NETZERO CORE

building a sustainable future

Decarborizing the Steel Industry

Cost of Hydrogen Production

Increasing Efficiency of Indian Thermal Power Plants

Regreening Abandoned Mines in India

May 2025, Issue 1/1

Indian Minerals
WE MINE INFORMATION

Content

As I See It

Welcome to the inaugural issue of NET ZERO Core. We all know that Net Zero refers to a state in which the greenhouse gases going into the atmosphere are balanced by removal out of the atmosphere.

The fact of the matter remains that globally temperature is increasing at a steady pace. . The Earth's average surface temperature has increased by about 1.2°C compared to pre-industrial levels. 2024 was the warmest year on record, and the 10 warmest years have all occurred in the past decade. Yet there are palpable strands of optimism as a number of nations and globally acclaimed business units have announced strings of steps to address the issue. In this context, we have long felt the need to bring out a magazine flagging the key issues especially with Indian perspective. However Net Zero is a vast topic with diverse facets for which it is difficult for a single magazine to cover all the aspects of the entire gamut of industries. Hence we will restrict our coverage to Net Zero issues concerning the core sector.

Seven core sectors together currently emit an estimated 11.2 gigatonnes of greenhouse gases a year, representing about 20% of total global emissions. They are: aluminium, cement and concrete, chemicals, steel, aviation, trucking and shipping. To reduce this humongous amount of emission, we need to integrate technological attributes with social and environmental integrity. Net zero must be aligned with broader sustainable development objectives and the pursuit for broader economic opportunities as we say good bye to many obsolete trades.

Trust you will find our content useful and we eagerly look forward to your feedback.

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The Green News

Nextracker Achieves 10 GW Solar Tracker Milestone in India

Nextracker a global leader in advanced solar energy solution has announced that it has surpassed 10 gigawatts (GW) of solar tracker deployments in India—a major milestone reinforcing its market leadership and the country's accelerating solar adoption. With 1.8 GW of projects added in the last quarter alone, Nextracker's India portfolio now totals over 10 GW, underscoring strong momentum in solar adoption. Recent project wins include a 305 MW project with ReNew in Anantapur, along with 1.5 GW of projects through partnerships with key EPCs (engineering, procurement, and construction companies) across the country—highlighting Nextracker's expanding presence in India's high-growth solar regions.

Potash blocks auctioned for first time as India hands out 10 mining leases

The government has successfully concluded the auction of 10 out of 15 critical and strategic mineral blocks put up for bidding under the fifth tranche launched on 28 January. These 10 blocks comprise critical and strategic minerals such as graphite, phosphorite, phosphate, rare earth elements, vanadium; and for the first time, potash and halite spread across Chhattisgarh, Karnataka, Madhya Pradesh, Odisha, Rajasthan and Uttar Pradesh.

India registers 3-fold growth in renewable energy capacity to 232GW in last decade

India has logged threefold growth in its renewable power capacity in the last decade, with the installed green energy capacity reaching 232GW, including large hydro power plants, currently compared to 75.52GW capacity in March 2014, official sources said. India has emerged as a global front runner in renewable energy space as the traiff of the grid-connected solar power plants has gone down by 80 per cent to Rs 10.95 per unit (for 170MW at Neemuch), sources said. In March 2014, India's installed solar energy capacity was 2.82 GW, which has crossed 108GW now, recording multifold growth. Wind energy capacity has more than doubled to 51GW presently from 21GW in 2014.

Adani Green Energy operational RE capacity increases to 14,528.4 MW

Adani Green Energy Ltd's total operational renewable generation capacity has increased to 14,528.4 MW. Adani Renewable Energy Fifty Seven Ltd, a wholly-owned step down subsidiary of the company, has operationalised an incremental solar power project of 187.5 MW at Khavda, Gujarat. With operationalisation of this plant, AGEL's total operational renewable energy generation capacity has increased to 14,528.4 MW, the company said in a filing.

Reliance to start solar module factory this year

As per information received, Reliance Industries will start its solar photovoltaic modules factory this year. India has been scrambling to meet its clean energy targets after falling short in 2022. Over the past year, the country has ramped up investments in the sector, but needs to double capacity additions over the next five years to meet its target of 500 GW non-fossil power capacity by 2030, a Global Energy Monitor report showed. Reliance aims to eventually scale up solar module capacity to 20 GW per year.

Juno Joule Partners with Germany's Select Energy for $1.3 Billion Green Hydrogen Facility in Andhra Pradesh

India's Juno Joule Green Energy and Germany's Select Energy GmbH have signed an MoU to build a $1.3 billion (₹10,000 crore) green hydrogen and ammonia export facility at Mulapeta Port in Andhra Pradesh. Planned in three phases, the project aims to produce 180 KTPA of green hydrogen by 2029, converting it into one million tons of green ammonia annually for export.

Coal gasification at Deucha Pachami Coal Block

WB Govt. plans to use clean coal gasification technology to tap into the vast Deocha Pachami coal reserves.The move is part of the govt's push towards sustainable energy solutions and energy security. The Deocha Pachami coal block will see 30% of its reserves used for underground coal gasification in areas where conventional mining is unfeasible. The remaining 70% will be mined through open-cast and underground methods.

Tata Steel advances green steelmaking plans through major crane project

Tata Steel UK has taken another major step in its journey to produce green steel, with a new contract awarded to JASO Industrial Cranes, a leading manufacturer of process cranes globally. As part of Tata Steel's 1.25 billion pound investment in sustainable steel production at Port Talbot in the UK, JASO will supply seven high-capacity process girder cranes to support the operation of the plant's Electric Arc Furnace (EAF) facility. When fully operational in 2028, Tata Steel's Electric Arc Furnace will be one of the largest in the world and reduce the site's carbon emissions by 90 per cent - equivalent to five million tonnes of CO_2 a year.

ArcelorMittal Nippon Steel India targets green steel by 2027

ArcelorMittal Nippon Steel India (AM/NS India) plans to invest ₹2.6 lakh crore to increase steel production capacity and advance green steel initiatives, potentially reshaping India's steel industry. The joint venture between global steel giants ArcelorMittal and Nippon Steel intends to increase total capacity to 40 million tonnes per annum (MTPA) by 2035.

