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Copper in Sustainable World

The economic growth has increased the standard of living globally and lifted people from poverty. The GDP per capita has increased 15-times from $812 in 1970 to $12,235 in 2021. At the same time poverty has reduced significantly. 8% of the world's population lived on less than $2.15 a day in 2019, down from 44% in 1981. However, we are paying the price in increased emissions. The global carbon dioxide emissions have climbed from 15 Gt in 1990 to 60 Gt in 2022. Globally, there is a clear need to decarbonize the economy and promote sustainable growth by drastically limiting our emissions.

To reduce the emissions, several different means can be adopted:

1). to increase efficiency to optimized consumption, self-generation or circular processes;
2). power generation from cleaner sources;
3). electrification of power consumption like electric vehicles (EV); and
4). new technologies, like green hydrogen, biogas, carbon capture and storage.

A sustainable world needs metals, more than ever. Fig. 1 demonstrates the dominant role of copper in various ways to decarbonize societies. Although other metals may be present in EV batteries in higher quantities than copper (Fig. 2), none of the other metals is needed in all the potential decarbonization technologies. Furthermore, the power generation from renewable sources is more copper-intensive than conventional electricity production (Fig. 3). Clearly, although also copper production generates emission, copper is clearly more part of the solution than a problem in decarbonization.

Fig. 1: Metals needed in various decarbonization technologies (source World Bank, ICA)

	Al 5	Mn 4	Cu 7	Zn 1	Pb 3	Ni 6	Li 2	Mo 4	Co 4	Ag 3	In 3
Solar PV	●		●	●	●	●		●		●	●
Wind	●	●	●		●	●		●			
Nuclear			●		●	●		●	●	●	●
EVs		●	●			●	●		●	●	●
Batteries	●	●	●			●	●		●		
Electric Engines	●		●								
CCS	●	●	●			●		●	●		

Fig. 2: Example of the share of different metals in an electric vehicle battery

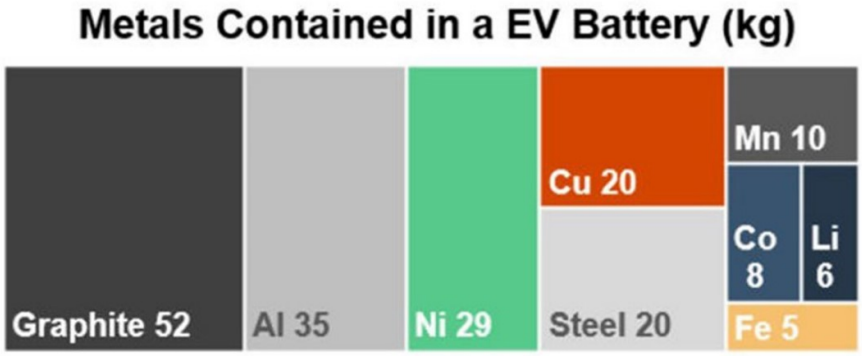
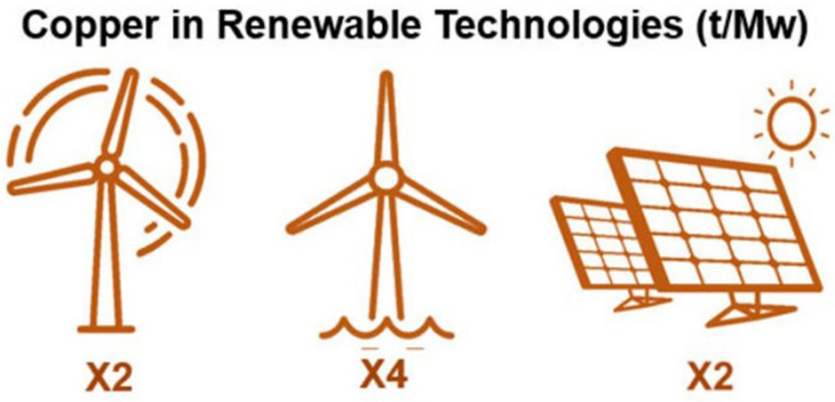
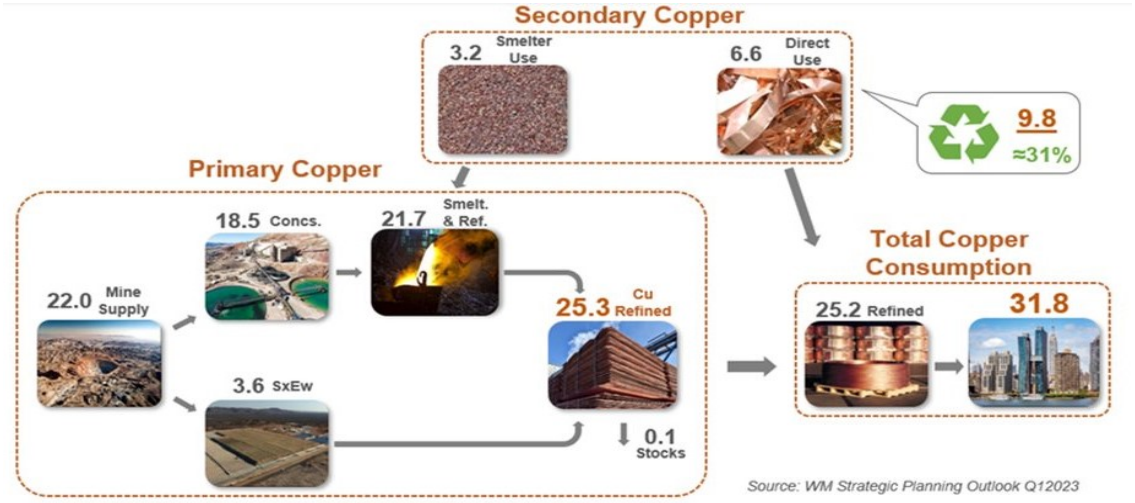


