BY SPEED POST

Steel Authority of India Limited
Rourkela Steel Plant
Rourkela – 769011
Fax : 0661-2510183

Ref. No. : 691/EE/59/169,
Date : 03/11/2025.

Dear Sir,

Sub : Implementation Status of Env. Clearance Conditions issued to RSP.
Ref.: EC vide ref. no. F No. J-11011/66/2014-IA II(I), dated 30/03/2022.

Thank you very much for granting the following Environment Clearance for Modernization & Expansion of Rourkela Steel Plant to enhance the capacity of 4.855 MTPA Hot Metal, 4.850 MTPA Crude Steel & 4.325 MTPA Saleable Steel, within the premises of Rourkela Steel Plant of M/s Steel Authority of India Limited (SAIL) at village Rourkela, Tehsil Rourkela, District Sundergarh, Odisha.

EC vide ref. no. F No. J-11011/66/2014-IA II(I), dated 30/03/2022 for Modernization cum Expansion SAIL – Rourkela Steel Plant for enhancing Hot Metal Production from 4.500 to 4.855 MTPA, Crude Steel Production from 4.200 to 4.850 MTPA and Saleable Steel Production from 3.880 to 4.325 MTPA by installing Coke Oven Battery#7, Steel Melting Shop#3, New Normalising Furance in New Plate Mill, New Oxygen Plant, Natural Gas Pipe Line Network inside the existing plant premises and adopting technological measures in existing Blast Furnaces for enhancing production viz., Granshot, Stove No.4 in BF#5 and Micro Pellet Plant.

A time bound action plan for implementation of the special and general conditions mentioned in the above Environment Clearance order is prepared and the same is enclosed herewith as Annexure-5. The softcopy is mailed and uploaded to the web sites of MoEFCC & SAIL.

Thanking you sir,

With warm regards,

Yours faithfully,
For Rourkela Steel Plant,

(P C Dash)
General Manager I/c
Environmental Engg. Department

Note : Soft copy mailed to roez.bsr-mef@nic.in; mef.or@nic.in

To,
The Dy. Director General of Forests,
Integrated Regional Office,
Ministry of Environment & Forests,
A/3, Chandrasekharpur,
Bhubaneswar. – 751023.

सेल SAIL

Annexure-5

Steel Authority of India Limited
Rourkela Steel Plant's Modernisation cum Expansion Project
(Environment Clearance vide ref.no. F No. J-11011/66/2014-IA II(I), dated 30/03/2022)

Action Plan for Compliance to EC Conditions

Contact Person : Sri P C Dash, GM I/c (Env. Engg.) Phone : 0661-2447258; 8895500627 & V V R Murty, GM(Env.Engg.) M:8895500628
(April – September.,2025)

Project: **Modernization cum Expansion SAIL – Rourkela Steel Plant for enhancing Hot Metal Production from 4.500 to 4.855 MTPA, Crude Steel Production from 4.200 to 4.850 MTPA and Saleable Steel Production from 3.880 to 4.325 MTPA by installing Coke Oven Battery#7, Steel Melting Shop#3, New Normalising Furance in New Plate Mill, New Oxygen Plant, Natural Gas Pipe Line Network inside the existing plant premises and adopting technological measures in existing Blast Furnaces for enhancing production viz., Granshot, Stove No.4 in BF#5 and Micro Pellet Plant.**

A) Specific Conditions of EC :

SN.	Specific Conditions of EC	Implementation Status of Action Plan
i.	Tailings from Iron Ore beneficiation plant shall be dewatered in filter press and no slime /tailing pond shall be permitted.	The present project does not envisage Iron Ore Beneficiation.
ii.	Sinter Plant shall be equipped with Sinter cooler waste recovery system and suitable technology for control of dioxins and furans emissions from the plant.	The present project does not envisage Sinter Plant. However, the existing Sinter Plant#2 & Sinter Plant#3 of RSP are provided with sinter cooler waste recovery systems and the waste heat is gainfully utilised back in the sintering process.
iii.	Solid waste utilization : • PP shall install a slag crusher to convert steel slag into aggregate for use in construction industry, fine sand for use as flux in steel plant, sand in brick making and as lime in cement making. • PP shall recycle/reuse 100% solid waste generated in the plant. • Used refractory shall be recycled as far as possible.	• Crushing facilities for converting steel slag into aggregates of different sizes are envisaged under the project. After crushing, the crushed material of bigger sizes will be utilised in construction industry, finer sizes will be used as flux in steel making process, brick making and as lime in cement making. • Micro Pelletisation Plant is envisaged under this project for achieving 100% utilisation of solid wastes. Project has been finalised and contract was signed on 29/08/2024, erection is under progress. • Used refractories are gainfully utilised 100%.

SN.	Specific Conditions of EC	Implementation Status of Action Plan
iv.	Coke oven plant shall be equipped with coke dry quenching facility.	Coke dry quenching facility is envisaged in the proposed project of Coke Oven Battery#7 and is being implemented.
v.	Coke Oven Gas shall be desulfurized.	Coke Oven Gas desulphurisation facilities are envisaged under this project and the same is being implemented.
vi.	Blast Furnaces shall be equipped with Top Recovery Turbine, dry gas cleaning plant, stove waste heat recovery, cast house and stock house ventilation system and slag granulation facility.	The present project does not envisage installation of Blast Furnace. However, Top Recovery Turbine has been provided in Blast Furnace#5. The Stove Waste Heat recovery systems, inhouse slag granulation systems, Cast House and stock house ventilation systems are already provided in both Blast Furnace No. 1 & Blast Furnace No. 5.
vii.	Secondary fume extraction system shall be installed on converters of Steel Melting Shop.	Secondary fume extraction system is envisaged in the present project New SMS#1 and will be implemented. RSP has already implemented Secondary fume extraction system in all existing SMS#2 converters.
viii.	Basic Oxygen Furnace (BOF) gas shall be cleaned dry.	Basic oxygen furnace (BOF) gas cleaning through Dry systems is envisaged in the present project – New SMS#1 and will be implemented.
ix.	85-90 % of billets shall be rolled directly in hot stage. RHF shall operate using only Light Diesel Oil or Mixed BF /CO gas.	Billets are not envisaged in the present project. Basically Rourkela Steel Plant is a flat product plant. All the Reheating Furnaces are being operated with Mixed Gas (Mixer of waste gases generated from Coke Ovens, Blast Furnaces and Steel Melting Shops). In case of emergency/start up of furnaces only, LDO will be used.
x.	Cold Rolling Mill (CRM) shall have CETP to treat and recycle the treated water from CRM complex. Sludge generated at CRM ETP shall be sent to TSDF.	The Cold Rolling Mill unit has been put down due to aging. A new CRM is under planning for which a separate EC proposal will be submitted.
xi.	Dust emission from Steel Plant stacks shall be up to 30 mg/Nm3.	The present project envisages all air pollution control systems with a stack emission < 30 mg/Nm3.

SN.	Specific Conditions of EC	Implementation Status of Action Plan
xii.	250929 KLD water shall be drawn from Brahmani River. No GW abstraction is permitted.	No ground water will be drawn. Water drawl from river Brahmani is limited to 2,50,929 KLD, as permitted in earlier ECs.
xiii.	Performance test shall be conducted on all pollution control systems every year and report shall be submitted to Regional Office of the MoEF&CC.	RSP has got carried out performance evaluation of all existing Air Pollution Control systems through an external competent party. The performance evaluation report for the financial year 2024-25 has already been submitted along with EC compliance reports of the period Oct., - March.,2025. For the year 2025-26, tenders have been issued for engaging the external agency.
xiv.	The recommendations of the approved Site-Specific Wildlife Management Plan shall be implemented in consultation with the State Forest Department. The implementation report shall be furnished along with the six-monthly compliance report to the concerned Regional Office of the MoEF &CC.	Based on the recommendation and the approval received from the Principal Chief Conservator of Forests and Chief Wild Life Warden, Dept. of Forests, Govt. of Odisha, RSP has transferred Rs. 1220.79 Lakh to Dept. of Forests for implementation of approved Site-Specific Wildlife Management Plan through DFO, Rourkela. Copy is given as Annexure -1.
xv.	Three tier Green Belt shall be developed in a time frame of one year covering 600.16 ha area with native species all along the periphery of the project site of adequate width and tree density shall not be less than 2500 per ha. Survival rate of green belt developed shall be monitored on periodic basis to ensure that damaged plants are replaced with new plants in the subsequent years. Compliance status in this regard, shall be submitted to concerned Regional Office of the MoEF &CC. In addition, Block plantation shall be done on vacant land within the premises of the plant.	RSP has sanctioned Rs. 418.52 Lakh for carrying out plantation of 2 lakh saplings inside the plant premises which includes new plantation and strengthening of Green Belt, and their subsequent maintenance for two years. Two external agencies have been engaged for carrying out the tree plantation. During 2025-26, plantation of 1 lakh saplings is planned and is under under progress. 30,508 number of saplings have been planted during Apr-Sept., 2025. Survival rate is monitored and casualties will be replaced with the new saplings. The bloc plantation at proposed location is under progress within the premises of the plant.
xvi.	Greening and Paving shall be implemented in the plant area to arrest soil erosion and dust pollution from exposed soil surface.	Being implemented in different areas inside the plant.
xvii.	Zero Liquid Discharge (ZLD) scheme for the entire complex shall be implemented by March, 2023 as committed.	The Treatment System has been established and taken in to line and presently in operation. The treated water after RO system is completely recycled back to water distribution network for gainful utilisation.

B) General Conditions :

SN.	General Conditions of EC	Implementation Status of Action Plan
I.	**Statutory compliance:** i. The Environment Clearance (EC) granted to the project/ activity is strictly under the provisions of the EIA Notification, 2006 and its amendments issued from time to time. It does not tantamount/ construe to approvals/ consent/ permissions etc., required to be obtained or standards/conditions to be followed under any other Acts/Rules/Subordinate legislations, etc., as may be applicable to the project.	Is being followed.
II.	**Air quality monitoring and preservation**	
i.	The project proponent shall install 24x7 continuous emission monitoring system at process stacks to monitor stack emission as well as 04 Nos. Continuous Ambient Air Quality Station (CAAQS) for monitoring AAQ parameters with respect to standards prescribed in Environment (Protection) Rules 1986 as amended from time to time. The CEMS and CAAQMS shall be connected to SPCB and CPCB online servers and calibrate these systems from time to time according to equipment supplier specification through labs recognized under Environment (Protection) Act, 1986 or NABL accredited laboratories.	i. RSP has already installed 34 no. of online continuous (24x7) Continuous Emission Monitoring Systems (CEMS) in different existing Stacks in the plant which are in continuous operation. ii. RSP has also installed 4 no. Ambient Air Quality Monitoring Stations (AAQMS) covering 4 directions and are in continuous operation. iii. All these stations are uplinked with SPCB & CPCB servers through GPRS system. iv. The monitoring report is submitted on monthly basis to SPCB, CPCB & MoEFCC. v. All the new stacks envisaged under this project will be provided with CEMS and the monitoring data will be uplinked with the servers of CPCB & SPCB.
ii.	The project proponent shall monitor fugitive emissions in the plant premises at least once in every quarter through laboratories recognized under Environment (Protection) Act, 1986 or NABL accredited laboratories.	RSP has deployed a NABL accredited laboratory for monitoring Fugitive emissions, inside the plant and the reports are submitted to SPCB, CPCB through monthly Environment Status Reports.
iii.	Sampling facility at process stacks and at quenching towers shall be provided as per CPCB guidelines for manual monitoring of emissions.	Being taken care during establishment of project.