The investment of ₹1.35 lakh crore will establish a 17.8 MTPA integrated steel plant in Anakapalli district, Andhra Pradesh. The plant will be developed in two phases. Phase 1 will include a 7.3 MTPA unit with an investment of ₹55,964 crore and is expected to be operational by January 2029. Phase 2 will add 10.5 MTPA at a cost of ₹80,000 crore, with completion scheduled for 2033.

Decarbonizing the Steel Industry

Decarbonizing the steel industry is critical, as it accounts for ~7-9% of global CO_2 emissions, largely due to its reliance on coal in blast furnaces.

India, the second-largest steel producer, has clearly outlined its intention to reduce the emissions intensity of its GDP by 33-35% by 2030 from 2005 levels at COP21 (UNFCCC, NDCs, 2015). At COP26, India made a commitment to achieve net-zero emissions by 2070, an ambitious goal for its rapidly expanding steel industry (COP26, 2022). At the event, the Government of India presented five nectar elements (Panchamrit) of India's climate action plan:

i. Reach 500GW non-fossil energy capacity by 2030.
ii. 50% of its energy requirements from renewable energy by 2030.
iii. Reduction of total projected carbon emissions by one billion tonnes from now to 2030.
iv. Reduction of the carbon intensity of the economy by 45% by 2030, over 2005 levels.
v. Achieving the target of net zero emissions by 2070.

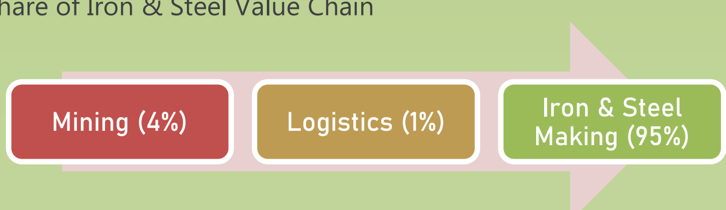
> "In India, Green Steel is defined by its carbon emissions relative to the established threshold. Steel must emit less than 2.2 tonnes of CO2 per tonne to be considered green. The rating system categorizes steel by its emissions reductions, with five stars awarded to steel emitting less than 1.6 tonnes."

STEEL MAKING PATHWAY IN INDIA

RAW MATERIALS	IRON MAKING	STEEL MAKING
Coal	Blast Furnace	Basic Oxygen Furnace (43%)
Iron Ore	DRI	Electric Arc Furnace (22%)
Lime Flux	Smelting	Induction Furnace (35%)
Scrap		
Others		

The iron and steel sector are highly energy consuming and high emissions industry. It accounts for 8% of global energy use and 7% of direct CO2 emissions and 3% indirect CO2 emission (IEA, 2020). In India, total CO2 emissions from this sector is 250 MtCO2 which is around 10% of total emission and this will further increase to 800 MtCO2 by 2050, if no concerted action to decarbonise is taken. Iron and steel production alone is responsible for around 95% of overall emissions in the Iron and Steel value chain, from mining to steel making.

Emission Share of Iron & Steel Value Chain



GREEN STEEL MAKING PATHWAYS

Green Hydrogen: Using hydrogen produced from renewable energy as a reducing agent in direct reduced iron (DRI) processes. Projects like HYBRIT in Sweden aim for fossil-free steel by 2035, with pilot plants already operational. Hydrogen-based DRI could cut emissions by up to 95% compared to traditional blast furnaces.

Electrification: Electric arc furnaces (EAFs) powered by renewable energy, paired with recycled scrap steel, emit significantly less than coal-based methods. EAFs are already widely used (e.g., ~70% of U.S. steel production), but scaling requires more scrap availability and clean energy grids.

Carbon Capture and Storage (CCS): Retrofitting blast furnaces with CCS can capture 65-90% of CO2 emissions. Projects like ArcelorMittal's Ghent plant in Belgium are testing large-scale CCS, though high costs and energy demands remain challenges.

Alternative Fuels and Processes: Biomass (e.g., charcoal) or synthetic gases like syngas can replace coal in some processes. Emerging tech like molten oxide electrolysis (e.g., Boston Metal) could produce steel without emissions but is still in early stages.

GLOBAL EMISSIONS:

Steel production accounts for 7-9% of global CO_2 emissions, ~2.6-3.4 billion tons annually (IEA, 2023).

- Energy Intensity: Traditional blast furnaces emit ~1.8-2.2 tons of CO_2 per ton of crude steel; electric arc furnaces (EAFs) using scrap emit ~0.4-0.6 tons (World Steel Association, 2024).
- Production Volume: Global steel output is ~1.9 billion tons/year, with China producing ~54% (~1 billion tons, 2023).

CHALLENGES:

- Cost: Green steel production is 20-40% more expensive due to higher energy and tech costs.
- Scale: Global steel demand (~1.9 billion tons/year) requires massive infrastructure shifts.
- Energy: Decarbonized processes need vast amounts of renewable electricity (e.g., 4,000 TWh globally for hydrogen-based steel by 2050).
- Energy Demand: Shifting to hydrogen-based steel could require 4,000 TWh of renewable electricity globally by 2050, ~10% of current global electricity production (Bloomberg NEF, 2024).
- Cost Premium: Green steel production costs 20-40% more than conventional methods ($600-800/ton vs. $400-500/ton, 2024 estimates).

PROGRESS:

- Over 50 global projects are piloting low-carbon steel (e.g., H_2 Green Steel in Sweden, targeting 5M tons by 2030).
- Policy support like the EU's Carbon Border Adjustment Mechanism and U.S. clean energy incentives are driving investment.
- Companies like SSAB and Tata Steel aim for net-zero by 2045-2050.