Fig. 3: The amount of copper in renewable energy generation compared to conventional power generation



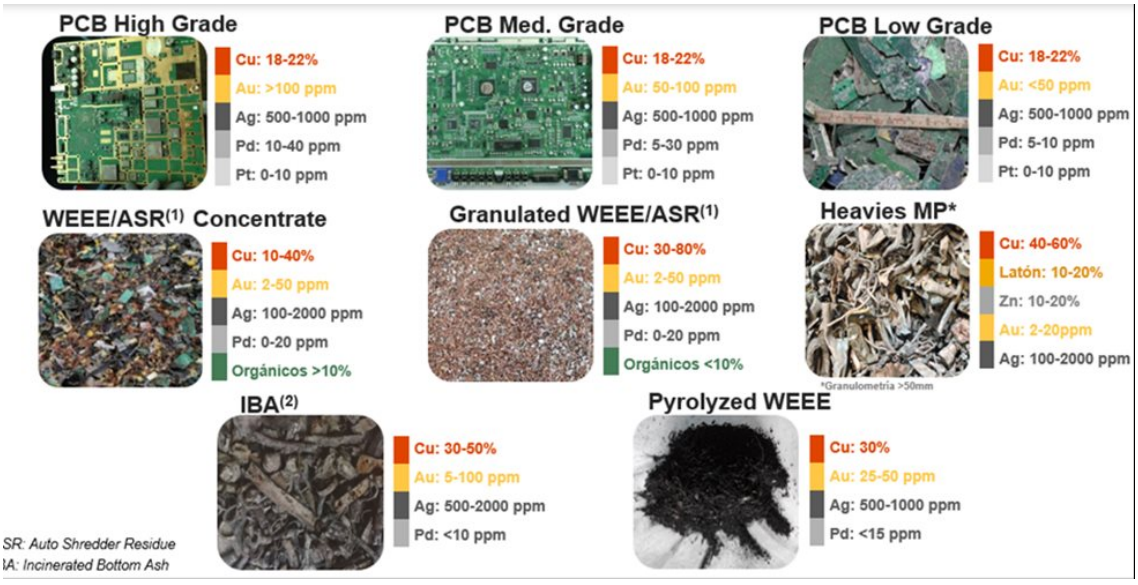
Copper is instrumental in the transformation to a low-carbon society. It is needed in e.g. renewable power generation and in electric vehicles and their charging systems. Because of this, the copper demand is expected to grow. Currently, primary production of copper is 25.3 Mt and secondary production accounts for 9.8 Mt (Fig. 4). Secondary copper includes both high-grade melted scrap and low-grade scrap.

Fig. 4: Various ways and amounts of copper production



Secondary copper sources are not able to satisfy the growing copper demand although the amount of e-Waste is growing rapidly. In most applications, copper stays in use for decades. A windmill may last 25-30 years and buildings 60-70 years. Furthermore, opposite to concentrates, scrap "disappears" from markets in periods of lower prices. On the other hand, e-Waste offers an opportunity to recover also other valuable metals (Fig. 5).

Fig. 5: Types and qualities of e-waste



It is not foreseeable in a reasonable time horizon that global copper demand can be satisfied based on recycling. However, Circular Economy and recycling will need strong support and development to complement the primary route and to reduce the use of natural resources. In parallel with fostering recycling and reuse, there are opportunities to reduce the footprint of primary processes, mining, smelting and refining. Success in facing all those ambitious challenges in the short, medium and long term will depend, above any other thing, on our people.

Source: Smelting Newsletter 2023, 14 Dec. 2023, METSO

IAI Backs Aluminum Emissions Reduction Target

Several members of the International Aluminium Institute have signed on to the organization's initiative to meet a COP28-related emissions reduction target.

The London-based International Aluminium Institute (IAI) has launched an initiative it says commits to transparently and publicly track ambition and progress in the greenhouse gas (GHG) reduction of all its member companies.

An IAI scrap guidelines document point to recycling being a vital part of the aluminium sector's emissions reduction goals.

This initiative, launched in coordination with the United Nations Climate Change Conference (COP 28) in the United Arab Emirates (UAE), has been backed by several global aluminium producers. Early signatories include Aluminerie Alouette, Aluminium Bahrain (Alba), Alcoa Corp., Alumina Ltd., Companhia Brasileira de Alumínio (CBA), Emirates Global Aluminium (EGA), Hindalco Industries Ltd. (which also owns Novelis Inc.), Norsk Hydro, Mitsubishi Corp., Rio Tinto Aluminium, Rusal, Sohar, Aluminium and South32. Combined, the companies produce 221 million tons of GHG emissions annually, according to IAI.

As part of initiative, IAI says it is committed to tracking and reporting on its member companies' ambition and progress in GHG reductions and reporting total global GHG emissions of the aluminium industry on a public and annual basis.