SN.	General Conditions of EC	Implementation Status of Action Plan
iv.	Appropriate Air Pollution Control (APC) system shall be provided for all the dust generating points including fugitive dust from all vulnerable sources, so as to comply prescribed stack emission and fugitive emission standards.	Being taken care during establishment of project.
v.	The project proponent shall provide leakage detection and mechanized bag cleaning facilities for better maintenance of bags.	Being taken care during establishment of project.
vi.	Sufficient number of mobile or stationery vacuum cleaners shall be provided to clean plant roads, shop floors, roofs, regularly.	Two number of truck mounted vacuum cleaners has already been deployed inside the plant. In addition to this, a truck mounted mist canon has been deployed to suppress the dust. Procurement action has taken for procurement of another two number of truck mounted mist canons.
vii.	Recycle and reuse iron ore fines, coal and coke fines, lime fines and such other fines collected in the pollution control devices and vacuum cleaning devices in the process after briquetting/ agglomeration.	The present project envisaged installation of 0.18 MTPA Micro pellet plant for gainful utilisation of fines collected from air pollution control systems, water pollution control systems. Contract has been awarded and the erection work is under progress.
viii.	The project proponent shall be use leak proof trucks/dumpers carrying coal and other raw materials and cover them with tarpaulin	All raw materials like Coal and others are being transported with closed belt conveying systems. Suitable Dust Extraction & Dust Suppression systems are provided.
ix.	Facilities for spillage collection shall be provided for coal and coke on wharf of coke oven batteries (Chain conveyors, land based industrial vacuum cleaning facility).	Chain Conveyor Belt for collection of coke/coal spillages and land based industrial vacuum cleaning facilities are envisaged under COB#7 project and is being implemented.
x.	Land-based APC system shall be installed to control coke pushing emissions.	Land based APC system is envisaged under this project and being implemented.
xi.	Monitor CO, HC and 02 in flue gases of the coke oven battery to detect combustion efficiency and cross leakages in the combustion chamber.	Are being carried out regularly.

SN.	General Conditions of EC	Implementation Status of Action Plan
xii.	Vapor absorption system shall be provided in place of vapour compression system for cooling of coke oven gas in case of recovery type coke ovens.	Vapor absorption system is envisaged under COB#7 project and being implemented.
xiii.	Wind shelter fence and chemical spraying shall be provided on the raw material stock piles.	The envisaged additional coal requirements as raw material will be kept in silos. Dust extraction/suppression systems are envisaged under this project. However water spray arrangements will be made in the old raw material handling plant stock piles.
xiv.	Design the ventilation system for adequate air changes as per prevailing norms for all tunnels, motor houses, Oil Cellars.	Being considered during designing the systems and being complied to.
III.	**Water quality monitoring and preservation**	
i.	The project proponent shall install 24x7 continuous effluent monitoring system with respect to standards prescribed in Environment (Protection) Rules 1986 vide G.S.R 277 (E) dated 3pt March, 2012 (Integrated iron & Steel); G.S.R 414 (E) dated 30th May, 2008 (Sponge Iron) as amended from time to time; S.O. 3305 (E) dated 7th December, 2015 (Thermal Power Plants) as amended from time to time and connected to SPCB and CPCB online servers and calibrate these system from time to time according to equipment supplier specification through labs recognized under Environment (Protection) Act, 1986 or NABL accredited laboratories.	i. 4 number of Continuous Effluent Monitoring Systems have already been provided as per E(P) Rules, 1986 and amended from time to time. ii. All the 6 CEMS are connected to the servers of SPCB and CPCB. iii. These systems are being calibrated from time to time as per specifications.
ii.	The project proponent shall monitor regularly ground water quality at least twice a year (pre- and post-monsoon) at sufficient numbers of piezometers/sampling wells in the plant and adjacent areas through labs recognized under Environment (Protection) Act, 1986 and NABL accredited laboratories.	RSP established 6 number of bore wells with water sampling and monitoring facilities along the plant boundary covering all directions. The water table and water quality are being monitored half yearly basis.

SN.	General Conditions of EC	Implementation Status of Action Plan
iii.	Sewage Treatment Plant shall be provided for treatment of domestic wastewater to meet the prescribed standards.	RSP has established a new Sewage Treatment Plant with MBBR – Moving Bed Bio Reactor Technology, for treating the plant sewage in Sept., 2022 and the same is in operation.
iv.	The project proponent shall provide the ETP for coke oven and by-product to meet the standards prescribed in G.S.R 277 (E) dated 3 pt March, 2012 (Integrated iron & Steel); G.S.R 414 (E) dated 30th May, 2008 (Sponge Iron) as amended from time to time; S.O. 3305 (E) dated 7th December, 2015 (Thermal Power Plants) as amended from time to time as amended from time to time;	Provision of a new Biological Oxydation and De-Phenolisation Plant (BOD Plant) based on MBR/MBBR technology along with RO, is envisaged under this project and will be implemented along with COB#7.
v.	Garland drains and collection pits shall be provided for each stock pile to arrest the run-off in the event of heavy rains and to check the water pollution due to surface run off.	Network of drains along with collection pits are provided in the existing plant and the same will be extended to the new projects also.
vi.	Tyre washing facilities shall be provided at the exit and entrance of the plant gates:	RSP established a Tyre Washing Facility at Hirakud Gate and is in operation.
vii.	Water meters shall be provided at the inlet to all unit processes in the steel plants.	Water meters will be installed in all units envisaged under this project.
IV.	**Noise monitoring and prevention** Noise pollution shall be monitored as per the prescribed Noise Pollution (Regulation and Control) Rules, 2000 and report in this regard shall be submitted to Regional Officer of the Ministry as a part of six-monthly compliance report.	Noise monitoring is being carried out regularly and being submitted on half yearly basis to MoEFCC.

SN.	General Conditions of EC	Implementation Status of Action Plan
V.	**Energy Conservation measures**	
i.	Use torpedo ladle for hot metal transfer as far as possible. If ladles not used, provide covers for open top ladles.	The present project has not envisaged installation of Blast Furnace. However, RSP is using Torpedo Ladles along with open top ladles in existing Blast Furnaces for hot metal transfer.
ii.	Restrict Gas flaring to< 1 %.	Being followed.
iii.	Provide solar power generation on roof tops of buildings, for solar light system for all common areas, street lights, parking around project area and maintain the same regularly	The following Solar Systems are planned under this project; 1. Installation of 291 number of Solar Street Lighting Systems at 20 locations in Bisra, Lathikata & Nuagaon Blocks by allocation of Rs. 150.00 Lakh. 2. 100 number of Solar Street Lighting Systems in the vicinity of Rourkela Steel Plant and Township by allocation of Rs. 69.00 Lakh. 3. Providing 5 number of Solar Drinking Water Systems in Slums around Rourkela by allocation of Rs. 51.90 Lakh Total Budget allocation for Solar Systems = Rs. 270.90 Lakh
iv.	Provide LED lights in their offices and residential areas.	All the packages covered under this project are designed with LED lighting System. In addition all solar street lighting are provided with LED lighting system.
v.	Ensure installation of regenerative/recuperative type burners on all reheating furnaces.	Being complied during establishment of project.

SN.	General Conditions of EC	Implementation Status of Action Plan
VI	**Waste management**	
i.	Oil Collection pits shall be provided in oil cellars to collect and reuse/recycle spilled oil. Oil collection trays shall be provided under coils on saddles in cold rolled coil storage area.	Oil collection trays and pits are provided in the oil cellars to collect and reuse/recycle spilled oil.
ii.	Kitchen waste shall be composted or converted to biogas for further use.	Bio compost plant has already been installed inside Rourkela Steel Plant for converting the kitchen (canteen) waste into compost and the same is gainfully utilised as manure in different gardens inside plant.
VII	**Green Belt**	
i.	The project proponent shall prepare GHG emissions inventory for the plant and shall submit the programme for reduction of the same including carbon sequestration by trees.	The GHG emission inventory report along with reduction programme with Caron sequestration is prepared and attached as **Annexure-2.**
ii.	Project proponent shall submit a study report on De-carbonization program, which would essentially consist of company's carbon emissions, carbon budgeting/ balancing, carbon sequestration activities and carbon capture, use and storage after offsetting strategies. Further, the report shall also contain time bound action plan to reduce its carbon intensity of its operations and supply chains, energy transition pathway from fossil fuels to Renewable energy etc. All these activities/ assessments should be measurable and monitor able with defined time frames.	RSP has engaged M/s Dastur & Co which is a NABET accredited organisation and expert in Steel Industry for preparation of Decarbonisation programme considering the future expansions and adoption of new technologies for Carbon Capture Utilisation Storage (CCUS) The study by M/s Dastur & Co has been completed and the report is attached as **Annexure-3.**
VIII	**Public hearing and Human health issues**	
i.	Emergency preparedness plan based on the Hazard identification and Risk Assessment (HIRA) and Disaster Management Plan shall be implemented.	Is being implemented.
ii.	The project proponent shall carry out heat stress analysis for the workmen who work in high temperature work zone and provide Personal Protection Equipment (PPE) as per the norms.	PPEs are provided as per the norms. Heat stress analysis for workmen is being carried out by Occupational Health Services Centre of Rourkela Steel Plant regularly.

SN.	General Conditions of EC	Implementation Status of Action Plan
iii.	Occupational health surveillance of the workers shall be done on a regular basis and records maintained.	Health check up of all employees, once in a year in Occupational Health Service Centre of Rourkela Steel Plant is made compulsory and the history is maintained digitally.
IX.	**Environment Management**	
i.	The project proponent shall comply with the provisions contained in this Ministry's OM vide F.No. 22-65/2017-IA.III dated 30/09/2020. As part of Corporate Environment Responsibility (CER) activity, company shall adopt nearby villages based on the socio-economic survey and undertake community developmental activities in consultation with the village Panchayat and the District Administration as committed.	RSP established a dedicated CSR department for taking care the overall development of Peripheral villages. RSP adopted 16 villages in 4 number of revenue blocks and are being developed as Model Steel Villages. The villages are Bankibahal, Baniguni, Dumerjore, Jagdishpur, Jaidega, Ushra, Lodosera, Laing, Bijadhi, Dalposh, Jabaghat, Jamsera, Jabapanposh, Kapatmunda, Pograbahal & Chikatmati which are in the revenue blocks of Kuarmunda, Rajgangpur, Bisra & Lathikata. Under CER, a sum of Rs. 741.50 Lakh has been earmarked for overall development of Peripheral villages . The developmental activities in these Peripheral villages are being taken up in consultation with local district administration and other stake holders.
ii.	The company shall have a well laid down environmental policy duly approve by the Board of Directors. The environmental policy should prescribe for standard operating procedures to have proper checks and balances and to bring into focus any infringements/deviation/violation of the environmental / forest / wildlife norms / conditions. The company shall have defined system of reporting infringements I deviation/ violation of the environmental/ forest/ wildlife norms/ conditions and/ or shareholders / stake holders. The copy of the board resolution in this 'regard shall be submitted to the MoEF&CC as a part of six-monthly report.	Steel Authority of India Limited (SAIL) under which RSP is one integrated steel plan has an Environment Policy duly signed and released by Chairman, SAIL. Scanned copy is attached as **Annexure-4.** SAIL-RSP has established a system of capturing violations/ deviations/ ingringements w.r.t. Environment/Forests/Wild Life norms. Under this system the deviation report is prepared on quarterly basis which is duly signed by Director I/c, Rourkela Steel Plant and submitted for review by Board Level Sub Committee of SAIL on quarterly basis. The duly approved copy of the deviation report for the period July - September, 2025 is attached as **Annexure-5.**
iii.	A separate Environmental Cell both at the project and company head quarter level, with qualified personnel shall be set up under the control of senior Executive, who will directly to the head of the organization.	SAIL – Rourkela Steel Plant established a dedicated Environment Engg. Department in Rourkela in the year 1989. The department along with a Environment Laboratory is provided with qualified Environment Engineers and headed by a senior officer in the rank of General Manager I/c.

SN.	General Conditions of EC	Implementation Status of Action Plan
X	**Miscellaneous**	
i.	The project proponent shall make public the environmental clearance granted for their project along with the environmental conditions and safeguards at their cost by prominently advertising it at least in two local newspapers of the District or State, of which one shall be in the vernacular language within seven days and in addition this shall also be displayed in the project proponent's website permanently.	A paper advertisement was released in three news papers viz.,Sambad, Dainik Jagaran &Indian Express covering Odia, Hindi and English languages respectively on 12/04/2022. The scanned copies of the advertisements released are attached as **Annexure-6.**
ii.	The copies of the environmental clearance shall be submitted by the project proponents to the Heads of local bodies, Panchayats and Municipal Bodies in addition to the relevant offices of the Government who in tum has to display the same for 30 days from the date of receipt.	The Environment Clearance copies are submitted to the heads of the following on 06/04/2022; 1. The District Magistrate & Collector, Sundargarh 2. The Commissioner, Rourkela Municipal Corporation 3. The Regional Officer, OSPCB, Rourkela 4. The Secretary, Rourkela Development Authority 5. The General Manager, District Industries Centre, Sundargarh 6. The Chairman, Zilla Parishad, Sundargarh
iii.	The project proponent shall upload the status of compliance of the stipulated environment clearance conditions, including results of monitored data on their website and update the same on half-yearly basis.	The status reports are being uploaded to the web sites of SAIL (www.sail.co.in) & MoEFCC on half yearly basis.
iv.	The project proponent shall monitor the criteria pollutants level namely; PM10, SO2, NOx (ambient levels as well as stack emissions) or critical sectoral parameters, indicated for the projects and display the same at a convenient location for disclosure to the public and put on the website of the company.	The monitored Ambient Air Quality & Stack Emission data viz., PM10, SO2, NOx is being displayed in the form of Flex Boards, in front of Main Gate of RSP and the data is updated once in a quarter. In addition, RSP has established an electronic display board in front of Main Gate to display the Ambient Air Quality and Stack Emission levels continuously for the disclosure to the public. This data is uploaded to the SAIL's website on half yearly basis (www.sail.co.in)
v.	The project proponent shall submit six-monthly reports on the status of the compliance of the stipulated environmental conditions on the website of the ministry of Environment, Forest and Climate Change at environment clearance portal.	Being followed strictly.