DECARBONIZATION POTENTIAL:

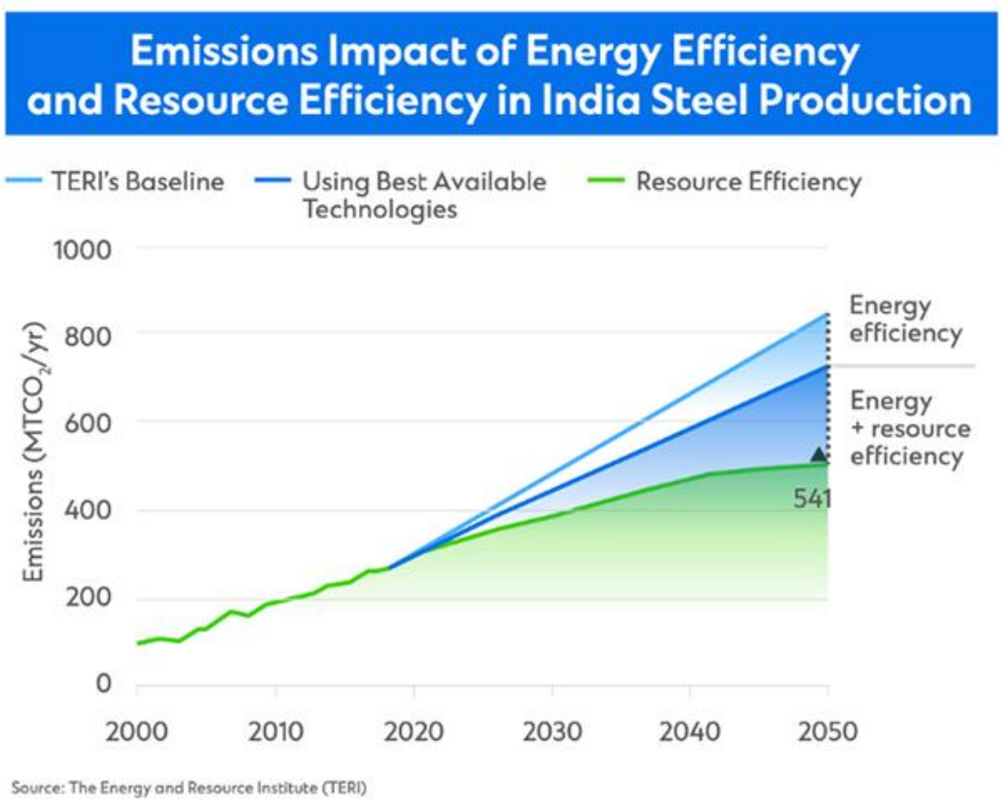
- Hydrogen-based DRI: Up to 95% emissions reduction compared to blast furnaces (HYBRIT, 2024).
- CCS: Captures 65-90% of blast furnace emissions, with pilot projects achieving 1.5 tons CO2 captured per ton of steel (ArcelorMittal, 2023).
- EAF with renewables: ~70% lower emissions than coal-based methods when using 100% scrap and clean energy (IEA, 2022).
- Investment Needs: $1.4 trillion required by 2050 for net-zero steel, including $600 billion for hydrogen infrastructure (IEA, 2023).
- Project Scale: Over 50 low-carbon steel projects globally, e.g., H2 Green Steel (Sweden, 5M tons/year by 2030) and SSAB (1M tons fossil-free steel by 2026).
- Policy Impact: EU's Carbon Border Adjustment Mechanism (CBAM) could add €50-100/ton to high-carbon steel imports by 2026 (European Commission, 2023).

PROGRESS TIMELINE:

- 2030: Industry aims for 10-15% emissions reduction (IEA Net Zero Roadmap).
- 2050: 50% emissions cut needed for 1.5°C pathway, with 25% of global production from low-carbon methods (Mission Possible Partnership, 2024).

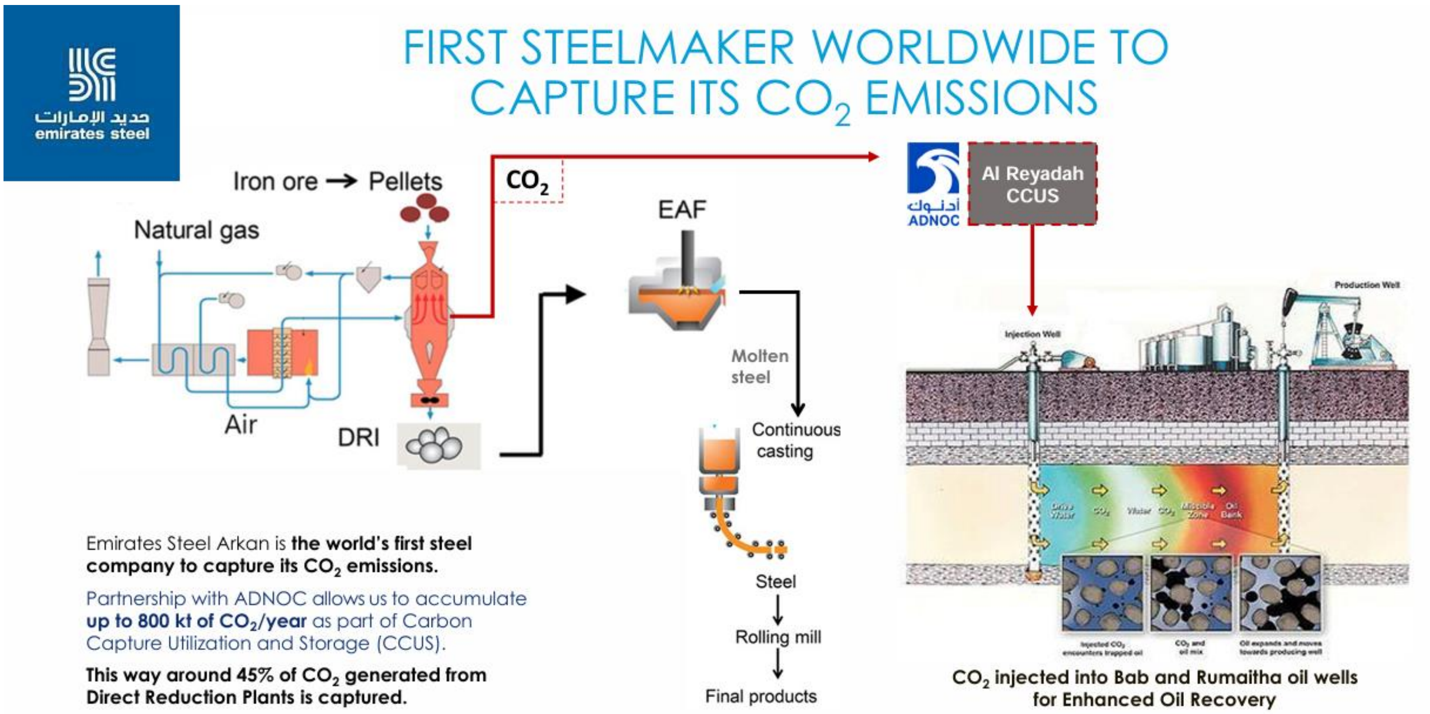
Fuel and Feedstocks	BF-BOF (actual)		BF-BOF (assuming DRI-EAF energy intensity)		NG DRI-EAF		H_2 DRI-EAF
	Energy (GJ/ton steel)	Emissions ($kgCO_2$/ ton steel)	Energy (GJ/ton steel)	Emissions ($kgCO_2$/ ton steel)	Energy (GJ/ton steel)	Emissions ($kgCO_2$/ ton steel)	Energy (GJ/ton steel)
Electricity In DRI In EAF	0.7	87	0.5	58	2.5	312	2.9 1.2 1.8
Coal	18.0	1592	12.0	1059	0.5	44	
Natural Gas	1.0	50	0.7	33	10.1	508	
Hydrogen							8.2
Biomass In EAF In Other (Pellets, Lime)							2.0 1.4 0.6
Total Energy and CO_2	19.7	1730	13.1	1150	13.1	864	13.1