"Emissions reduction will require investment in new equipment and technology at company and facility level," the association says. One component of the process specifically mentioned by IAI entails the use of aluminium scrap as a feedstock.

The initiative calls for setting a long-term GHG emission reduction target, possibly in 2024, and preferably setting and achieving a net-zero target by 2050. An interim GHG emission reduction target also is likely for 2030, according to IAI.

Signatory facilities will agree to use the "IAI Good Practice for Calculation of Primary Aluminium Carbon Footprint Methodology," as well as the "IAI Guidelines on Transparency – Aluminium Scrap" as calculation references.

The aluminium industry is committed to rapidly reducing GHG emissions and acknowledges that investment and action is required to achieve global goals. The IAI has consistently managed programs to foster collaboration and action on sustainability and this initiative will drive ambition and action to decarbonize aluminium supply chains.

Because of its infinite recyclability, aluminium is ideal for circularity—the carbon footprint of recycled metal is just 5 percent of primary smelting.

The world needs aluminium for the transition to a lower carbon world. Alcoa has an ambition to achieve net zero by 2050, and is working to get there with mid-term goals while also boosting the percentage of renewable energy to power our smelters.

Norway-based Norsk Hydro, which has growing recycled-content production capacity in the United States, says, "Hydro set ambitious targets to reduce GHG emissions by 30 percent by 2030 and become carbon neutral by 2050.

Source: Recycling Today, Dec 11, 2023

Emission Monitoring – More Pollutants, Sources and Significant Figures

There is a healthy and necessary interest in the accurate monitoring of pollutant emissions. Earlier, there were standard methods for measuring

major pollutants such as particulate matter, SO_2 and trace elements, with methods for trace elements (including mercury) being new. Now, concern is far more diverse, reflecting just how complex and challenging it has become to achieve valid pollution data. There are many different and fascinating reasons:

- **Lower concentrations** – tightened emission standards have successfully lowered emissions of pollutants by several orders of magnitude. Monitors therefore need to be significantly more sensitive whilst still providing accurate and reliable data.

- **New pollutants are being added to the watch list** – such as PFAS (per- and poly-fluoroalkyl substances) from advanced chemical production processes. Utility sources such as coal-fired power plants will soon have to widen their monitoring strategies to include ammonia and hydrogen due to growing cofiring strategies and fuel mix modifications.

- **New sources are being scrutinised** – large stationary sources such as coal plants have been monitored for decades but will now be joined by sources which, so far, have flown under the radar. Agricultural activities, landfill sites and battery production facilities are being added to the update of the EU Industrial Emissions Directive. Other sources include aviation, marine transport, and flaring (from oil and gas, as well as chemical processing sites). Coal mines, even those which are no longer active, may soon be required to report fugitive methane emissions. Emissions from abandoned and legacy coal mines, especially in developing countries, can be identified and quantified remotely with satellite monitoring. However, it will be challenging to reduce these emissions, as they are dilute and dispersed across wide areas and may require legal action to determine who is responsible for the clean-up of these legacy sites.

- **Matching source emissions with atmospheric concentrations** – not all emission sources have been identified and, even if they were, the combination and interaction of pollutants from various different sources needs to be fully understood to protect public health. Methods such as fence-line monitoring, fugitive monitoring, drones and even

satellite analysis are building an overarching understanding of what has been termed 'atmospheric fall-out'. The field of emissions monitoring is evolving into environmental forensics, including advancements in CO_2 monitoring to determine whether emissions are from fossil, or more recent, carbon sources.

- **Regional variations and mismatches in methods** – as emission standards have evolved regionally, so have monitoring and training methods. The EU methods are quite distinct from the US methods, which can lead to challenges when both options are permitted, as is the case in India.

Steel in Car Manufacturing

Automotive and vehicle industry is a major consumer of steel sheets and cast finished components. The automotive and vehicle industry is one of the largest industries in the world, and it accounts for a significant portion of steel consumption. Steel is used in a variety of applications in the automotive industry, including body panels, chassis components, and engines. The demand for steel in the automotive industry is expected to continue to grow in the coming years, as the global population increases and the demand for vehicles grows. It provides a stable and growing market for steel products.

The reason why mainly steel is used in manufacturing automobiles instead of any other metal is because steel is strong and hard. All these properties make steel the perfect metal for car bodies.

The framework

Steel is used to create the framework of the vehicle. The skeletal frame of a car must be able to withstand extreme weather conditions and the pressure exerted by the vehicle, so car manufacturers use Advanced High Strength Steel (AHSS), which has high tensile strength and durability.

The quality of steel is determined by its tensile strength and ability to withstand physical forces. Therefore, car manufacturers use high-quality steel for the body frame and car chassis. One type of steel that is used in flooring in

many vehicles is MS checkered plate. For a shiny texture on the automobile, one can choose the steel in faucets and bumpers.

How is steel used in car manufacturing?

Steel is used in a variety of ways in automotive vehicles, including the underlying chassis, door beams, roofs, and body panels. The most common type of steel used in automotive vehicles is called "body in white," which is the foundation from which the rest of the vehicle is created.

Different types of steel are used in automotive vehicles, including stainless steel, high-strength steel, high-carbon steel, low-carbon steel, and galvanized steel. These types of steel are used in the production of various vehicle and engine components. A mechanically operated press is used to shape steel sheets. The press drives a punch against the steel sheet, forcing it into a simple die with enough pressure to produce a permanent change in the metal's shape.