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<tr><th>SN.</th><th>General Conditions of EC</th><th>Implementation Status of Action Plan</th></tr>
<tr><td>vi.</td><td>The project proponent shall submit the environmental statement for each financial year in Form-V to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently and put on the website of the company.</td><td>The Environment Statement in Form-V is prepared and submitted to OSPCB regularly before 30th September every year.</td></tr>
<tr><td>vii.</td><td>The project proponent shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities, commencing the land development work and start of production operation by the project.</td><td>
<table>
<tr><th>SN.</th><th>Project Package</th><th>Date of Financial Sanction & Final approval</th><th>Date of commencement of work</th><th>Remarks</th></tr>
<tr><td>1.</td><td>Coke Oven Battery no. 7</td><td>07/09/2024</td><td>Jan.,20025</td><td>Under execution.</td></tr>
<tr><td>2.</td><td>Oxygen Plant</td><td>25.08.2023</td><td>01.05.2024</td><td>Execution is under progress.</td></tr>
<tr><td>3.</td><td>New Steel Melting Shop</td><td>-</td><td>-</td><td>Project is under finalisation.</td></tr>
<tr><td>4.</td><td>Natural Gas Pipe Line Network</td><td>-</td><td>-</td><td>Project is under finalisation.</td></tr>
<tr><td>5.</td><td>New Normalising Furnace</td><td>-</td><td>-</td><td>Project is presently kept on hold due to market conditions.</td></tr>
<tr><td>6.</td><td>Micro Pellet Plant</td><td>01/07/2024</td><td>30/08/2024</td><td>Contract signed on 29/08/2024.</td></tr>
<tr><td>7.</td><td>Stove No. 4 in BF#5</td><td>Jan., 2025</td><td>Jan.,2025</td><td>Under execution</td></tr>
<tr><td>8.</td><td>Granshot in Blast Furnaces</td><td>-</td><td>-</td><td>Project is kept on hold.</td></tr>
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<tr><td>viii.</td><td>The project proponent shall abide by all the commitments and recommendations made in the EIA/EMP report, commitment made during Public Hearing and also that during their presentation to the Expert Appraisal Committee.</td><td>Will be adhered to.</td></tr>
<tr><td>ix.</td><td>No further expansion or modifications in the plant shall be carried out without prior approval of the Ministry of Environment, Forests and Climate Change (MoEF&CC).</td><td>Will be adhered to.</td></tr>
<tr><td>x.</td><td>Concealing factual data or submission of false/fabricated data may result in revocation of this environmental clearance and attract action under the provisions of Environment (Protection) Act, 1986.</td><td>Noted.</td></tr>
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SN.	General Conditions of EC	Implementation Status of Action Plan
xi.	The Ministry may revoke or suspend the clearance, if implementation of any of the above conditions is not satisfactory.	Noted.
xii.	The Ministry reserves the right to stipulate additional conditions if found necessary. The Company in a time bound manner shall implement these conditions.	Noted and will be complied.
xiii.	The Regional Office of this Ministry shall monitor compliance of the stipulated conditions. The project authorities should extend full cooperation to the officer (s) of the Regional Office by furnishing the requisite data/ information/monitoring reports.	Noted and will extend full co-operation to the Integrated Regional Office, MoEFCC, Bhubaneswar by furnishing the requisite data/ information/monitoring reports.
xiv.	Any appeal against this EC shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.	Noted.

Annexure-1

PCCF I/c CWLW's approval of Wild Life Conservation Plan

OFFICE OF THE PRINCIPAL CHIEF CONSERVATOR OF FORESTS
(WILDLIFE) & CHIEF WILDLIFE WARDEN, ODISHA,
BDA APARTMENT, 5TH FLOOR, PRAKRUTI BHAWAN, NILAKANTHA NAGAR, BBSR-12
Ph. No.0674-2564587, FAX No.0674-2565062
(Website:odishawildlife.org, E. mail: odishawildlife@gmail.com)

No. 9355 /1WL-SSP-54/2016
Dated, Bhubaneswar the 29th Nov, 2016

To

The Deputy General Manager (Projects),
Steel Authority of India Ltd.,
Rourkela Steel Plant,
Rourkela

Sub: ***Proposed 3 MTPA Hot Strip Mill, 3.3 MTPA Beneficiation & 2 MT Pellet Plant and Expansion of the existing Special Plate Plant within the premises of Rourkela Steel Plant of M/s SAIL at Rourkela in Sundargarh District - Site Specific Wildlife Conservation Plan***

Sir,

It is to inform you that M/s Steel Authority of India Ltd. has to implement a Site Specific Wildlife Conservation Plan for its proposed 3 MTPA Hot Strip Mill, 3.3 MTPA Beneficiation & 2 MT Pellet Plant and Expansion of the existing Special Plate Plant within the premises of Rourkela Steel Plant at Rourkela in Sundargarh district in compliance to the Generic ToR No.68 prescribed by Govt. of India, MoEF&CC in their letter in F.No. J-11011/66/2014-IA.II(I) dt 27.6.2014.

2. The Site Specific Wildlife Conservation Plan in respect of the above project has been approved by the undersigned with financial forecast of **₹1406.79 lakh** (Rupees fourteen crore six lakh seventy-nine thousand) only for the following activities.

a.	For activities to be implemented by the user agency in project area	₹186.00 lakh
b.	For activities to be implemented by DFO, Rourkela Division in project impact area	₹1220.79 lakh
	Grand Total:	**₹1406.79 lakh**

3. Various activities in the lease hold area will be executed by the Project proponent under the guidance of the Divisional Forest Officer, Rourkela Division. Instructions regarding modalities for deposit of funds of ₹1220.79 lakh for the purpose for implementation of various activities within the project impact area in Rourkela Division will be issued separately.

P.T.O.

-2-

4. The User Agency may be advised to note the following conditions for future compliance.

- This Plan may be revisited after 5 years and the User Agency will give undertaking to contribute towards the revised cost of the conservation plan till the project period, if any.
- The project proponent has to prepare and submit the Conservation Plan for the next 10 years. If there would be need for Site Specific Wildlife Conservation Plan after expiry of the present plan period, the user agency will have to submit another such plan at least one year before the expiry of the present Conservation Plan and deposit the outlay amount upon its approval. In case of delay, it will be dealt as per law for violations of Forest Conservation Act, 1980 and Environment (Protection) Act, 1986.
- The project proponent has to give an undertaking to bear the differential cost in case of enhancement of wage rate at the time of implementation of this plan.

Yours faithfully

Encl: 2 copies of approved
site specific WL Conservation Plan

28/11/16

Principal Chief Conservator of Forests (WL)
& Chief Wildlife Warden, Odisha

Memo No. 9356 /date 29-11-2016

Copy forwarded for information and necessary action to –

1. Special Secretary to Govt. of Odisha, Forest & Environment Deptt.
2. Principal Chief Conservator of Forests, Odisha
3. Regional Chief Conservator of Forests, Rourkela Circle with reference to his memo No.1848 dt 23.8.2016
4. Divisional Forest Officer, Rourkela Division alongwith a copy of the approved site specific wildlife conservation plan with reference to his memo No.5405 dt 22.9.2016

Principal Chief Conservator of Forests (WL)
& Chief Wildlife Warden, Odisha

Annexure-2

Rourkela Steel Plant
GHG Emission Inventory, Reduction and Carbon Storage by Trees
(2024 - 2025)

1. EC Condition :

> i. The project proponent shall prepare GHG emissions inventory for the plant and shall submit the programme for reduction of the same including carbon sequestration by trees.

2. Methodology followed for preparation of Carbon Budgeting for the period 2022-23 to 2029-30 :

a. MoEFCC has issued EC to RSP for a Hot Metal Production of 4.855 MTPA, Crude Steel Production of 4.850 MTPA & Saleable Steel Production of 4.325 MTPA on 30/03/2022.

b. As per the plan the proposed projects will be established over a period of 57 months after getting financial sanctions and finalization of contract. The projects are expected to be established by 2028-29 and will be fully commissioned by 2030.

c. The GHG emission inventory is prepared based on the production level of 2021-22. For the year 2021-22, the Hot Metal Production is 4.337 MTPA & Crude Steel Production is 3.987 MTPA.

d. The Specific CO2 emissions are calculated based on the latest World Steel Association methodology (User Guide Version 11).

e. The CO_2 emissions on account of power consumption in new projects and phasing out of existing old units area considered.

f. Carbon di Oxide sequestration rate of 8.47 kg/Tree/year is considered for Rourkela, as per the suggestion of TFRI, Jabalpur .

g. The survival rate of trees is considered as 80%.

3. Carbon Budgeting for (2020-21 TO 2029-30)

SN.	Description	2020-21	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30
1	Total Crude Steel Production capacity of Rourkela Steel Plant for which EC is obtained (Unit : MTPA)	4.2	4.850	4.850	4.850	4.850	4.850	4.850	4.850
2	Target/Actual production of total crude steel achieved. (Unit : MTPA)	3.499	4.161	4.045	4.390	4.400	4.400	4.400	4.850
3	CO_2 emissions								
3a.	Sp. CO_2 emission Target/Actual from existing steel plant calculated based on IISI methodology for base year (Unit : T/TCS)	2.677	2.613	2.521	2.338	2.330	2.326	2.308	2.199
3b.	Quantum of CO_2 emission from the existing Rourkela Steel Plant (SN. 2 x 3a) (Unit : Tonnes/Year)	9366823	10872693	10197445	10263820	10252000	10234400	10155200	10665150
3c.	Additonal Renewable Power (Hydel & Solar) and Green Power (TRTG & BPTG) MW/Year	0	0	0	15000	15000	15000	15000	15000
3d.	Equivalent quantum of CO_2 emission reduction after commission of newRenewable Energy & Green Energy projects (@ 1 MW = 0.504 Tons of CO_2) (Unit : Tonnes)	0	0	0	7560	7560	7560	7560	7560
3e.	Total net quantum of CO_2 emissions from the existing Rourkela Steel Plant & New Projects (SN. 3b - 3d) (Unit : Tonnes/Year)	9366823	10872693	10197445	10256260	10244440	10226840	10147640	10657590
4	Carbon Sequestration :								
4a.	Plantation made / planned to made in coming years	51299	7792	11481	50000	50000	50000	50000	50000
4b.	Cumulative no. of trees planted since inception.	5105637	5169375	5180856	5230856	5280856	5330856	5380856	5430856
4c.	No. of saplings distributed free of cost to villagers, educational institutions & others for plantation	0	0	0	0	0	0	0.000	0.000
4d.	Cumulative no. of saplings distributed free of cost to villagers, educational institutions & others for plantation	500000	500000	500000	500000	500000	500000	500000	500000
4e.	Total no. of trees planted	5605637	5669375	5680856	5730856	5780856	5830856	5880856	5930856
4f.	No. of tree survived (Survival rate @ 80%)	4084509.6	4135500	4144684.8	4184684.8	4224685	4264685	4304684.8	4344684.8
4g.	Carbon di Oxide sequestration through trees in Rourkela as per TFRI, Jabalpur (@ 8.47 kg/tree/year)	34596	35028	35105	35444	35783	36122	36461	36799
5	Net Carbon di Oxide emission (SN. 3e- 4g) (Unit : Tonnes/day)	25568	29692	27842	28002	27969	27920	27702	29098
6	Reduction of CO_2 in Tons	-	-305	1850	-160	33	49	218	-1396
7	% reduction in quantum of CO_2 reduction w.r.t. previous year	-	-1.0%	6.2%	-0.6%	0.1%	0.2%	0.8%	-5.0%
8	% Reducton in Sp. CO_2 emissions.	-	1.95%	3.52%	7.26%	0.34%	0.17%	0.77%	4.72%

Annexure - 3

[redacted]

[redacted]

[redacted]

[redacted]

Milestone -1 Report

on

Inventorization of Greenhouse Gas Emissions

to

SAIL - Rourkela Steel Limited

Submitted by
M. N. Dastur & Company (P) Ltd.

