel production. The first stage of the project includes a DRI plant with 2 million metric tons of annual capacity, an EAF with 1.9 million metric tons of crude steel capacity per year and an electrolysis unit to produce up to 200 normal meters cubed per hour of hydrogen with a nominal output of 720 kilowatts alternating current.

Similarly, the HYBRIT project, a collaboration between Swedish companies SSAB, LKAB and Vattenfall, is pioneering hydrogen-based steel production, with test production underway. The HYBRIT demonstration project plans to realize the breakthrough of fossil-free steel production by developing a complete, new value chain based on fossil-free hydrogen, resulting in annual production of 1.2 million metric tons of crude steel.

H2 Green Steel, also of Sweden, aims to establish a DRI unit powered by green hydrogen, setting a benchmark for the future.

London-based Liberty Steel's plans to install EAFs at its Czech and Romanian plants further signify the shift toward carbon-neutral operations. Liberty Steel's plants in the Czech Republic have an annual liquid steel production capacity of 3.6 million metric tons, and its Ostrava mill will install two hybrid EAFs with a combined annual production capacity of 3.5 million metric tons. The Romanian plant can produce 4 million metric tons per year, and Liberty plans to install two EAFs with a combined production capacity of 3 million metric tons of unrefined steel per year.

ArcelorMittal is investing heavily in hydrogen-based steelmaking in Germany, including a new DRI and EAF plant at its Bremen site, showcasing the company's commitment to green steel. It plans to use green hydrogen made using renewable energy to produce up to 3.5 million metric tons of steel annually at the Bremen and Eisenhuttenstadt sites by 2030, with significantly lower CO_2 emissions.

Austria-based Voestalpine's plan to transition to EAF technology by 2027 highlights the broader industry trend toward sustainable steel production. The new EAF at its Donawitz, Austria, plant will produce 850,000 metric tons of green steel annually. This is part of the company's Voestalpine Greentec Steel plan, which aims to reduce emissions by approximately 30 percent by transitioning to this technology. Voestalpine also is applying a mix of EAF, BF/BOF and DRI technologies at its Linz, Austria, site. This facility will have 1.6 million metric tons of green steel capacity per year, with the new EAF commissioning in 2027.

Others are following suit. For example, the Celsa Group in Barcelona, Spain, focuses on projects like Steellowcarbon and Circular Steel to reduce resource use and promote a circular economy within steelmaking. Acerinox Europa in Andalucía, Spain, also is transitioning to green hydrogen, replacing natural gas in its stainless-steel production.

Italy-based Tenova S.p.A. is set to supply a DRI tower and EAF for Italian multinational consulting engineering research, development, inspection and certification company RINA's Italian steel project. The project aims for hydrogen-powered steel production by 2025, targeting up to 7 tons of steel per hour, or 61,320 metric tons per year.

This collective move toward EAF technology and green steel production underlines the steel industry's dedication to environmental sustainability and its proactive response to global climate change challenges.

Challenges of this transition, including economic pressures, raw material shortages and geopolitical tensions affecting gas availability. Moving away from the conventional BF/BOF route, which contributes a large portion of the industry's CO_2 emissions, has major emissions reduction potential.

Transitioning to a gas-based direct reduction and EAF route, coupled with the use of hydrogen, offers a promising path for substantial emissions reduction.

Near-term challenges

However, the transition to EAF-based steelmaking, given the tight timeline, is cost-intensive and includes substantial technical adjustments. Moreover, EAFs require more electricity with estimates pointing to a need for around 400 trillion watt hours of CO_2-free energy yearly for this region. Energy needs and fluctuating costs of raw materials like ferrous scrap could raise operating costs for steelmakers by 10 to 35 percent.

According to 2021 research by New York-based McKinsey & Co., Europe's steel sector faces three challenges in its journey toward decarbonization:

- structural overcapacity as COVID-19 impacts and industry shifts could lead to a long-term capacity utilization of only 70 percent to 75 percent.
- rising CO_2 costs, potentially reaching 50 to 100 euros per metric ton by 2030, meaning steelmakers must invest in new technologies; and
- investments in decarbonization that could require as much as 100 billion euros by 2050.

Still, transitioning to EAFs offers opportunities to meet Europe's growing demand for sustainable steel, improve the industry's environmental reputation and attract green investment.

European policies and incentives, including renewable energy subsidies, tax breaks for green investments and support for the circular economy, encourage the adoption of EAFs.

Despite challenges, the transition to EAF technology in Europe's steel industry represents a crucial step toward increased sustainability. With policy support and industry innovation, this transition will offer a pathway to reduced CO_2 emissions, greater economic efficiency and a more sustainable future.

Source: Recycling Today, 28 may 2024

Russia Sends Coal to India by Train for First Time

Russia has for the first time sent two trains laden with coal to India via the International North-South Transport Corridor (INSTC), which connects Russia to India via Iran.

A multimodal route that includes a railway, roadway network and seaports, the INSTC spans 7,200km (4,500 miles) from St. Petersburg to the port of Mumbai in India.

For the first time, two trains with Kuzbass coal headed to India along the International North-South Transport Corridor. The trains set off from the Kemerovo region. They followed along the eastern branch of the INSTC through Kazakhstan and Turkmenistan to the Iranian port of Bandar Abbas.

The coal will be shipped by sea along the final part of the route from Iran's port of Bandar Abbas to the Indian port of Mumbai.