(Source: Sources: IEA 2019; HYBRIT 2018; EIA 2020e, 2020g)

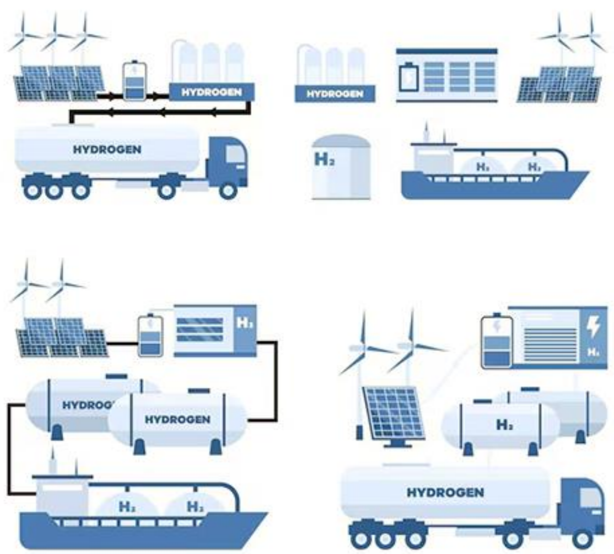


THE DECARBONIZATION PATH

	SMART CARBON USAGE (SCU)		CARBON DIRECT AVOIDANCE (CDA)
PATHWAYS	PROCESS INTEGRATION WITH REDUCED USE OF CARBON (+ CCS)	CARBON VALORIZATION/ CARBON CAPTURE & USAGE (CCU) (+ CCS	HYDORGEN ELECTRICITY
DESCRIPTION	PROCESS INTEGRATION & INTERNAL USE OF GASES	USE CO / CO_2 FROM STEEL MILL AS RAW MATERIAL (CONVERSION TO HYDROCARBON)	RENEWABLE ELECTRICITY IN BASIC STEELMAKING, EG: PRODUCTION OF H_2 TO REPLACE CO.
INITIATIVES	HISARNA TGR-BF-PLASMA, PEM STEPWISE, TORERO	STEELANOL, CARBON2CHEM, i³UPGRADE, FReSMe EVERSET CARBON2VALUE	H2FUTURE, SUSTEEL HYBRIT, GrInHy, SALCOS, HYDROGEN, HAMBURG, SIDERWIN


emirates steel
FIRST STEELMAKER WORLDWIDE TO CAPTURE ITS CO_2 EMISSIONS
Iron ore → Pellets
CO_2
Natural gas
Air
DRI
EAF
Molten steel
Continuous casting
Steel
Rolling mill
Final products
ADNOC
Al Reyadah CCUS
Injection Well
Production Well
Emirates Steel Arkan is **the world's first steel company to capture its CO_2 emissions.**
Partnership with ADNOC allows us to accumulate **up to 800 kt of CO_2/year** as part of Carbon Capture Utilization and Storage (CCUS).
This way around 45% of CO_2 generated from Direct Reduction Plants is captured.
CO_2 injected into Bab and Rumaitha oil wells for Enhanced Oil Recovery


emirates steel



COST OF HYDROGEN PRODUCTION

Hydrogen can be produced through numerous methods, but current production is dominated by just two, steam reforming of methane and gasification of coal. Both of these production processes emit significant quantities of CO_2, but they can be decarbonized if combined with CCUS. The leading alternative low-carbon production method is electrolysis using power from nuclear or renewable energy sources.

TYPES OF HYDROGEN:

Sl. No.	Name	Comment
1.	Grey Hydrogen	from natural gas via steam methane reforming, SMR, without carbon capture
2.	Brown Hydrogen	from Coal (without CCUS)
3.	Blue Hydrogen	from natural gas with carbon capture, utilization, and storage, CCUS
4.	Green Hydrogen	from renewable electricity via electrolysis

Other Methods:

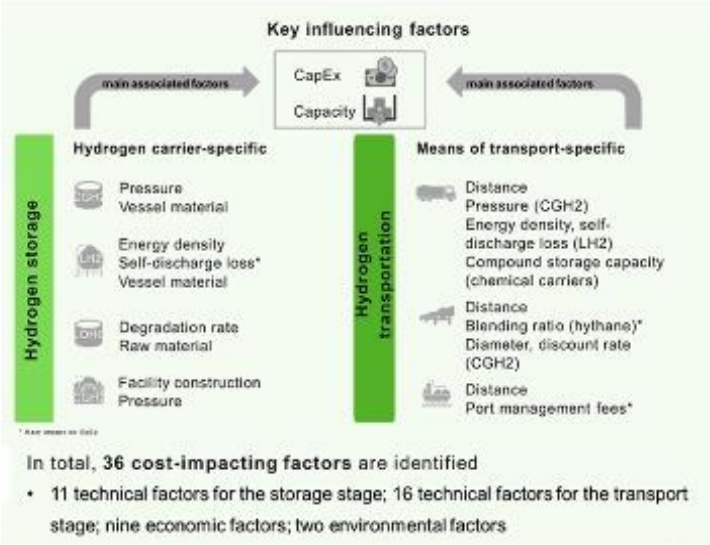
- Electrolysis using grid electricity or nuclear power: \$4–6/kg in the US, depending on energy costs.
- Solar thermochemical or wind-based methods: \$3.6–3.7/kg, but less common.
- Geologic (white) hydrogen: Potentially under \$0.5/kg in resource-rich areas, though not yet widely commercialized.