January 2024

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Report

on

Inventorization of GHG Emissions at SAIL Rourkela Steel Plant

1.0 INTRODUCTION

The Steel manufacturing process is a significant contributor to global GHG emissions, mainly due to the energy-intensive processes involved in converting iron ore into steel. These emissions primarily consist of carbon dioxide (CO_2) which is a potent greenhouse gas. As the world strives to meet ambitious climate targets, inventorization of GHG emissions in the steel industry plays a crucial role in fostering a more sustainable and environmentally responsible future.

As a developing economy, India ranks fourth on the list of highest CO_2 emitters only behind China, USA, and the European Union. Though, India's per capita CO_2 emissions are about 1.9 tonnes per annum, which is less than 40% of the global average and about one-fourth of that of China, we need a sustainable solution for the decarbonization of sectors that contribute to 70% of emission which includes the steel industry.

In line with Government of India's recent commitments at COP26, SAIL reaffirmed its commitment to substantially reduce CO_2 emission and increase share of renewable/non-conventional energy by 2030 through implementation of phase wise decarbonisation road map, primarily focusing on energy efficiency, resource efficiency and energy transition through maximising renewable energy in the energy mix.

To further complement their commitment towards reducing CO_2 emissions, SAIL - Rourkela Steel Limited (RSP) has engaged Dastur to undertake the Low Carbon Transition of SAIL- Rourkela by inventorization of different categories of CO_2 emissions across various facilities/units of RSP and formulation of strategies for mitigation including implementation of new technologies for process improvement, carbon capture and carbon sequestration through tree plantation.

Rourkela Steel Plant, the first integrated steel plant in the Public Sector, was set up with German collaboration with an installed capacity of 1 million tonnes. Its 1st Blast Furnace ‘Parvati’ was lighted up by Dr. Rajendra Prasad, the then President of India on 3rd February 1959.

Rourkela Steel Plant (RSP) in India underwent significant modernization and expansion, increasing its capacity to 4.5 million tonnes of hot metal and 4.2.(1) million tonnes of crude steel. The expansion, dedicated by Prime Minister Narendra Modi on April 1, 2015, marked a substantial growth from its initial capacity. RSP was the first plant in India to adopt LD technology for steel making and is the sole producer of silicon steels for the power sector and high-quality pipes for the oil and gas sector within the Steel Authority of India Limited (SAIL). The plant's product range includes a variety of flat, tubular, and coated products. Additionally, the Odisha group of Mines associated with RSP operates four iron ore mines, contributing to both internal SAIL requirements and supplying raw materials to external customers, with a combined annual capacity of 20.05 million tonnes.

RSP is designed to produce products like Hot Rolled Coils, Hot Rolled Plates, Checkered Plates, Cold Rolled Coils, Cold Rolled Sheets, electrolytic Tin Plates, Galvanised Sheets, Silicon Steel sheets and coils, Spiral Weld Pipes and ERW Pipes. RSP has provided a strong raw material base for a variety of modern engineering industries including automobile, pipe and tube, LPG cylinder, barrel and drum producing industries.

2.0 CARBON EMISSIONS - GHG PROTOCOL

The Kyoto Protocol, the first international treaty to set legally binding targets for cutting greenhouse gas emissions, was adopted on 11 December 1997, in Kyoto, Japan.

It committed industrialized countries to reduce their greenhouse gases emissions in accordance with agreed individual targets. The Protocol mandated that 37 industrialized nations plus the European Community cut their greenhouse gas emissions by an average of 5 per cent below 1990 levels, and established a system to monitor countries’ progress.

In December 2012, after the first commitment period of the Protocol ended, parties to the Kyoto Protocol met in Doha, Qatar, to adopt an amendment to the original Kyoto agreement. This so-called Doha

Amendment added new emission-reduction targets for the second commitment period, 2012–2020, for participating countries.
In 2015, however, countries agreed on yet another legally binding climate treaty, the Paris Agreement, which entered into force in November 2016 and effectively replaced the Kyoto Protocol.[(2)]

The Paris Agreement commits countries to reduce greenhouse gas emissions to keep the global temperature rise below 1.5 degrees Celsius to avoid the worst impacts of climate change. GHG Protocol arose out of the need to help countries and companies account for, report, and mitigate emissions, based on a report that identified an action agenda to address climate change that included the need for standardized measurement of GHG emissions.

3.0 DECARBONIZATION TARGET FOR INDIA

India has continued to demonstrate climate leadership and a firm commitment for achieving the clean energy transition. At COP26 in Glasgow, the Prime Minister of India announced the five nectar elements or Panchamrit - The Gift of Five Elixirs. The four targets to be achieved by the year 2030 included the following:

1. India will reach its non-fossil energy capacity to 500 GW by 2030.

2. India will meet 50% of its energy requirements from renewable energy by 2030.

3. India will reduce the total projected carbon emissions by one billion tonnes from now onwards till 2030.

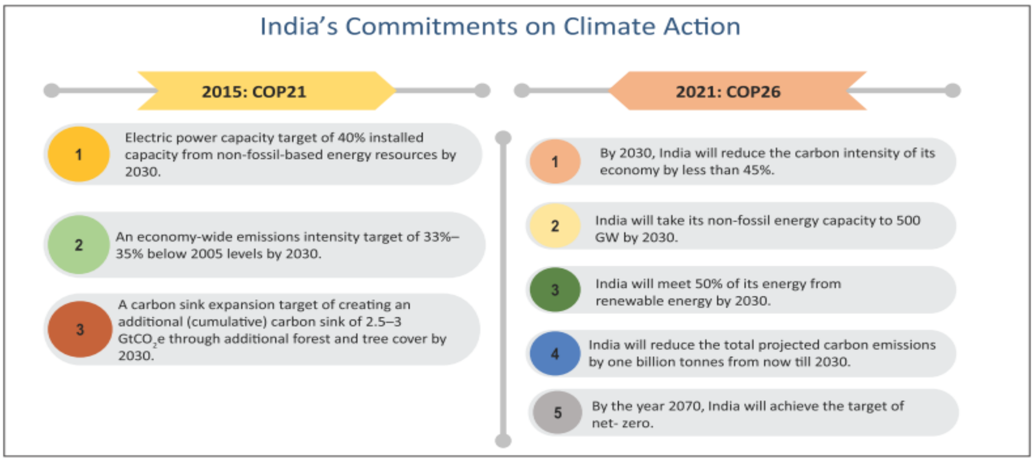
4. By 2030, India will reduce the carbon intensity of its economy by less than 45%.

5. The fifth target announced at COP26 is India’s commitment to net-zero by 2070.

India’s Nationally Determined Contributions (NDCs) were announced at COP21 in 2015 in Paris. The year 2015 marked a seminal moment in the low-carbon transition of India’s power sector when it committed to increase its non–fossil fuel power-generation capacity to 40% by 2030 and installing 175 gigawatt (GW) of renewable capacity by 2022. India’s total non-fossil fuel based power producing capacity, including nuclear, stood at 165 GW in April 2022. It represents 41% of total installed electricity capacity of 401GW (MNRE, 2022). The target of having 40% of non-fossil fuel power capacity by 2030 has already been achieved. India had also achieved emission reduction of 28% over

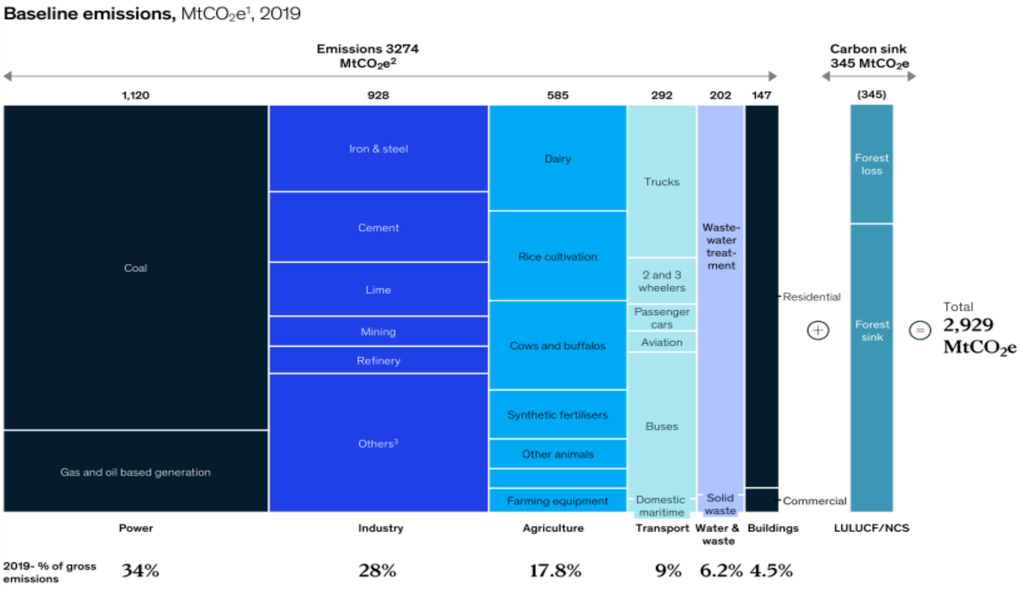
2005 levels and is set to exceed its NDC commitments well before 2030. India's climate ambition has increased substantially from Paris (COP21) to Glasgow (COP26). A snapshot of India's commitments at COP21 and COP26 is given in Fig.-1.[4]

Fig.-1 - India's commitment of Climate Ambition at COP21, Paris and COP26, Glasgow



Over three fourths of the India of 2050 (and 80+ percent of the India of 2070) is yet to be built. This growth could multiply demand across sectors: power (eightfold), steel (eightfold), cement (triple), automotive (triple) and food (double). If policies are set in place to create the right demand signals within this decade, then the capacities India adds in the two decades thereafter will be low carbon ones. For example, in steel, the early imposition of a carbon price could lead to 200 Mt of steel capacity being built on the low carbon hydrogen route instead of the coal route by 2050. India's current carbon emission mix based on McKinsey Report released in October 2022 is shown in Fig.-2.

Fig.-2 - Current Carbon Emission Mix. India

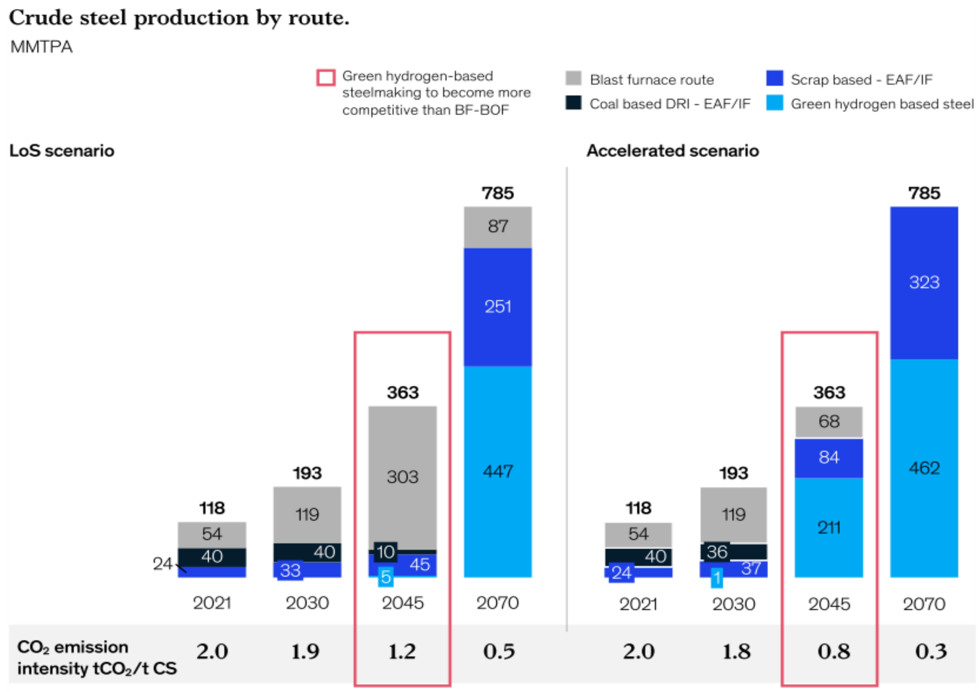


1. Converting GHGs into CO_2e assuming GWP-100 and AR5 methodology with India's BUR-3 reported emissions for 2016 as baseline.
2. Gross and net emissions for 2019 based on Climate Action Tracker overall emissions for India.
3. Others include: other industry oil & coal use, ammonia, aluminium, F-gases and ethylene.