Steel brings a lot of benefit to the manufacturing of Automobiles, Some of which is:

- **Flexibility of Design:** Steel is a versatile material that can be used in a variety of automotive design processes, regardless of the machining process used. It is ideal for making automotive steel components with excellent corrosion resistance and aesthetic appeal. Steel is often referred to as the "universal building product" because of its versatility. The wide range of automotive steel products in use today is a testament to steel's design flexibility.
- **Recyclability:** The ability to reuse steel material is another enormous benefit. Steel is a highly recyclable material. In fact, most steel products today contain approximately 88% recycled steel. This recycling process is energy-efficient, as it requires less energy to melt recycled steel than to produce steel from raw materials.
- **Cost Efficiency:** When partnering with a supplier or purchasing steel, the cost is often a top consideration for manufacturers. Fortunately, steel is a cost-effective material that can save manufacturers money in the long run. This is because steel is durable and can withstand wear and tear, which means that it requires less maintenance than other materials.

Additionally, steel can be quickly fabricated, which allows manufacturers to produce products more quickly and efficiently.

- **Durability and Quality:** The durability of steel is one of the main reasons why automotive manufacturers choose it. Steel is a strong and long lasting metal that can withstand the wear and tear of everyday use.

Source: Z.V Steels Pvt. Ltd.

First Stone Laid for 'World's Largest Hydrogen Ready Steel Plant'

The ground-breaking ceremony for the world's largest hydrogen ready steel plant, led by Vulcan Green Steel, part of Jindal Steel Group, took place in Oman.

Scheduled for completion by 2026 and with production starting in 2027, Vulcan Green Steel's plant in Duqm, Oman, will establish a fully integrated green hydrogen-ready steel plant, producing 5Mt/yr of green steel with approximately 85% less CO_2 emissions than the current global average, before the end of the decade.

The steel facility will cater to the automotive, wind turbine, and consumer goods sectors. The project is estimated to achieve 12Mt/yr in CO_2 savings, through the use of renewable energy sources such as wind and solar.

Source: Weekly News from Steel Times International; Dec. 6, 2023

Hydrogen Based Ladle Preheating Technology

Given its potential to revolutionize and redesign the steelmaking process, (green) hydrogen is among the most sought-after solutions. Steel companies worldwide are directing their attention to its use. Hydrogen-based steelmaking´s potential to spark change notwithstanding, the matter of finding the right technology that ensures an efficient and cost-effective process remains.

Sarralle has recently put into operation the world´s first ladle preheating station capable of running entirely on green hydrogen. The ladle preheater was an existing piece of equipment that operated with natural gas. The project consisted of improving the efficiency of the equipment by installing a new oxy-combustion burner technology which operates normally with 100% natural gas, 100% hydrogen, or blends of both gases.

Several heating and drying trials have been carried out by operating the ladle preheater with 100% green hydrogen, in order to ensure that the new equipment can satisfactorily reproduce all the required temperatures for ladle casting, achieve homogeneous heating of the refractory and that it has no negative impact on the refractory material. Seeing as the steelmaking plant does not have a continuous hydrogen supply at the moment, the green hydrogen for the trials was supplied by NipponGases and transported by semi-trailers.

It is important to stress that safety was top priority during the project. Due to the fact that hydrogen was used as a fuel within the steel plant for the first time, safety procedures were put into place, and H_2 detection sensors and individual portable sensors were installed.

The transition from the traditional operation with natural gas and air to oxy-combustion results in fuel savings of between 10-50% with consequent reduction of CO_2 emissions.

Currently, most high-temperature heating equipment in the steel industry operates with natural gas as fuel and air as an oxidizing agent. Disregarding water vapor, atmospheric air contains around 79% nitrogen and only 21% oxygen. Therefore, during the air combustion process, nitrogen must be heated, losing process efficiency. Seeing as the nitrogen component is not heated during oxy-combustion, fuel consumption is reduced.

The transition from the traditional operation with natural gas and air to oxy-combustion results in fuel savings of between 10-50% depending on the current operation of the equipment, with consequent reduction of CO_2 emissions. For instance, for ladle preheaters, a natural gas consumption reduction of 50% is obtained with a subsequent decrease in OPEX costs. The

introduction of hydrogen as a fuel will mark an even greater reduction in CO_2 emissions, making the goal of zero CO_2 emissions highly achievable.

Oxy-combustion technology allows for a more efficient use of green hydrogen compared to that of air combustion. Given the technological and social challenges associated with the green hydrogen production increase that is expected in the coming years, the most efficient technology for hydrogen consumption should be applied. In fact, Sarralle partnered with NipponGases for the design and manufacturing of oxy-combustion hydrogen burners which will enable full replacement of natural gas in industrial heating systems.

A major advantage of oxy-combustion over air-combustion is the potential for the reduction of NO_x emissions (nitrogen oxides, NO and NO_2). Thermal NO_x refers to the NO_x formed through high-temperature oxidation of the nitrogen found in the combustion air. Since oxy-combustion uses pure oxygen as the oxidizing agent, there is almost no nitrogen present in the combustion process, therefore, NO_x are not formed. When oxy-combustion technologies are applied, the only NO_x formation comes from infiltration of air in and around the equipment, along with some N_2 that can be present in both the natural gas and oxygen. The ladle preheater project included the measuring of the exhaust gases, in order to confirm the reduction of CO_2 and NO_x emissions.