COST OF HYDROGEN VS COST OF GASOLINE IN INTERNATIONAL MARKET:

Item	Green Hydrogen	Gasoline
Source	Water	Crude Oil
Supply	Infinite	Finite
Renewable	Yes	No
Carbon Footprint	No	Yes
Cost	\$3.00 –8.0kg (gge)	\$2.32/gallon
Source cost	\$0.0015/gallon	\$1.98/gallon
Refinery Costs	\$700 – \$3,500/bpd	\$1,000 – \$5,000/bpd
Mileage	81/kg	18–31/gallon

COST OF HYDROGEN:

Cost-effective hydrogen supply chains are crucial for accelerating hydrogen deployment and decarbonizing economies, with the storage and transportation sectors representing major challenges. The cost of hydrogen production in 2025 varies significantly depending on the production method, energy source, and region.



(Source: Xing Lu AnneCharlotte Krutoff , Mona Wappler , Anja Fischer)

The Cost Component:

Items	Grey Hydrogen	Blue Hydrogen	Green Hydrogen
Cost:	Approximately €1–2 per kilogram (kg) or $0.98–2.93/kg, depending on regional natural gas prices	Around $1–4.7/kg, typically $2.8–3.5/kg with gas prices of $6–11/MMBtu.	Currently $3–8/kg, with some estimates at $4.5–6.5/kg. In regions with abundant renewables (e.g., Middle East, Australia), costs can be $3–5/kg.
Factors:	Cheapest option due to low-cost natural gas in regions like the Middle East, Russia, and North America. Costs are driven by fuel prices (45–75% of total cost) and capital expenses	Costs include carbon capture and storage, which add to expenses but reduce emissions. Competitiveness depends on carbon pricing and regulations.	Electricity cost is the largest driver (50–70% of LCOH), requiring ~50 kWh/kg H_2 at $0.03–$0.10/kWh for competitive pricing. Electrolyzer CAPEX has dropped 60% since 2010 (from $10–$15/kg to $4–$6/kg), but rose 50% from 2021–2024 due to higher capital costs.

Other Methods:

- Electrolysis using grid electricity or nuclear power: $4–6/kg in the US, depending on energy costs.
- Solar thermochemical or wind-based methods: $3.6–3.7/kg, but less common.
- Geologic (white) hydrogen: Potentially under $0.5/kg in resource-rich areas, though not yet widely commercialized.

Regional Variations:

- EU: Green hydrogen costs are high ($3–8/kg) but expected to drop with policy support (e.g., EU Green Deal).
- US: Benefits from low natural gas prices ($3.89/MMBtu in 2018) for grey/blue hydrogen ($1.06–2.4/kg) and tax credits (up to $3/kg) for green hydrogen under the Inflation Reduction Act.
- Australia/Middle East: Emerging as low-cost green hydrogen producers ($1–3/kg by 2030) due to abundant solar/wind resources.
- Japan/Korea: Higher costs ($>2/kg by 2050) due to limited renewables, likely relying on imports.

GREEN HYDROGEN

costs could fall 30–50% by 2030, potentially reaching $1–2/kg in optimal regions by 2030–2050, driven by cheaper renewables, electrolyzer advancements, and policies like the US Hydrogen Shot ($1/kg by 2031)

BLUE HYDROGEN

price may stabilize or slightly decrease with improved CCUS, but its role depends on stricter emissions regulations.

GREY HYDROGEN

cost advantage may diminish as carbon pricing increases.

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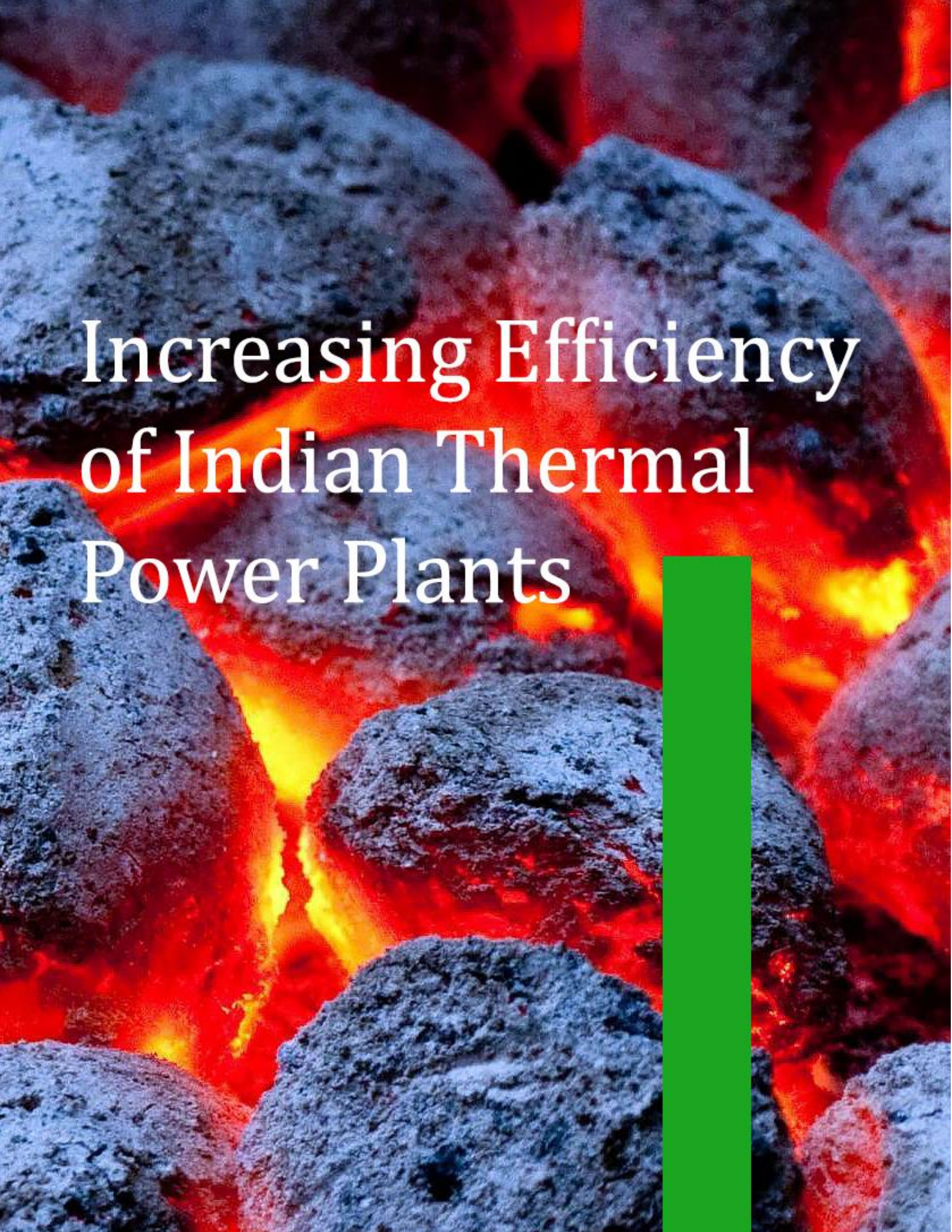
Increasing Efficiency of Indian Thermal Power Plants