Source: McKinsey India Decarbonisation Scenario Explorer

Steel industry would also need growth in hydrogen based green steel capacity from nil today to 152 Mt by 2040 while blast furnace–basic oxygen furnace (BF-BOF) capacity would need to see an increase from 55 Mt today to 119 Mt by 2030. Route-wise Crude Steel production is shown in Fig.-3.

Fig.-3 - Route-wise Crude Steel production



Note: Assumes scrap rate increasing from 10% currently to 20% in BF-BOF by 2040; scrap rate in green hydrogen-based EAF at 10%; DRI usage in EAF scrap at 10% of total metallic mix.

Source: McKinsey decarbonisation TCO model v14, Metal Bulletin

Accelerating hydrogen adoption in steel-making will help India build sustainable assets that could help India in its decarbonisation journey. The steel industry will likely make an investment of about $265 billion over the next 30 years in the new BF-BOF capacity installation, which could run the risk of getting stranded in case of climate shock or early closure, even with India's 2070 net-zero NDC. This can be avoided by investing early in green hydrogen-based steelmaking instead of going down the conventional blast furnace route to the tune of 200 Mt starting from 2030 (see Fig.-3 above).

This would need to be enabled by the right policies including a carbon price of $50/t, plans for which would have to be in place within two or three years for steelmakers to plan their investments.

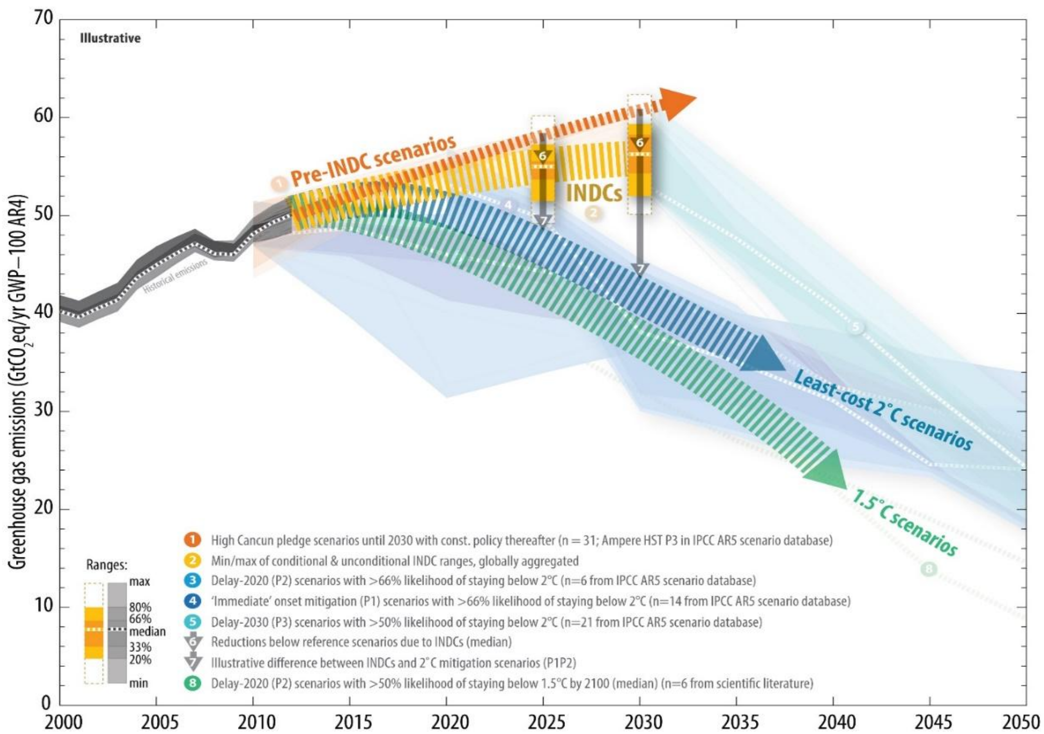
This would create additional carbon space of 5.7 $GtCO_2e$, and result in cumulative Forex savings of $280 billion on coking coal imports by 2050. Early adoption of hydrogen also enables Forex savings of $420 billion on oil & gas imports.[5]

4.0 NDCs FOR STEEL SECTOR

In 2017, atmospheric CO_2 concentrations reached 405.5 parts per million (ppm) (up from 400.1 ppm in 2015), representing 146 per cent of pre-industrial levels. Global carbon emissions need to fall by a staggering 45 per cent by 2030 from 2010 levels and continue at a steep decline to achieve net zero emissions by 2070.

As of May 2019, 186 Parties had ratified the Paris Agreement. Parties to the agreement are expected to prepare, communicate and maintain successive NDCs (including targets, policies and actions planned in response to climate change). As of that same date, 183 Parties (182 countries plus the European Union) had communicated their first NDCs to the United Nations Framework Convention on Climate Change Secretariat, and one Party had communicated its second NDC. GHG emission levels resulting from the implementation of current NDCs and under other scenarios is shown in Fig.-4.[6]

Fig.-4 - Greenhouse Gas Emission levels resulting from the implementation of current NDCs and under scenarios (gigatons of equivalent CO_2 per year)



As per the provisions of the UNFCC Convention, in 2010 India took a voluntary pledge to reduce the emission intensity of its GDP by 20-25 per cent by 2020 from 2005 levels (excluding emissions from agriculture). In 2015, India further enhanced ambition in its NDCs to reduce the emission intensity of its GDP by 33-35 per cent by 2030 from 2005 level.[7]

In 2014-15 steel production in India was around 88 million tonnes with about 45% production through integrated route.

GHG emission in Indian Integrated Steel Plants (ISP) is relatively high varying in the range of 2.4 - 3.0 Tonnes/per tonne of crude steel (T/tcs) as compared to the international benchmark of 1.8 - 1.9 T/tcs mainly because of technological obsolescence, limited adoption of waste heat/energy recovery system and constraints in Indian raw material quality i.e. high alumina content in iron ore and high ash content in coal.

Accordingly, it is projected that with adoption of state-of-art technologies and practices, specific GHG emission will reduce to 2.4 - 2.6 T/tcs by 2020 and 2.2 - 2.4 T/tcs by 2030. Of course, absolute GHG emission will increase in view of additional manufacturing capacity build up.

There are 18 energy efficient clean and green technologies identified for adoption in Indian steel plants with an overall estimated investment of Rs. 30,000 - 36,000 crores.[8]

The effect of these technologies include electricity savings, fuel savings and CO_2 reductions.

a) Coke Dry Quenching (CDQ) - Power generation from the waste heat from CDQ
b) Sinter Plant Heat Recovery (Power generation from Sinter Cooler Waste Heat)
c) Bell Less Top Equipment (BLT) in Blast Furnace
d) Top Pressure Recovery Turbine (TRT) in Blast Furnace
e) Pulverized Coal Injection (PCI) system in Blast Furnace
f) Hot stove waste heat recovery in Blast Furnace
g) Dry type Gas Cleaning Plant (GCP) in Blast Furnace
h) Cast House/ Stock House Dedusting system.
i) Converter Gas Recovery in BOF
j) Energy Monitoring & Management System
k) Secondary Fume Extraction System in Steel Melting Shop
l) Regenerative Burners in Re-heating Furnaces of Rolling Mills

m) Hot charging process of continuously cast products at higher temperature directly to Rolling Mills
n) Direct Rolling Process eliminating the need for Re-heating furnaces.
o) Energy efficient technology for Hot Strip Mill: Flexible Thin Slab casting & rolling.
p) Near Net Shape casting: Bloom cum Beam Blank caster, Bloom cum Round caster etc.
q) Adoption of Variable Voltage Variable Frequency (VVVF) Drives for high-capacity electric motors

This has resulted in considerable reduction in the Specific CO_2 Emission (in terms of tonnes per tonne of crude steel). Specific CO_2 emission has reduced from around 3.1 T/tcs in 2005 to around 2.5 T/tcs in 2020. (reduction from 2.65 T/tcs in 2015 to 2.5 T/tcs in 2020).

With the adoption of the aforementioned initiatives the steel industry has already achieved the 2020 target and well placed for achieving the 2030 targets.[9]

5.0 DECARBONIZATION PLANS OF SAIL RSP

India ratified the Paris Agreement and the steel industry being a high GHG emission sector has firmed-up an ambitious CO_2 emission reduction plan by submission of process-wise NDC targets through the Ministry of Steel.

SAIL RSP has fixed a target of less than 2 ton of CO_2 emissions per ton of crude steel production by 2030. In line with Government of India’s enhanced ambitions at COP26, SAIL has committed to substantially reduce CO_2 emission and increase share of renewable/non-conventional energy by 2030 as well as to achieve net zero emission by 2070.

Decarbonisation strategy of SAIL RSP is broadly classified into three distinct zones in time scale, based on the existing architecture & logistics, established technology, product basket & market dynamics, technology infusion rate and availability of fund, future expansion plan with an eye on future market, green technology of tomorrow, government policies, carbon sequestration, shadow carbon pricing and over and above, social commitment of the Company.

6.0 METHODOLOGY FOR CO_2 INVENTORIZATION

The reporting boundary covers the gate-to-gate emissions of SAIL RSP. The data for calculation of CO_2 emissions has been collected based on the CO_2 data reporting template developed by World Steel Association (WSA) and the methodology developed for use across all SAIL Plants in consultation with SAIL EMD, RDCIS, SAIL and all individual stakeholders for specific CO_2 emission calculation.

A key aspect of CO_2 accounting is the categorization of emissions into four scopes: Scope 1, Scope 1.1, Scope 2, and Scope 3. These scopes offer a comprehensive view of an organization's emissions sources, which carbon accounting methodologies then build upon to provide more detailed and accurate measurements.

6.1 Scope 1: Direct CO_2 Emissions

Direct Emissions from the production process from the combustion of fuel. This typically occurs within the plant/facility premises.

6.2 Sope 1.1: Direct CO_2 Emission of Exported Co-product Gas

It is the direct CO_2 emission of exported co-product gas like Coke Oven gas, Blast Furnace gas and Basic Oxygen Furnace Gas. This was added as a separate group to capture these emissions as the co-product gases are reused.

6.3 Scope 2: Utility-related Indirect Emissions

Emission associated with the purchase of utilities (electricity and steam). It also includes upstream emissions of exported co-product gas considering the potential savings in electricity generation.

6.4 Scope 3: Other Indirect CO_2 Emissions

In-direct emissions associated with product purchase & dispatch and credit from sale of by-products like slag, pig iron etc.

The methodology adapted accounts for emissions based on the activities performed by the organization and involves recording raw data, which is then quantified into emissions data.

The series of steps may involve:

Data Collection: This information encompasses various aspects, such as raw material consumption, energy consumption, production volumes, and consumption of utilities such as power and steam.

Emission Factors: These signify the average CO_2 emissions per unit of activity depending on the carbon balance of the process and the intensity of overall energy consumption.

Calculating Emissions: By multiplying the activity data for each process by its pertinent emission factor, total carbon emissions can be estimated. This process is performed for all activities within the organization's scope, with the sum of these values representing the company's carbon footprint. (11)

7.0 CO_2 EMISSION INVENTORIZATION OF SAIL RSP FOR FY 21-22

The CO_2 inventorization for SAIL-RSP was carried out considering the production data of FY 2021-22 as per the figures published in the Annual Statistics of SAIL - Rourkela Steel Plant. In 2021-22 the crude steel production of SAIL RSP stood at 39,87,259 tons.

The calculation of CO_2 emission was done, based on the Action Points enumerated in the Chairman's Review Meeting held on 20th September 2023 and VC held on 25th September 2023.

The following points were taken into consideration:

a) Specific CO_2 Emissions using grid emission factor as 0.504 tonne CO_2/MWh of Global Average Mix for all external calculation and reporting was used.

b) Power plant and oxygen plant was kept outside the plant boundary limit for determining Specific CO_2 Emission.

c) Power/steam generated from waste heat recovery/energy efficiency projects such as CDQ, TRT was considered inside plant boundary.

d) 100 % BF slag generation considered as sold/delivered.

e) In a particular reporting period, stocked material at individual shops as sold/delivered was considered and the same will be reconsidered as purchased/procured during the subsequent reporting period.

f) Stocking/Destocking of plant-generated intermediate materials has been considered as sold/purchased respectively. In this case plant-specific emission values have been considered.

g) All externally supplied BOF slag and internally consumed BOF slag have been considered.

h) Crude tar is the only by-product that has been considered for Coke Ovens.

i) SMS sludge, BF sludge, Flue dust, Diesel and Fe-Nb are the only materials which are included in the calculation outside the WSA sheet.

j) 'Carbon content' of iron ore not to be considered for CO_2 emission calculation till RDCIS analyze and decision is taken.

k) CO_2 Emission Reduction projects to be substantiated with supplementary/additional projects/schemes.