Steelmakers are initiating industrial testing of their heating equipment within the framework of hydrogen-based use, which is the most important step. The positive results obtained in the trial campaigns performed at the ladle preheater confirm that it is feasible to operate this heating equipment with 100% hydrogen.

It is worth mentioning that the burner technology used for the ladle preheater is also applicable to other heating equipment such as tundish preheaters and reheating furnaces.

Reheating furnaces in the steelmaking plant are also responsible for the facility´s CO_2 emissions. Improving the efficiency of the reheating furnaces via oxy-combustion and taking a step further to operate them with 100% hydrogen will allow the almost complete decarbonization of EAF-based plants.

HyInHeat is a European-funded project and one of the largest consortiums that are working on the topic of integrating hydrogen technologies industrially in the steel industry. It is based on the collaboration of 30 partners from 12 countries. Within this project, Sarralle is working on converting the combustion system of an existing industrial walking beam reheating furnace, from natural gas and air combustion to 100% hydrogen oxy-combustion.

Source: Green Steel World News, 15 Dec. 2023

COP 28 Launches 'Steel Standards Principles'

'Steel Standards Principles' were launched during the first day of COP 28, aimed at aligning how greenhouse gas emissions are measured in the steel sector. The announcement took place during the Business and Philanthropy Climate Forum roundtable at the COP28 UN Climate Change Conference.

The 'Steel Standards Principles', developed by standard setting bodies, international organizations, steel producers and industry associations, recognize that the iron and steel sector accounts for approximately 8% of annual global greenhouse gas emissions and that these emissions will need to be reduced by at least 90% for the sector to play a credible role in achieving climate targets.

The Principles call for establishing common methodologies on measuring greenhouse gas emissions within the iron and steel sector in order to accelerate the transition to near-zero emissions.

Fragmented and uncoordinated trade policies make it harder for the steel industry to decarbonize. They add uncertainty for producers, hamper cross-border movement of green technologies and inputs, and slow investments in clean technology.

Over 35 key steelmakers, industry associations, standard setting bodies, international organizations and initiatives have endorsed the Steel Standards Principles.

The diversity of standards for measuring steel carbon emissions makes assessing how one tonne of steel compares to another extremely challenging. The 'Steel Standards Principles' establish the key foundations of a common

framework that is needed for driving the decarbonisation of the industry globally. The Principles will help create broader alignment on how to define low carbon steel.

There is not just one way to make steel and different steels have different carbon footprints depending on the input metallics and the technology. A system that recognises this is important, particularly when the transition to net zero will take many years.

Source: Weekly News from Steel Times International; Dec. 6, 2023

Hindalco Plans Rs. 800 Crore Unit for Battery Grade Aluminium in Odisha

Hindalco Industries is looking at investing Rs 800 crore to set up a new plant, for manufacturing fine-quality aluminium foil in Sambalpur, Odisha.

The facility, which will have an initial capacity to produce 25,000 tonnes of fine-quality aluminium foil used in rechargeable batteries for electric vehicles (EVs) and energy storage systems, will be commissioned by July 2025.

Hindalco Industries is seeing a fast traction in battery materials demand, driven by an impressive outlook for the electric vehicle and Grid Storage sectors. Raw material localization is critical in such strategic sectors.

Hindalco said the demand for battery grade aluminium foil is expected to grow manifold to 40,000 tonnes, primarily driven by demand from gigafactories for advanced cell manufacturing.

Hindalco currently has manufacturing facility in Mouda (Maharashtra). The company is in the process of qualifying with lithium-ion cell manufacturers in India, Europe, and the United States. The new unit will further expand its capacity to supply materials to gigafactories across the world.

Source: The Economics Times, Dec. 12, 2023

So, Is Copper the New Lithium?

In the world of minerals and metals, copper doesn't attract the headlines or excitement that lithium, cobalt, nickel and rare earths do. Perhaps that is because, unlike the 'new age' metals, copper is almost as old as civilisation. Even the Bronze Age, when copper was first blended with tin, occurred 5,000 years ago. Yet, copper is as much a critical mineral for the economies of the future as lithium is. It deserves a significant focus in discussions on mineral supply and supply-chain security.

For long, copper has been the most preferred metal for electrical conduction due to its unique features like strength, ductility, corrosion resistance, and safest conduction of electricity and heat. It has now emerged as a critical metal in the energy transition technologies:

- **Riding on EV:** On average, an EV requires around 83 kg of copper compared to 23 kg for a conventional vehicle. Not only is copper usage fourfold but, as per IEA, EV sales are projected to grow from 10 million units in 2022 to 37 million units by 2030.
- **RE hunger:** Wind and solar photovoltaic energy systems are significant consumers of copper. While an onshore wind installation uses around 3.8 tonnes of copper per MW, offshore wind-mills use nearly 10.5 tonnes of copper per MW in cable, wiring, turbine components and transformers. Similarly, one MW of solar power systems contains about 5.5 tonnes of copper.

Global RE generation capacity is projected to more than double from 3,600 GW in 2022 to 8,600 GW in 2030, and over five times to 19,000 GW in 2050. The demand for coper will grow rapidly as the world acts on climate change. But there are several challenges:

- **Supply hurdles:** The global lead time of any greenfield mining project has increased to an average of 12-15 years due to substantial delays in getting regulatory clearances. A prolonged bear market in copper from 2011 until Covid struck also weighed down on the exploration of copper. Major discoveries almost dried up.
- **Quality cuts:** The quality of copper ore has also been falling. For example, the grade of copper ore in Chile, the world's leading producer, has declined

by 30% in the last 15 years. Issues relating to resource nationalism and trade restrictions are also on the rise.