Net Efficiency (in %) =

860*(1-APC)/

Gross Heat Rate; or

Net Efficiency (in %) = 860/

Net Heat Rate

Where: APC is expressed in percentage; gross station heat rate and net station heat rate are expressed in kcal/kWh

In spite of focus on Renewable Energy, thermal power is the most viable power generation option in India due to a host of factors. India alone uses more than 70% of its total electrical power from thermal stations. There are three kinds of thermal power plant operations in India that contribute a total capacity of 221,802.59 MW. Thermal stations use a variety of fuels like coal, gas, and diesel (Petroleum) out of which more than 62% of the thermal power generation in India is with Coal. National Thermal Power Corporation (NTPC) owns the five biggest thermal stations in India.

REASONS FOR THERMAL POWER'S POPULARITY IN INDIA:

Thermal power is the most popular source of electricity in India due to a combination of historical, economic, infrastructural, and resource-related factors which are as follows:

- Abundant Coal Reserves: India has vast coal deposits, making coal-based thermal power plants a cost-effective and reliable option. Coal is domestically available, reducing reliance on imported fuels.
- Established Infrastructure: Thermal power plants, particularly coal-based ones, have been the backbone of India's energy sector for decades. The existing infrastructure, including plants, transmission lines, and expertise, supports their continued dominance.
- High Energy Demand: India's rapidly growing economy and population drive a massive demand for electricity. Thermal power plants can generate large amounts of power consistently, meeting base-load requirements effectively.
- Cost-Effectiveness: Despite environmental concerns, coal-based thermal power remains cheaper in the short term compared to alternatives like solar or wind, especially when factoring in initial setup costs and grid integration.
- Reliability and Scalability: Thermal plants provide stable, round-the-clock power, unlike renewable sources that depend on weather or time of day. They can be scaled up to meet increasing demand.
- Policy and Historical Momentum: Government policies and investments in thermal power since India's independence have created a robust ecosystem, including supply chains and technical know-how, making it easier to maintain than transition to newer technologies.
- Challenges with Alternatives: While renewables like solar and wind are growing, challenges such as land acquisition, high initial costs, and grid integration issues have slowed their adoption compared to thermal power.

Today, thermal generation capacity stands at around 245 GW (with average PLF around 60-65%). Of this, coal accounts for around 86.8 per cent (or 211 GW) of thermal generation capacity, while the rest is contributed by gas at 24.8 GW (10.2 per cent), lignite at 6.6 GW (or 2.7 per cent) and diesel (0.2 per cent or 589 MW). India sees renewed thermal power investment surge after a decade-long lull. NTPC, Adani, and Tata Power ramp up capacity as demand rises. Govt targets 95 GW addition by 2032. Shift driven by peak power needs, slow RE integration, and shorter gestation of coal projects.

High ash content in Indian coal (30-40%), aging infrastructure, and financial constraints limit efficiency gains. Addressing these requires coordinated efforts between government, utilities, and private players.

EFFICIENCY OF INDIAN THERMAL POWER PLANTS VIS-À-VIS INTERNATIONAL STANDARDS

The efficiency of thermal power plants in India, particularly coal-based ones, generally lags behind global standards, though there are exceptions and ongoing improvements.

Most coal-based thermal power plants in India operate at an efficiency of around 30-35% (measured as the plant load factor or heat rate efficiency). Older subcritical plants, which dominate India's thermal fleet, have lower efficiencies, often below 33%. Newer supercritical and ultra-supercritical plants achieve efficiencies closer to 38-42%, but these are a smaller share of the total capacity.

Globally, advanced economies like Japan, South Korea, and parts of Europe achieve efficiencies of 40-45% or higher in modern coal plants using ultra-supercritical technology or integrated gasification combined cycle (IGCC) systems. For instance, Japan's Isogo Thermal Power Plant operates at around 45% efficiency. Gas-based thermal plants globally can reach efficiencies above 60% in combined-cycle configurations, while India's gas plants are less common and often less optimized.

Reasons for the Gap:

- Aging Infrastructure: Many of India's thermal plants, especially those operated by state utilities, are old (20-30+ years) and use outdated subcritical technology, leading to lower efficiency.
- Coal Quality: Indian coal has high ash content (30-40%), thereby reducing combustion efficiency and increasing maintenance costs compared to higher-quality coal used in countries like Australia or the US.
- Operational Challenges: Inconsistent maintenance, overloading of plants, and suboptimal operating practices in some Indian plants further reduce efficiency.
- Limited Adoption of Advanced Technology: While countries like China and Japan widely use supercritical and ultra-supercritical technologies, India's transition to these is slower due to cost constraints and reliance on existing infrastructure.

Recent Improvements:

India has been upgrading its thermal power fleet. Newer plants, like those built by NTPC or private players, use supercritical technology, achieving efficiencies closer to 38-40%. The government's push for cleaner coal technologies and retrofitting older plants is narrowing the gap. For example, NTPC's Vindhyachal plant has seen efficiency improvements through modernization.

India's thermal power plants are not yet at par with global standards, primarily due to older technology and coal quality issues, but newer supercritical plants and modernization efforts are closing the gap. The average efficiency of 30-35% in India compares to 40-45% in advanced global plants.