Plant unit wise emissions at SAIL RSP

Sinter Plant (SP):

The scope wise emissions for the Sinter Plant are shown in Table 1.

Table-1 - Sinter Plant - Scope-wise Emissions

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO_2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2 / t Crude Steel)	Scope 1.1 emission intensity (t CO_2 / t Crude Steel)	Scope 2 emission intensity (t CO_2 / t Crude Steel)	Scope 3 emission intensity (t CO_2 / t Crude Steel)
SP-1	4,58,501	(15,676)	42,446	-	0.11	(0.00)	0.01	-
SP-2	5,83,659	(8,380)	51,294	-	0.15	(0.00)	0.01	-
SP-3	11,08,230	(14,527)	78,604	-	0.27	(0.00)	0.02	-
SP (Total)	21,50,390	(38,583)	1,72,344	-	0.54	(0.01)	0.04	-

The emissions per ton of crude steel and per ton of gross sinter are shown in Fig.-5.

Fig.-5 – CO_2 Emissions at Sinter Plant

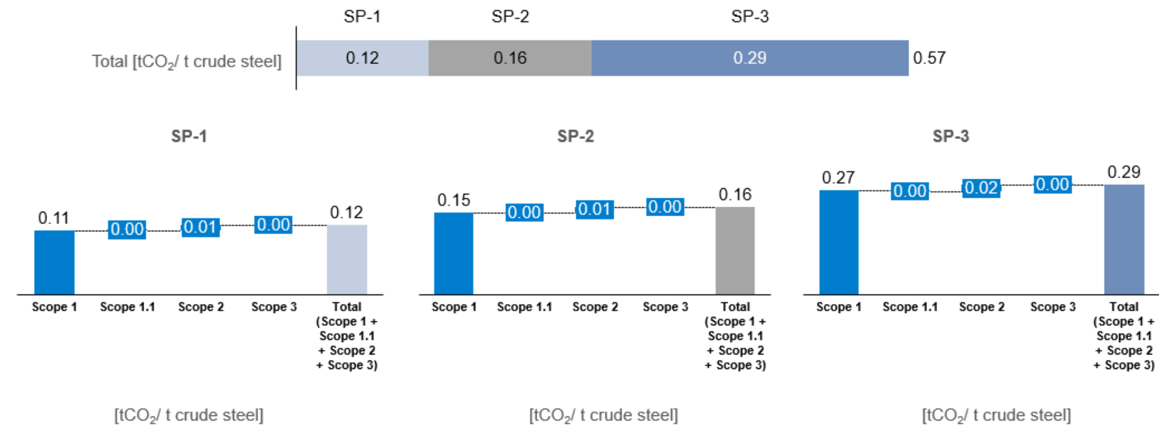


Table 2 shows the comparison of CO_2 emissions per ton of gross sinter across the three Sinter machines.

Table-2 - Sinter Plant - Scope-wise Emissions/t of Gross Sinter

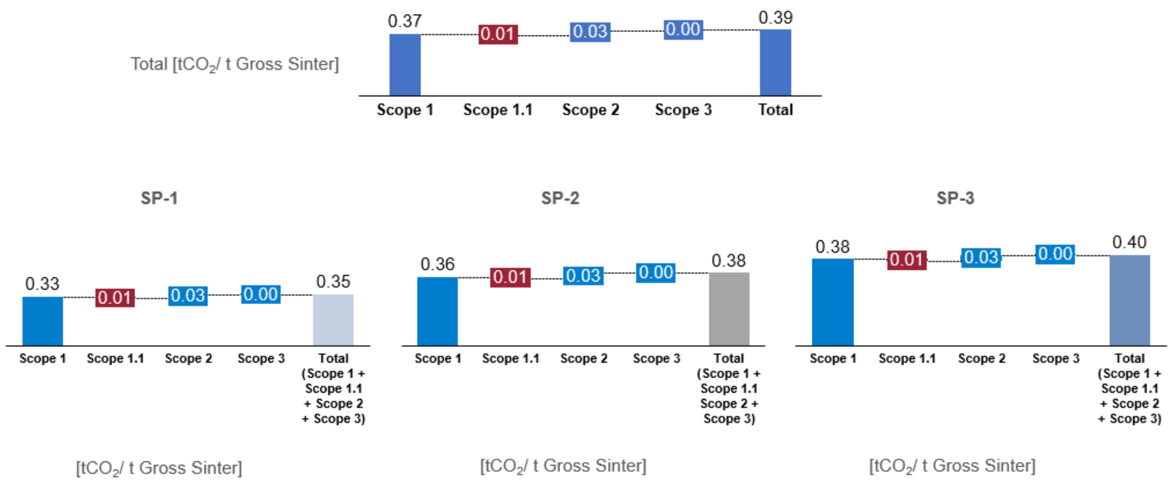
Plant Unit	Emission Intensity				
	Scope 1 emission intensity (t CO_2 / t Sinter)	Scope 1.1 emission intensity (t CO_2 / t Sinter)	Scope 2 emission intensity (t CO_2 / t Sinter)	Scope 3 emission intensity (t CO_2 / t Sinter)	Total
SP-1	0.33	(0.01)	0.03	0.00	**0.35**
SP-2	0.36	(0.01)	0.03	0.00	**0.38**
SP-3	0.38	(0.01)	0.03	0.00	**0.40**
SP (Total)	0.37	(0.01)	0.03	0.00	**0.39**

As Per Dastur database CO_2 emission per ton of sinter should be around 0.28 for an efficient sinter plant. In RSP the average CO_2 emission per ton of sinter is around 0.39, which is on the higher side due to higher consumption of coke and fluxes per ton of sinter (limestone and dolomite).

Specific emissions per ton of gross sinter is observed to be higher in SP-2 and SP-3 in comparison to SP-1 due to higher coke consumption per ton of gross sinter.

The Sinter machine wise comparison of emissions is shown graphically in Fig.-6.

Fig.-6 - Emission Intensity (t CO_2/t Sinter)



Coke Oven Battery:

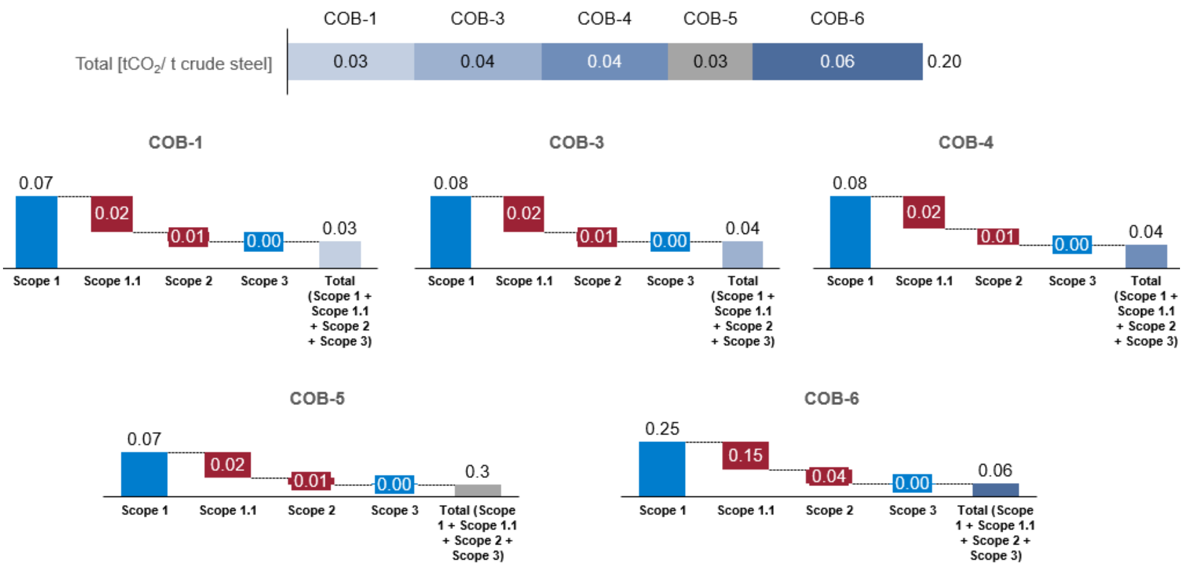
The scope wise emissions for the Coke Ovens are shown in Table 3.

Table-3 - Coke Oven Plant - Scope-wise Emissions

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO_2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2 / t Crude Steel)	Scope 1.1 emission intensity (t CO_2 / t Crude Steel)	Scope 2 emission intensity (t CO_2)/ t Crude Steel)	Scope 3 emission intensity ((t CO_2) / t Crude Steel)
Battery-1	2,85,655	(91,341)	(53,658)	(1,243)	0.07	(0.02)	(0.01)	(0.00)
Battery-3	3,02,579	(96,864)	(56,904)	(1,317)	0.08	(0.02)	(0.01)	(0.00)
Battery-4	3,09,253	(98,886)	(58,091)	(1,345)	0.08	(0.02)	(0.01)	(0.00)
Battery-5	2,65,755	(84,977)	(49,919)	(1,156)	0.07	(0.02)	(0.01)	(0.00)
Battery-6	9,95,478	(5,99,441)	(1,51,711)	(2,490)	0.25	(0.15)	(0.04)	(0.00)
COB (Total)	21,58,720	(9,71,509)	(3,70,283)	(7,551)	0.54	(0.24)	(0.09)	(0.00)

The emissions per ton of crude steel and per ton of gross coke is shown in Fig.-7.

Fig.-7 – CO_2 emissions at Coke Ovens



NOTE:The sum of Scope 1, Scope 1.1, Scope 2, and Scope 3 values is calculated with rounding to two decimal places for each scope. This rounding precision can lead to a slight discrepancy between the aggregated total and the sum obtained by directly adding the individual scope values, resulting in a minor variance or parity from the exact arithmetic summation.

Table 4 shows the comparison of CO_2 emissions per ton of gross coke across the seven Coke Oven Batteries.

Table-4 - Coke Oven - Scope-wise Emissions/t of Gross Coke

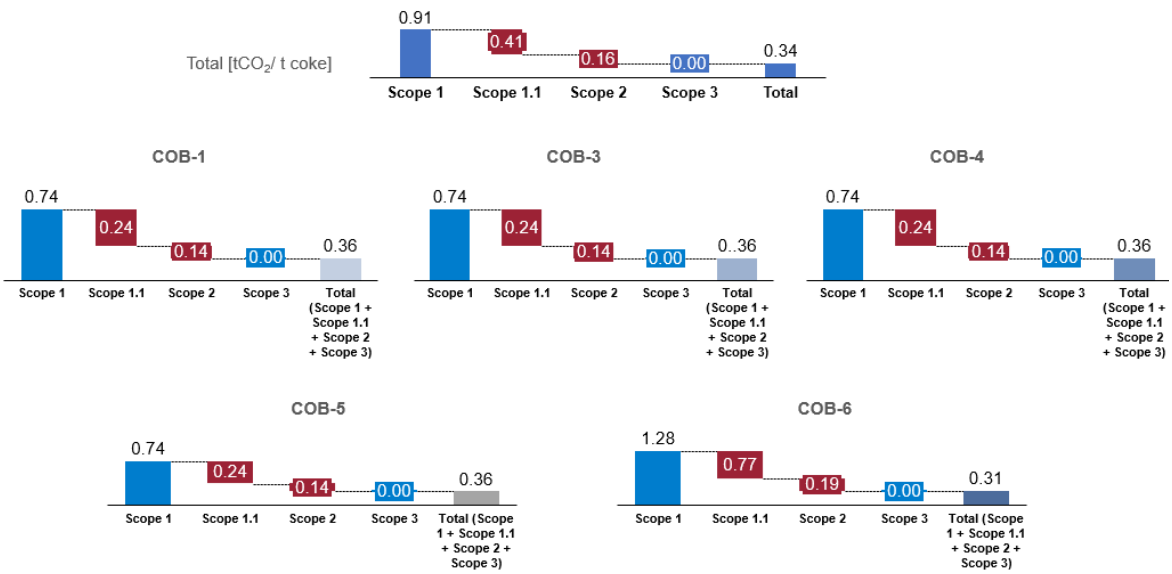
Plant Unit	Emission Intensity				
	Scope 1 emission intensity ($t\ CO_2$ / t Coke)	Scope 1.1 emission intensity ($t\ CO_2$ / t Coke)	Scope 2 emission intensity ($t\ CO_2$ / t Coke)	Scope 3 emission intensity ($t\ CO_2$ / t Coke)	Total
Battery-1	0.74	(0.24)	(0.14)	(0.0)	**0.36**
Battery-3	0.74	(0.24)	(0.14)	(0.0)	**0.36**
Battery-4	0.74	(0.24)	(0.14)	(0.0)	**0.36**
Battery-5	0.74	(0.24)	(0.14)	(0.0)	**0.36**
Battery-6	1.28	(0.77)	(0.19)	(0.0)	**0.31**
COB (Total)	0.91	(0.41)	(0.16)	(0.0)	**0.34**

As per Dastur database, Scope-1 CO_2 emission per ton of coke should be around 0.9 for an efficient Coke Ovens. In RSP it is around 0.91, so it is as par with the benchmark value.