- Chile has passed a bill to set a maximum tax rate of around 47% on companies producing over 80,000 tonnes of fine copper yearly.
- Indonesia, another major producer, will stop the export of copper concentrate once its two domestic copper producers complete the building of smelters and commence output in 2024. The bottom line is that the copper market is likely to face a supply shortage.

- **Rebound expected:** A recent McKinsey report predicts that the copper market will be in a deficit of 6.5 Mt in 2031 as demand (36.6 Mt) will outstrip supply (30.1 Mt). Currently, copper prices are down by 30% from the peak of $10,466 per tonne in early 2022, mainly due to rising interest rates and the slowdown in China. But as the interest-rate cycle is close to its peak, the possibility of a rebound in copper price looks likely, and that may encourage exploration and investment.
- **Wider application:** Despite the 'gold rush' for lithium, nickel, cobalt and rare earths, copper may have an edge from a long-term investment point of view due to its wider application. This future-proofs demand against changes in the technology landscape, unlike the new-age metals, which rely heavily on demand from battery manufacturing.

As per an IEA estimate, by 2050, nearly 80% of lithium demand will be tied up with battery manufacturing, and 35-40% of demand for nickel will be dependent on EV batteries. On the other hand, exposure of copper to battery manufacturing is likely to be limited to 4% in 2050 - not much of a change from its current level.

This is important because the relative importance of, and demand for, lithium, cobalt or nickel may fall if newer technologies like sodium-ion batteries or zinc-air batteries become commercially successful – early signs of which are visible. Green hydrogen could be another disruptor. This is not the case for copper, which is used in all parts of the energy transition technologies, not just batteries.

We may yet be heading for a new 'Copper Age'. Governments and investors must adequately prepare for it.

Source: The Economic Times, Dec. 28, 2023

Global Installed Green Hydrogen Capacity Passes 1GW Mark

The global deployment of electrolysers at green hydrogen projects has finally passed the gigawatt mark, having risen 60% in the past year to 1.1GW.

This amounts to roughly 150,000 tonnes of green hydrogen per year, compared to an annual capacity of 710,000 tonnes of "low-carbon" hydrogen.

A total of 400MW has been installed in the past year, mainly in China.

While the growth rate has doubled in the past two years, 260MW of the 400MW was for the Kuqa project in northwest China, which is operating at well below full capacity due to problems with its Chinese electrolysers.

China has installed 610MW of electrolysers — including the world's second-largest green hydrogen facility, the Ningxia project in Inner Mongolia, which is also not operating at full capacity.

In joint second place are Germany and the US, each with 60MW, followed by Spain, Taiwan, Sweden and Canada, each with "about 20MW".

However, deployment is not moving as fast as previously expected by developers. Although announcements in 2021 indicated 6GW of the electrolysis would be operational by the end of 2022, operational deployment as of October 2023 stands at 1.1GW, or about. 20% of that number.

Nevertheless, a further 12GW of electrolysis projects have reached final investment decision (FID), representing 1.3 million tonnes of green hydrogen. Roughly 7GW of that capacity is in China, with 2GW in the Middle East and 2GW in the US and Europe.

This volume of electrolysers should not be difficult to produce, with annual electrolyser manufacturing capacity having risen from 9GW to 11GW this year.

About 305GW of electrolysis projects have been announced and are due to be completed by 2030, representing 32 million tonnes of green hydrogen.

Of the seven million tonnes of clean-H_2 production capacity announced in the past nine months, more than 90% is for renewable hydrogen driven by the high growth in announcements coming from renewables-rich regions in the global south.

Only 7% of announced clean hydrogen projects (including blue hydrogen, infrastructure and end use) have reached FID, representing investments totalling $39bn.

Source: Accelerate Hydrogen Newsletter, 14 Dec. 2023

Cost of Producing Green Hydrogen Has Risen by 30-65%

The cost of producing unsubsidised green hydrogen rose by 30-65% in the 12 months up to June 2023, reaching $4.50-6.50/kg, according to Hydrogen Council and management consultancy McKinsey. This compares to figures of $2.50-4.50/kg in the middle of last year.

Multiple factors have caused this increase - higher labour and material costs, higher cost for building the balance of electrolyzer plants, 3-5 percentage points higher cost of capital, and an increase of renewable power cost by more than 30%.

Nevertheless, the “outlook remains positive”, and the cost of green hydrogen production will is expected to fall.

Despite the recent increases, the cost of producing renewable hydrogen is expected to decline to $2.50-4/kg towards 2030, driven by advancements in electrolyser technology, manufacturing economies of scale, design improvements, and reduction in renewable power cost.

Reductions in electrolyzer costs of up to 70% through 2050 are considered to be the strongest lever to bring down renewable hydrogen CapEx and overall costs.

However, further measures - such as the standardization of projects - are required to fully optimize renewable hydrogen production CapEx, and while it could fall by 45% through 2030, project optimization could decrease costs by

an additional 25%. Optimizing renewable hydrogen production could cut CapEx by half vs 2023 levels.