India has been ramping up purchases of both coking and thermal coal from Russia. Despite its efforts to expand renewable energy, India continues to rely heavily on coal as its primary source of power generation.

Source: Coal Insights, 25 June 2024

CIL may Join Hands with US Firm for Lithium Blocks in Argentina

Coal India Ltd is exploring lithium blocks in Argentina along with a U.S. company to secure supplies of the battery material,.The efforts are part of India's membership under the U.S.-led Minerals Security Partnership (MSP), which New Delhi joined last year to ensure adequate supplies of minerals to meet zero-carbon goals.

Co-Investment Plan

India and the United States said that they were co-investing in a lithium resource project in South America and a rare earths deposit in Africa to diversify critical minerals supply chains.

India has been in talks with several countries, including the U.S., to collaborate in lithium processing.

Under the minerals partnership, India was invited to participate in 20-25 critical minerals projects, of which four have been identified by the govt, with two of these are in collaboration with the U.S. The second project is in the Kangankunde block in Malawi, which is being explored by India's state-owned IREL (India) Ltd for rare earths.

The Hindu, 18th June 2024

Visit of Shri M P Sharma, Jt. Secretary, IIM Delhi Chapter to JNARDDC

Shri M P Sharma, Jt. Secretary, IIM Delhi Centre was invited by Jawaharlal Nehru Aluminium Research Development & Design Centre (JNARDDC) for interaction on utilization of Aluminium Oxide generated after the extraction of Aluminium Metal from Aluminium Dross, and other areas related to Aluminium/Aluminium Alloy Castings and Processing Technologies. He visited JNARDDC during 8th July 2024 and received warm welcome and excellent hospitality.

Shri Sharma delivered a technical talk on *Aluminium Processing Technology* and had a detailed interaction with Director (JNARDDC) and other senior scientists of the JNARDDC. He was taken around to different laboratories of the Centre. He was also briefed about the work being carried out in the different laboratories of the Centre.

Some of the visuals of the visit are as under:

AGM of IIM Delhi Chapter

The **72nd Annual General Meeting(AGM)** of Delhi Chapter was held at the Chapter's premises on 22nd June 2024.

In this connection notice of the meeting was sent to all the members of the Chapter on 29th May 2024. 16 members of the Chapter attended the AGM.

The highlights of the AGM are as under:

- Presentation of Activities undertaken by the Chapter in 2023-24.
- Adoption of audited accounts of the Chapter for 2023-24
- Circulation Met-Info
- Preparatory activities relating to MMMM 2024 Conference to be held from 27th to 29th September 2024 at New Delhi.
- Approval of the slate of officer bearers and members of the Executive Committee for 2024-25

Some of the visuals of the AGM are as under:

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Shri Navneet Singh, B. Tech in Industrial Electronics from Amravati University, founded YOGIJI DIGI (formerly DIGI DRIVES) in 1993 just after completing his engineering. He has spear headed the 500 people strong group, a Rs.400 crore company, to be amongst the leading and reliable brands in the world for flat steel processing lines. In last 14 years the group has gained significant market share and supplied completely indegenous 35 Cold Rolling Mills, 18 Pickling Lines, 26 Metal Coating Lines and 21 Color Coating Lines.

The company has a state-of-the-art design and manufacturing set up in Palwal, Haryana equipped with latest CNC machining centres and one of the biggest assembly area amongst peers. The focus has been on producing import substitutes such as Mill Housings, Tension Reels, Coil Coaters etc. in house and has contributed significantly to the cause of Self Reliant India (आत्मनिर्भरभारत).The company is now also desigining and producing Non-ox Furnaces and Baking Ovens for metal coating lines.

He has been instrumental in the development of the "GREEN COLD ROLLING MILL", a completely indigenous technology which consumes less water and electricity and saves around 356 Tons of CO^2 emissions on each mill. A technical paper on the same has been presented at the AISTech2021conference held at Nashville, TN, USA. A patent has also been granted on this innovation with title "A COLD ROLLING MILL" vide Indian Patent Certificate No. 485316. A Poster Presentation was also made on the subject at 75th Annual Technical Meeting at IIM ATM 2021. A brief note on the same subject is also published in the August 2021 publication of Indian Institute of Metals (IIM). Delhi Chapter.

He has significant contribution in the development of DIGI-IMPACT time based Automatic Gauge Control (AGC) system for rolling mills which maximizes yield and is 3X more efficient than the traditional length based AGC systems available in the market. A technical paper on the same was presented at the AISTech2023 held at Detroit, USA. It was also presented in the poster format at 77th Annual Technical Meeting of IIM held at KIIT, Bhubaneswar in November 2023.

He also presented a technical paper on "The Discreet Techniques of Rolling Ultra-Thin Gauges" for Advanced High Strength Steels (AHSS) and Silicon Grade Steels at the AISTech2024 at Columbus, OH, USA.

Other technical papers on various subjects have also been presented at various editions of AISTech and other technical conferences held across India.

The company under his able leadership is prioritizing designs which are manufactured with efficiency, cost-effectiveness and high quality. With the concept of "Design and Make in India" company is able to offer truly innovative and globally competitive equipment and move up the global supply chain.

He has also been awarded the "ECONMIC TIMES MOST PROMISING BUSINESS LEADER OF ASIA 2018-19" at the Asian Business Leaders Conclave held at Hong Kong.