Specific CO_2 emissions and power consumptions are uniform across all batteries except Battery-6. It has lower sp. CO_2 emission due to power generated by CDQ that results in lower scope 2 emission than rest of the batteries.

The Coke Oven Battery wise comparison of emissions is shown graphically in Fig.-8.

Fig.-8 - Emission Intensity (t CO_2/t Coke)



Blast Furnace:

The scope wise emissions for the operating Blast Furnaces are shown in Table 5.

Table-5 - Blast Furnace - Scope-wise Emissions

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO_2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2) / t Crude Steel)	Scope 1.1 emission intensity (t CO_2) / t Crude Steel)	Scope 2 emission intensity (t CO_2) / t Crude Steel)	Scope 3 emission intensity (t CO_2)/ t Crude Steel)
BF-1	5,60,556	8,41,150	(90,048)	(1,52,554)	0.14	0.21	(0.02)	(0.04)
BF-4	5,34,254	7,69,984	(82,429)	(1,62,451)	0.13	0.19	(0.02)	(0.04)
BF-5	14,96,456	25,38,673	(4,14,296)	(4,69,715)	0.38	0.64	(0.10)	(0.12)
BF (Total)	25,91,266	41,49,807	(5,86,773)	(7,84,720)	0.65	1.04	(0.15)	(0.20)

The emissions per ton of crude steel and per ton of hot metal are shown in Fig.-9.

Fig.-9 – CO_2 Emissions at Blast Furnace

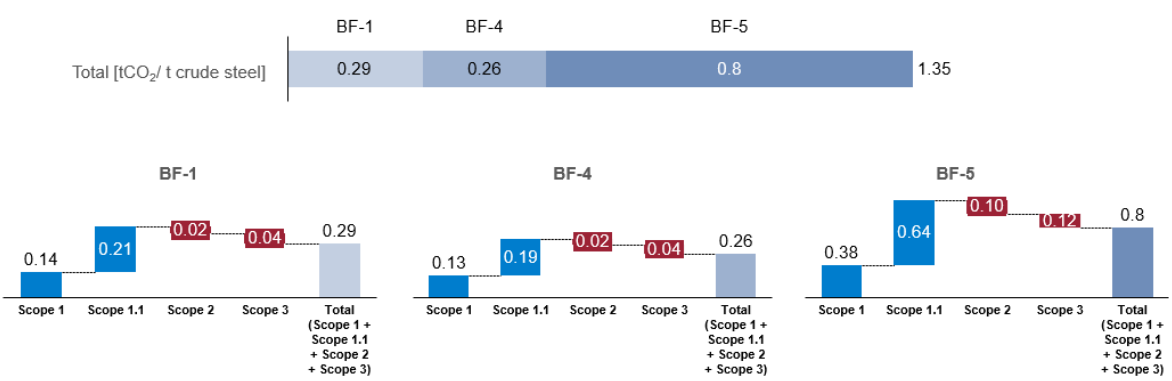


Table 6 shows the comparison of CO_2 emissions per ton of gross hot metal across the five Blast Furnaces.

Table-6 - Blast Furnace - Scope-wise Emissions/tonne of Hot Metal

Plant Unit	Emission Intensity				
	Scope 1 emission intensity (t CO_2 / t Hot Metal)	**Scope 1.1 emission intensity (t CO_2 / t Hot Metal)**	**Scope 2 emission intensity (t CO_2 / t Hot Metal)**	**Scope 3 emission intensity (t CO_2 / t Hot Metal)**	**Total**
BF-1	0.61	0.91	(0.10)	(0.17)	**1.25**
BF-4	0.62	0.90	(0.10)	(0.19)	**1.23**
BF-5	0.54	0.91	(0.15)	(0.17)	**1.13**
BF (Total)	0.57	0.91	(0.13)	(0.17)	**1.18**

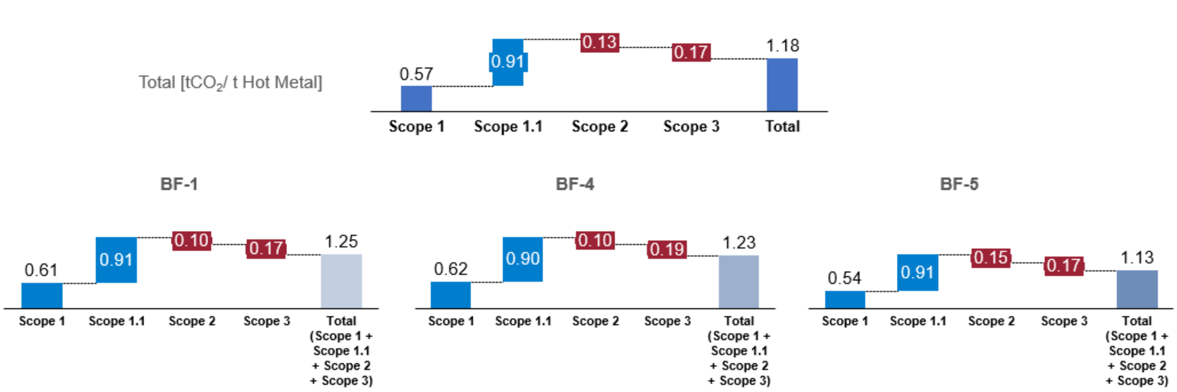
As per Dastur database Scope-1 CO_2 emission per ton of Hot Metal should be around 0.72 for an efficient Blast Furnace. In RSP it is around 0.57 the reason mainly being the large amount of BF gas generated per ton of Hot Metal.

The PCI rate in BF-5 is significantly more (~128 kg/tHM) than that of BF-1 and BF-4. So, the coke rate is also lower in BF-5 than rest of the BFs. This results in less scope 1 emission for BF-5. Moreover, electricity is generated from TRT in BF-5, resulting in lower scope 2 emission.

BF-2 and 3 were scrapped earlier. Therefore, the data represents emissions for BF-1, BF-2 and BF-5.

The Blast Furnace wise comparison of emissions is shown graphically in Fig.-10.

Fig.-10 - Emission Intensity (t CO_2/t hot metal)



Steel Melt Shop:

The scope wise emissions for the Steel Melt Shop are shown in Table 7.

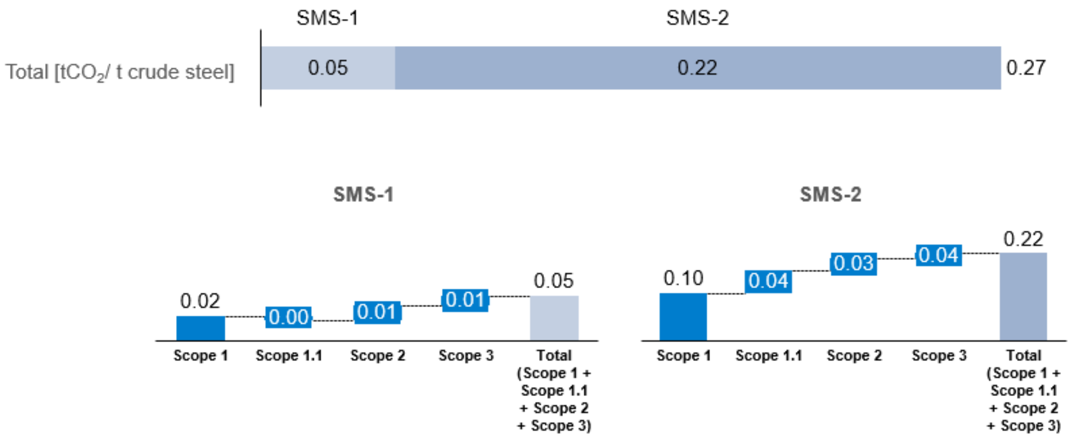
Table-7 - Steel Melt Shop - Scope-wise Emissions

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2) / t Crude Steel)	Scope 1.1 emission intensity (t CO_2) / t Crude Steel)	Scope 2 emission intensity (t CO_2/ t Crude Steel)	Scope 3 emission intensity (t CO_2/ t Crude Steel)
SMS-I	96,477	(15,391)	51,582	55,093	0.02	(0.00)	0.01	0.01
SMS-II	4,06,473	1,66,248	1,26,901	1,70,450	0.10	0.04	0.03	0.04
SMS (Total)	5,02,950	1,50,857	1,78,483	2,25,514	0.13	0.04	0.04	0.06

It is observed that BOF gas recovery for SMS-I rate is ~37 Nm^3/ton of liquid steel which is lower than the regular figure of ~82-85 Nm^3/ton of liquid steel. This results in higher scope 1 CO_2 emission than the benchmark figure of around 0.05 t CO_2/t CS as per Dastur experience.

The emissions per ton of crude steel are shown in Fig.-11.

Fig.-11 – CO_2 Emissions at SMS



NOTE:The sum of Scope 1, Scope 1.1, Scope 2, and Scope 3 values is calculated with rounding to two decimal places for each scope. This rounding precision can lead to a slight discrepancy between the aggregated total and the sum obtained by directly adding the individual scope values, resulting in a minor variance or parity from the exact arithmetic summation.

Table 8 shows the comparison of CO_2 emissions per ton of crude steel across the two Steel Melt Shops.

Table-8 - Steel Melt Shop - Scope-wise Emissions/tonne of product

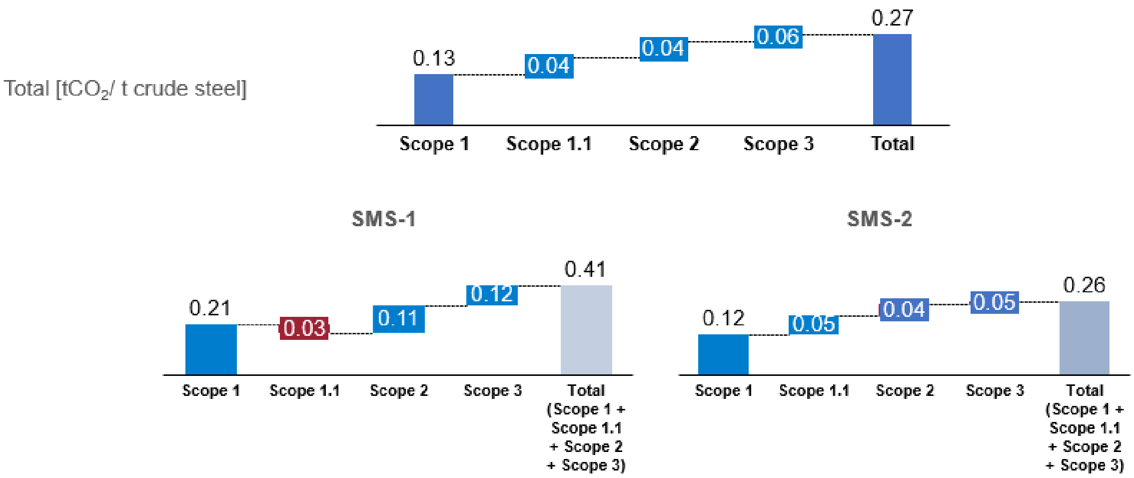
Plant Unit	Emission Intensity				
	Scope 1 emission intensity (t CO_2 / t product)	Scope 1.1 emission intensity (t CO_2 / t product)	Scope 2 emission intensity (t CO_2 / t product)	Scope 3 emission intensity (t CO_2 / t product)	Total
SMS-I	0.21	(0.03)	0.11	0.12	**0.41**
SMS-II	0.12	0.05	0.04	0.05	**0.26**
SMS (Total)	0.13	0.04	0.04	0.06	**0.27**

As per Dastur database Scope-1 CO_2 emission per ton of Crude Steel should be around 0.05 for an efficient Steel Melt Shop (SMS). In RSP it is around 0.13 which is on the higher side.