The Hydrogen Council - whose steering members include most of the world's largest oil companies, such as ExxonMobil, Saudi Aramco, BP, Shell and TotalEnergies - says that the cost of blue hydrogen will be slightly under that of green hydrogen from 2025 to 2050.

Source: Accelerate Hydrogen Newsletter, 14 Dec. 2023

Less Waste, More Sustainable Electronics

With the rapid growth of the e-waste stream and electronics replacements, high-tech manufacturers are urged to transform their operations for better waste management and more sustainable products and supply chains.

Some countries, like France, have introduced the repairability index, which requires stores to display products' repair scores and information. This index signals an intensified commitment to sustainable practices by encouraging consumers to choose more repairable products.

To respond effectively to the repairability index and other sustainability initiatives worldwide, manufacturers need to rethink their strategy and be guided by data to make the right decisions every time. Only then can they better manage the complexity and business risks from sustainability-focused regulations and consumer demand.

Three Goals for Greener Products and Processes

To begin reducing the e-waste stream and delivering sustainable electronics, manufacturers can rely on an integrated platform to create and explore a detailed virtual twin of their physical world.

Such a platform enables manufacturers to make optimized decisions to go beyond e-waste recycling and advance the following goals for greener outcomes:

- **Regulatory compliance**

Controlling costs and risks associated with regulations requires manufacturers to align with key directives that include Waste from Electrical and Electronic Equipment (WEEE), Restriction of Hazardous Substances (RoHS) and Substances of Very High Concern (SVHC).

A platform that integrates the entire product lifecycle will help manufacturers adhere to dynamic regulatory compliance by enabling smart material choices, collaboration, traceability and scalability to easily incorporate evolving requirements.

- **Zero-waste design and manufacturing**

Traditional product design and manufacturing processes are typically carried out in silos and rely on physical prototypes to finalize a decision.

Through virtual simulation technology, manufacturers can design devices for better reuse across multiple lifecycles. They're able to swiftly assess and increase a product's durability and recyclability by running its virtual twin through a wide range of simulated settings, from assembly and disassembly processes to product structures, drop tests and the use of new materials. Manufacturers can ensure first-time-right production results using a virtual twin of their manufacturing operations to determine the optimal production configuration.

- **Efficient product recovery**

With a platform that provides the virtual twin as a complete information model, manufacturers can implement steps to increase product repair, recycling and reuse.

The virtual twin brings together data from different product lifecycle stages and the platform, in turn, enables optimized decision-making between internal and external stakeholders based on the aggregated data. The virtual twin also helps accelerate the recycling process by providing end-to-end product information, allowing recyclers to implement efficient reverse manufacturing strategies that minimize tests and inspection.

The Platform That Unlocks Value in E-Waste

The 3DEXPERIENCE® platform is the model-based and data-driven collaboration platform that supports high-tech manufacturers to deliver sustainable value beyond improving e-waste management.

On this platform, manufacturers can create an accurate virtual twin of their operations and conduct multiscale and multiphysics simulations to assess their decisions' environmental impact. This allows manufacturers to identify risks earlier, ensure a higher manufacturing yield, minimize greenhouse gas emissions and leverage data for increased repair, recycling and reuse rates.

The intelligent platform also incorporates a compliance management capability, enabling manufacturers to access product information that includes components' breakdown and the chemical substance formulation of each material of construction. Manufacturers can compare the data to industry regulations and be alerted if a material or component is not compliant with regulations in a certain part of the world.

Supported by the **3D**EXPERIENCE platform and its suite of powerful capabilities, manufacturers can contribute toward a more sustainable high-tech industry — not only through **e-waste recycling** but also durable and repairable devices, waste-free operations and **carbon footprint reduction**.

Source: Dassault Digital Innovation Newsletter, December 2023

UK Start-up Engineered Efficient Alkaline Electrolyser

Three technological breakthroughs will enable the production of renewable H2 at a significantly lower cost than commercially available technology - claims a UK start-up *Electrogenos*. It claims to have developed a low-cost alkaline electrolyser that will be able to produce 1kg of green hydrogen from just 45kWh of electricity - far lower than the standard 50-55kWh for today's alkaline and PEM machines - significantly reducing the cost of renewable H_2 production.

Oxford-based Electrogenos says both the capital and operating costs of its unpressurised electrolyser will be lower than current top-of-the-range models,

due to three proprietary cost-cutting innovations: special electroplating and stack manufacturing methods, and a novel low-cost, highly active catalyst.

Electrogenos can make the disc-shaped stainless-steel electrodes really cheap by electroplating.

Catalysts for alkaline electrolysis usually cost around $400 per metre squared, to $1,500 if platinum is used. So Electrogenos is probably looking at something around $20 per metre squared for making catalysts, that allows to cut down on the cost of fabricating the stacks. The company utilises a “very cheap” type of electroplating. Other companies are using plasma spraying in a vacuum-sealed chamber to do their electroplating. That’s a batch process with very expensive equipment, and just not efficient. Electrogenos have developed a very scaleable, very cheap process to plate something very delicate that will last for a very long time.

Electrogenos developed an alloy that’s extremely active. It’s very difficult to get a catalyst that’s both active and also very durable. Proprietary catalyst material is an “alloy of transition metals, which include iron, nickel, copper, zinc and chromium.

Electrogenos is getting much higher current densities than was traditionally possible. They are getting 0.5 amps per centimetre squared [A/cm^2] at 1.7 volts [V], while most of other industry competitors do that at 2V. That’s a huge saving in efficiency. At 2V, they are getting $1.5A/cm^2$ — three times more than what the competition will be getting at that voltage.