CALCULATION OF EFFICIENCY OF THERMAL POWER PLANTS

The efficiency of a coal power plant is defined in terms of net efficiency, which is the energy input required for generating one unit of useful electricity injected into the grid. It is important to note that the net efficiency is a function of Heat Rate (HR) and Auxiliary Power Consumption (APC). Gross Heat Rate is defined by the Original Equipment Manufacturer (OEM) and is dependent on the technology type. APC expressed in percentage, is a measured value dependent upon various factors such as unit mix, plant layout and type of coal. Another metric to express net efficiency of a plant is operating Net Heat Rate (NHR). This is calculated for a given performance period taking into account the net electricity generation (gross generation minus APC) and the total fuel input (quantum of fuel consumption multiplied by the average fuel calorific value).

By virtue of design, every plant has a designed efficiency level which could be different from the efficiency achieved during operation.

Deviation of operating efficiency from the designed efficiency gives an indication of the variation in the plant performance and thus the level of inefficiency.

STEPS TO INCREASE EFFICIENCY:

Many Indian thermal plants operate at heat rates of 2,400–2,800 kcal/kWh, significantly higher than global best practices (~2,000 kcal/kWh). Targeting a 10-15% improvement in heat rate could save millions of tonnes of coal annually. Improving the efficiency of Indian thermal power plants, which are predominantly coal-based, involves addressing technical, operational, and policy-related aspects. Here are possible steps to enhance their efficiency:

ADOPT ADVANCED TECHNOLOGIES

Supercritical and Ultra-Supercritical Technology	Integrated Gasification Combined Cycle	Advanced Combustion Systems

UPGRADE EXISTING INFRASTRUCTURE

Retrofitting Old Plants	Improve Coal Quality	Modernize Control Systems

ENHANCE OPERATIONAL PRACTICES

Optimize Plant Load Factor (PLF)	Reduce Auxiliary Power Consumption	Regular Maintenance and Overhauls

IMPROVE HEAT RATE

Turbine Upgrades	Condenser Optimization	Waste Heat Recovery

FUEL MANAGEMENT

Coal Blending	Alternative Fuels

ENVIRONMENTAL AND EFFICIENCY SYNERGIES

Flue Gas Desulfurization (FGD)	Carbon Capture and Utilization

LEVERAGE DATA AND DIGITALIZATION

AI and Machine Learning	Digital Twins

POLICY AND REGULATORY MEASURES

Incentivize Efficiency Upgrades	Stricter Efficiency Standards	Phase Out Old Units

Source: Thermal Power Plants in India. Technical opportunities for improving efficiency and reducing emissions: Shakti Sustainable Energy Foundation

Regreening Abandoned Mines in India

Re-greening abandoned mines in India involves restoring degraded land to support ecological recovery and sustainable use through afforestation, soil rehabilitation, and community-focused initiatives.

There are provisions in the Mineral Conservation and Development Rules (MCDR), 2017, prescribing procedures for abandonment of mines which inter alia, require carrying out protective, reclamation and rehabilitation work in accordance with the mine closure plan.

As per Rule 24 of MCDR 2017, a Final Mine Closure plan is required to be submitted by the lessee to the Competent Authority for approval two years prior to the proposed closure of the mine. The Final Mine Closure Plan envisages type of land use proposed by the lessee after complete extraction of mineral which includes proposals for proper reclamation and rehabilitation of the area affected by mining. Mine Closure has to be completed within the specified time period. The mine owner has the responsibility to ensure that the protective measures including reclamation and rehabilitation works have been carried out in accordance with the approved mine closure plan. After the mine closure, the land can be put to alternate use.

The Indian Bureau of Mines (IBM) identified 297 abandoned mine sites before the 2003 Mine Closure Plan rules, with 82 still requiring reclamation. The National Mineral Policy 2019 and the Ministry of Environment, Forest and Climate Change (MoEFCC) emphasize re-grassing and ecological restoration as mandatory for mined-out areas. These examples align with India's push for sustainable mining and compliance with environmental regulations, though challenges like inadequate funding, lack of monitoring, and socio-economic impacts on local communities persist.

Name of the Project	Initiative	Details	Impact
Piparwar OCP, Central Coalfields Limited (CCL), Jharkhand	The Piparwar Open Cast Project developed 30 acres of backfilled and reclaimed land into "Kayakalp Vatika," a biodiversity restoration project.	The site features multiple species of medicinal plants, three water bodies, and a vermicompost unit to enhance soil fertility and reinstate ecological balance.	This initiative was recognized by the Comptroller and Auditor General (CAG) for its contribution to biodiversity restoration.
Bharatpur Opencast Mine, Mahanadi Coalfields Limited (MCL), Odisha	MCL implemented a unique reclamation project by growing vegetables on an overburden dump at the Bharatpur opencast mine.	This approach combines agricultural productivity with land restoration, utilizing the reclaimed land for sustainable food production.	The project demonstrates an innovative use of mined-out land, promoting both ecological and economic benefits.
Neyveli Lignite Corporation India Limited (NLCIL), Tamil Nadu	NLCIL reclaimed over 2,600 hectares of mined-out land through large-scale afforestation.	Nearly 28 lakh (2.8 million) saplings were planted to transform barren landscapes into green zones, focusing on ecological restoration.	The afforestation efforts have helped restore ecological balance and create thriving green areas in previously degraded mine sites.

Name of the Project	Initiative	Details	Impact
Panchapatmali Bauxite Mines, Koraput, Odisha	The National Aluminium Company Limited (NALCO) implemented a systematic restoration process at the Panchapatmali bauxite mines.	Topsoil and overburden are carefully removed, stored, and refilled in their original order after mining. Measures are taken to prevent muddy runoff, and extensive planting of native species is conducted to restore the hill and forest ecosystems.	This approach has shown visible positive results, restoring the landscape close to its original state and serving as a model for ecological restoration in mining areas.
Tummalapalle Uranium Mining Area, Cuddapah, Andhra Pradesh	A case study focused on reclaiming abandoned uranium mine tailings in Tummalapalle	The project involved phytostabilization using plants like sunflower and Indian mustard, which are known for accumulating uranium, to remediate contaminated soil. Soil amendments and native plant species were used to stabilize tailings and reduce environmental risks.	The initiative supports ecological remediation of radioactive waste sites, reducing health hazards for nearby communities and livestock while promoting biodiversity.