The third cost-cutting innovation is the way that Electrogenos manufactures the stack. The architecture of the stack is novel in that it is able to reduce the number of parts and use a different manufacturing technique, which allows it to be very capex efficient on terms of manufacturing. This allows to build smaller factories, to unlock economies of scale at a smaller scale. While other electrolyser manufacturers need to reach 1GW or more to reach economies of scale, Electrogenos can achieve its “cost-efficient point” at 200MW — which is why it plans to build multiple 200MW factories around the world to meet local demand, rather than build centralised gigawatt-scale plants like its competitors. Problem with gigafactories is that they’re labour-intensive and

they've got to compete with China. China's always going to have cheaper labour costs.

Although the company has not finalised its expected levelized cost of hydrogen, it is estimated to be $2/kg at an electricity price of $35/MWh. Such low renewable energy prices are already possible in sunny and windy parts of the world.

When will Electrogenos' technology be commercially available?

Electrogenos' electrodes and stacks are still at a fairly early stage of development, with only small versions of "a few hundred watts" having been proven in the laboratory. They are looking to do a 4kW stack by the beginning of next year, then 20kW and 100kW. In the meantime, in Italy, Electrogenos is going to be designing and building their first manufacturing plant — and that will allow to coat metre-squared-sized electrodes. That should be finished by the end of 2024, which means that in Q1 2025, Electrogenos should be building its first megawatt-sized electrolyser, and looking to test that with a corporate partner. They plan to do one 1MW unit first and then add more electrodes. Electrogenos hopes the 5MW model will be ready for sale in the summer of 2025.

Like many start-ups, the company still needs more funding to reach commercialisation, and last month opened a new £5m ($6.3m) "seed" funding round to help fund the Italian plant, scale up the electrolysers and keep the company operating "well into 2025".

***Source:** Accelerate Hydrogen newsletter, Dec 7, 2023*

On's New Running Clothes are Made from Air Pollution

On's Pace collection will use polyester that's been partially made from carbon emissions.

Polyester clothing is made in a process that uses ethanol - and that ethanol is normally made from petroleum or gas. But a new line of T-shirts, tanks, and shorts from On, the Swiss sportswear brand, is made, in part, from carbon emissions instead.

On partnered with LanzaTech, a biotech company that uses bacteria to transform emissions into chemicals. The company captures gas from a steel mill in China and then feeds it to microbes inside bioreactors. The process—similar to brewing beer—creates byproducts that can be made into ethanol that then can be turned into polyester.

Company wants to move away from fossil-based resources entirely. Last year, after six years of research, the company worked with LanzaTech to prototype a pair of sneakers with a midsole also made from carbon emissions. Sixty-four percent of the material that the brand uses for apparel and accessories is already fossil-free; the new clothing, called the Pace collection, is a step forward in reaching that goal in technical sportswear.

The final material, which the company calls CleanCloud, is engineered into a performance fabric. Design teams turn the polyester yarn into a garment with high functionality and aesthetics that feel suitable for running.

The company explored a few different paths to make ethanol from carbon emissions, and chose to work with LanzaTech after analyzing scalability, time to market, the investment needed, and the total carbon footprint. Right now, it's only possible to make a material from 20% recycled emissions. That's because polyester is made with 20% ethylene glycol—the part made from ethanol—and 80% from another material, PTA, that can't be made from CO_2. On is also exploring ways to de-fossilize PTA.

Some other clothing brands have launched capsule collections in collaboration with LanzaTech—like holiday dresses from Zara. But On wants to make the material an ongoing part of its supply chain.

Scaling the technology up across the apparel industry will require an appetite and investment from not only fellow brands, but consumers as well.

Iron Ore Production in India

FINANCIAL YEAR	QUANTITY (MN TONNES)	VALUE (₹ CRORE)
2023-24*	127.79	42,577.3
2022-23	257.85	79,930.61
2021-22	253.974	96,381.33
2020-21	205.042	52,729.25
2019-20	244.083	49,643.06
2018-19	206.495	45,346.58

*April to September; **Source:** Ministry of Mines

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Shri S C Suri graduated with a Bachelor Degree in Science (B.Sc.) in Chemistry Honours with second rank in Delhi University in 1957.

He completed his post graduate studies in Metallurgy from IISc Bangalore in 1959.

He joined SAIL in 1959.

During his various positions in SAIL, he travelled widely on several occasions to Europe, USA, UK and Japan.

Shri Suri superannuated from SAIL as Executive Director in September 1995.

After his superannuation, he worked as Advisor/ Consultant in SAIL, MMTC Centre for Policy Research.

He became a Life Member of IIM in 1988, Life Fellow of IIM in 1993 and Honorary Member in 2013. He has been associated with IIM Chapters at Durgapur, Ranchi and Delhi. Shri Suri was Chairman of IIM Delhi Chapter from 2013-14 to 2014-15. He was National Council Member of IIM for several years.

He was bestowed with IIM Outstanding Service Award in 2015.

He was closely associated with organising several Minerals, Metals, Metallurgy and Material (MMMM) International Conference & Exhibition, a biennial flagship event of IIM Delhi Chapter, at Pragati Maidan, New Delhi from 2010 to 2018.

Shri Suri wrote a Book on “Indian Steel Perspectives 2025”.