Panchapatmali Bauxite Mines, Koraput

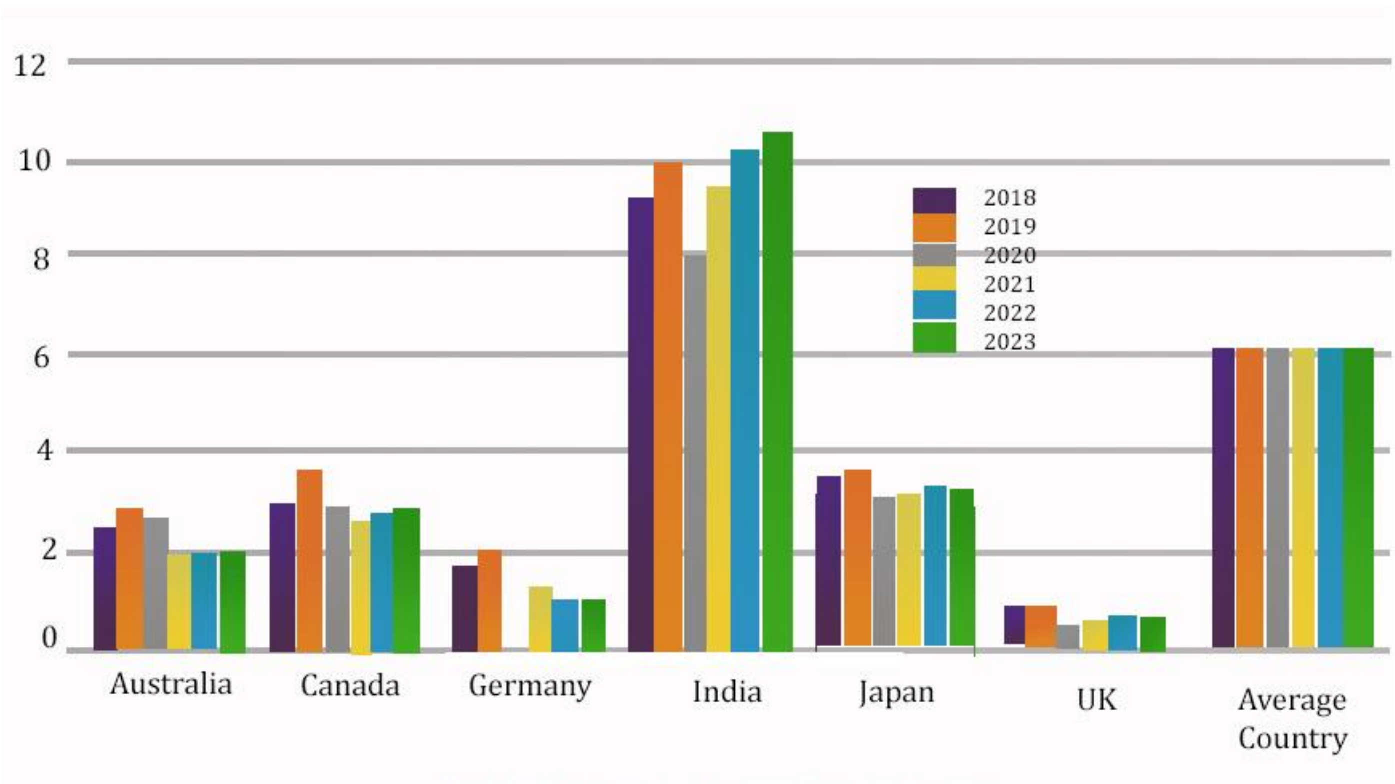
Key Strategies Used in These Examples:

- Afforestation and Reforestation: Planting native and medicinal trees, shrubs, and grasses to restore biodiversity and stabilize soil.
- Soil Amelioration: Using organic amendments (e.g., vermicompost, green manuring) and chemical treatments (e.g., gypsum for sodic soils) to improve soil fertility and structure.
- Phytoremediation: Employing plants like sunflower and Indian mustard to absorb heavy metals or stabilize contaminated soils, as seen in Tummalapalle.
- Backfilling and Recontouring: Refilling mined-out areas with overburden and topsoil in a systematic manner to restore the original landscape, as practiced in Panchapatmali.
- Innovative Land Use: Converting reclaimed land for agriculture (e.g., vegetable farming in Bharatpur) or biodiversity parks (e.g., Kayakalp Vatika) to ensure sustainable post-mining land use.

These initiatives highlight India's efforts to balance ecological restoration with socio-economic benefits, though scaling up and ensuring long-term monitoring remain critical for success.

Kayakalp Vatika, Piparwar OCP

Green Fact Sheet...



FOSSIL FUEL SUBSIDY (% OF GDP)

Here total subsidy means sum of explicit subsidies (undercharging for the supply costs of fossil fuels) and implicit subsidies (undercharging for environmental costs and forgone consumption tax revenues). The full gap between efficient prices (the sum of supply, environmental, and other costs) and retail prices multiplied by consumption equals the total fossil fuel subsidy. (Source: IMF)

Price Trends..

Name	Source	Price (USD)	Month
Silicon Wafers	UK	354/PC	April 2025
Undiffused Monocrystalline Silicon Wafers	China	0.15/PC	May 2025
Solar Module 615 W	China	60.76/PC	April 2025
Polysilicon Brick P Type	China	8.60/KG	May 2025
Lithium Metal	Germany	94/KG	May 2025
Cobalt Metal	Morocco	22.05/KG	May 2025
Cobalt Metal Powder AH 1	China	28.4/KG	May 2025
Nickel Metal Hydride	Malaysia	509.5/KG	May 2025
Copper	India	8.10/KG	April 2025
Natural Flake Graphite FC-90%	Madagascar	625/MT	April 2025
Natural Flake Graphite	India	1.4/KG	April 2025
Gallium Nitrate Hydrate	USA	1944/KG	May 2025
Manganese Sinter (Mn : 45.82%)	South Africa	215.5/MT	April 2025
Manganese Ore (Mn:46%)	Gabon	240/MT	April 2025
Zinc Ingots	Spain	2812/MT	May 2025
Zinc Ingots	India	2765/MT	May 2025
Rare Earth Metal	China	2750/KG	April 2025
Universal Zircon Sand	Australia	1.84/KG	April 2025
Zircon Sand Zig Grade	South Africa	1.9/KG	April 2025

(Prices are at Indian ports)