Scope 1 emission is higher in SMS-I as there is no BOF gas recovery. Energy consumption is also much higher in SMS-I that results in higher scope-2 emission.

The SMS wise comparison of emissions is shown graphically in Fig.-12.

Fig.-12 - Emission intensity (t CO_2/t crude steel)



Mills:

The scope wise emissions for Plate Mill are shown in Table 9.

Table-9 – Plate Mill - Scope-wise Emissions

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO_2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2/ t Crude Steel)	Scope 1.1 emission intensity (t CO_2/ t Crude Steel)	Scope 2 emission intensity (t CO_2/ t Crude Steel)	Scope 3 emission intensity (t CO_2/ t Crude Steel)
Plate Mill	44,473	(43,798)	1,31,600	64	0.01	(0.01)	0.03	0.00
New plate Mill	65,358	(64,415)	75,556	90	0.02	(0.02)	0.02	0.00

The scope wise emissions for HSM are shown in Table 10.

Table-10 – Hot Strip Mill - Scope-wise Emissions

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO_2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2/ t Crude Steel)	Scope 1.1 emission intensity (t CO_2/ t Crude Steel)	Scope 2 emission intensity (t CO_2/ t Crude Steel)	Scope 3 emission intensity (t CO_2/ t Crude Steel)
HSM-1	1,15,098	(1,13,834)	2,30,980	120	0.03	(0.03)	0.06	0.00
HSM-2	11,901	(11,687)	28,090	20	0.00	(0.00)	0.01	0.00

Table-11– Pipe Plant - Scope-wise Emissions

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO_2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2/ t Crude Steel)	Scope 1.1 emission intensity (t CO_2/ t Crude Steel)	Scope 2 emission intensity (t CO_2/ t Crude Steel)	Scope 3 emission intensity (t CO_2/ t Crude Steel)
ERW Pipe Plant	-	-	937	-	0.00	0.00	0.0002	0.00
SW Pipe Plant	-	-	1178	-	0.00	0.00	0.0003	0.00

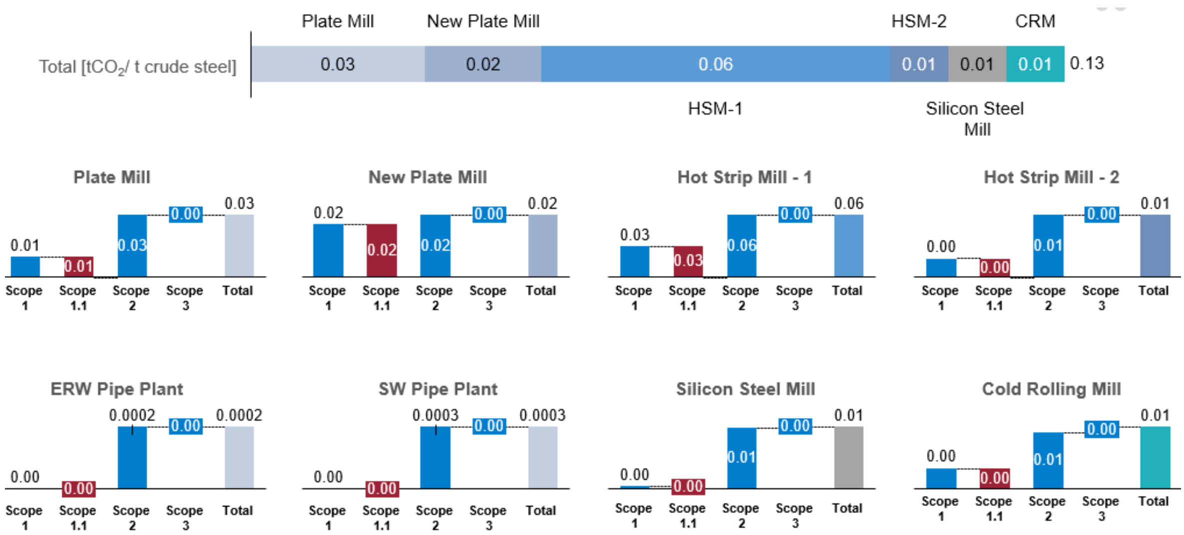
Table-12– Silicon Steel Mill - Scope-wise Emissions

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO_2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2/ t Crude Steel)	Scope 1.1 emission intensity (t CO_2/ t Crude Steel)	Scope 2 emission intensity (t CO_2/ t Crude Steel)	Scope 3 emission intensity (t CO_2/ t Crude Steel)
SSM	1,373	(1,373)	25,647	329	0.00	(0.00)	0.01	0.00

Table-13– Cold Rolling Mill - Scope-wise Emissions

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO_2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2/ t Crude Steel)	Scope 1.1 emission intensity (t CO_2/ t Crude Steel)	Scope 2 emission intensity (t CO_2/ t Crude Steel)	Scope 3 emission intensity (t CO_2/ t Crude Steel)
CRM	9,420	(9,420)	25,278	2,769	0.00	(0.00)	0.01	0.00

Fig.-13 – CO_2 Emissions at Mills



NOTE:The sum of Scope 1, Scope 1.1, Scope 2, and Scope 3 values is calculated with rounding to two decimal places for each scope. This rounding precision can lead to a slight discrepancy between the aggregated total and the sum obtained by directly adding the individual scope values, resulting in a minor variance or parity from the exact arithmetic summation.

Table 14 shows the CO_2 emissions for Plate Mill per ton of product.

Table-14 – Plate Mill - Scope-wise Emissions/tonne of plate

	Emission Intensity				
Plant Unit	**Scope 1 emission intensity (t CO_2 / t Plate)**	**Scope 1.1 emission intensity (t CO_2 / t plate)**	**Scope 2 emission intensity (t CO_2 / t plate)**	**Scope 3 emission intensity (t CO_2 / t plate)**	**Total**
Plate Mill	0.08	(0.08)	0.24	0.00	**0.24**
New Plate Mill	0.07	(0.07)	0.08	0.00	**0.08**

Table 15 shows the CO_2 emissions for HSM 1 & 2 per ton of product.

Table-15 – Hot Strip Mill - Scope-wise Emissions/ tonne of hot rolled coil

	Emission Intensity				
Plant Unit	**Scope 1 emission intensity (t CO_2 / t HRC)**	**Scope 1.1 emission intensity (t CO_2 / t HRC)**	**Scope 2 emission intensity (t CO_2 / t HRC)**	**Scope 3 emission intensity (t CO_2 / t HRC)**	**Total**
HSM-1	0.07	(0.07)	0.13	0.00	**0.13**
HSM-2	0.08	(0.08)	0.19	0.00	**0.19**

The scope-1 emissions per ton of HRC in case of RSP is within the benchmark figures as per Dastur database.

Table-16 – Pipe Plant - Scope-wise Emissions/ tonne of Pipe

Plant Unit	Emission Intensity				
	Scope 1 emission intensity (t CO_2 / t Pipe)	**Scope 1.1 emission intensity (t CO_2 / t Pipe)**	**Scope 2 emission intensity (t CO_2 / t Pipe)**	**Scope 3 emission intensity (t CO_2 / t Pipe)**	**Total**
ERW	0.00	(0.00)	0.03	0.00	**0.03**
SW	0.00	(0.00)	0.05	0.00	**0.05**

Table-17 – Silicon Steel Mill - Scope-wise Emissions/ tonne of Silicon Steel (SS)

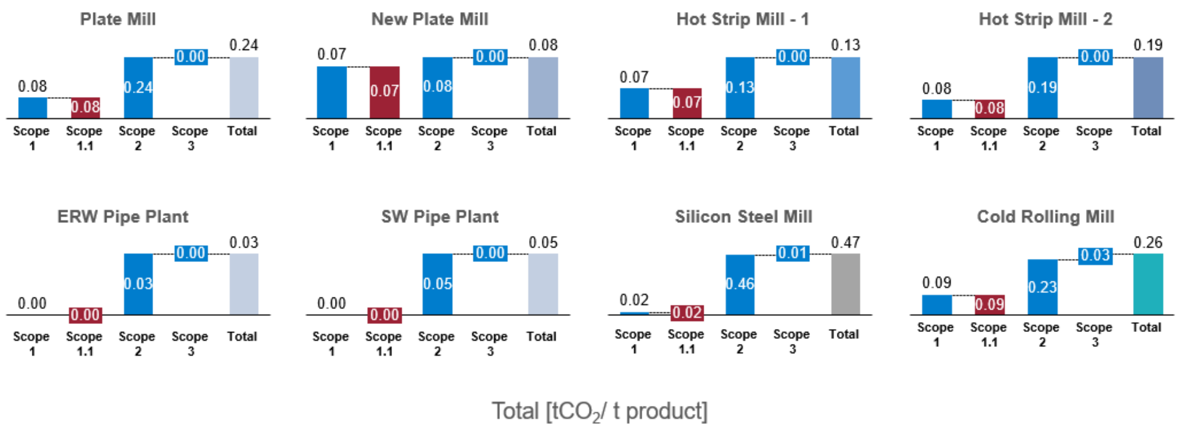
Plant Unit	Emission Intensity				
	Scope 1 emission intensity (t CO_2 / t SS)	**Scope 1.1 emission intensity (t CO_2 / t SS)**	**Scope 2 emission intensity (t CO_2 / t SS)**	**Scope 3 emission intensity (t CO_2 / t SS)**	**Total**
SSM	0.02	(0.02)	0.46	0.01	**0.47**

Table-18 – Cold Rolling Mill - Scope-wise Emissions/ tonne of Cold Rolled Coil

Plant Unit	Emission Intensity				
	Scope 1 emission intensity (t CO_2 / t CRC)	**Scope 1.1 emission intensity (t CO_2 / t CRC)**	**Scope 2 emission intensity (t CO_2 / t CRC)**	**Scope 3 emission intensity (t CO_2 / t CRC)**	**Total**
CRM	0.09	(0.09)	0.23	0.03	**0.26**

The Mill wise comparison of emissions is shown graphically in Fig.-14

Fig.-14 - Emission intensity (t CO_2/t rolled product)



LDCP:

The scope wise emissions for LDCP are shown in Table 19.

Table-19 - LDCP - Scope-wise Emissions/ t crude steel

Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2 / t Crude Steel)	Scope 1.1 emission intensity (t CO_2 / t Crude Steel)	Scope 2 emission intensity (t CO_2 / t Crude Steel)	Scope 3 emission intensity (t CO_2 / t Crude Steel)
LDCP-I	32,702	(5,967)	10,624	-	0.01	(0.00)	0.00	0.00
LDCP-II	4,03,242	(53,096)	71,633	(34,849)	0.10	(0.01)	0.02	(0.01)
LDCP (Total)	4,35,944	(59,063)	82,257	(34,849)	0.11	(0.01)	0.02	(0.01)

The emissions per ton of crude steel and per ton of calcined product are shown in Fig.-15.

Fig.-15 - Scope wise emissions form LCDP (t CO_2/t crude steel)

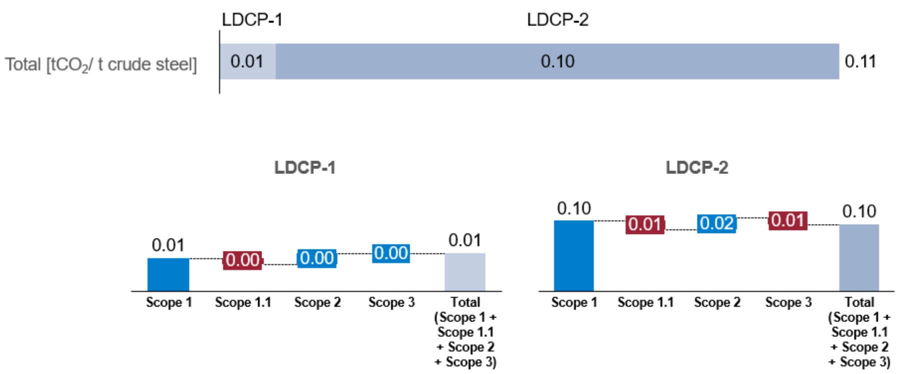


Table 20 shows the comparison of CO_2 emissions per ton of calcined lime/dolo across the two LDCP.

Table-20 - LDCP - Scope-wise Emissions/ tonne of Calcined Lime/ Dolo

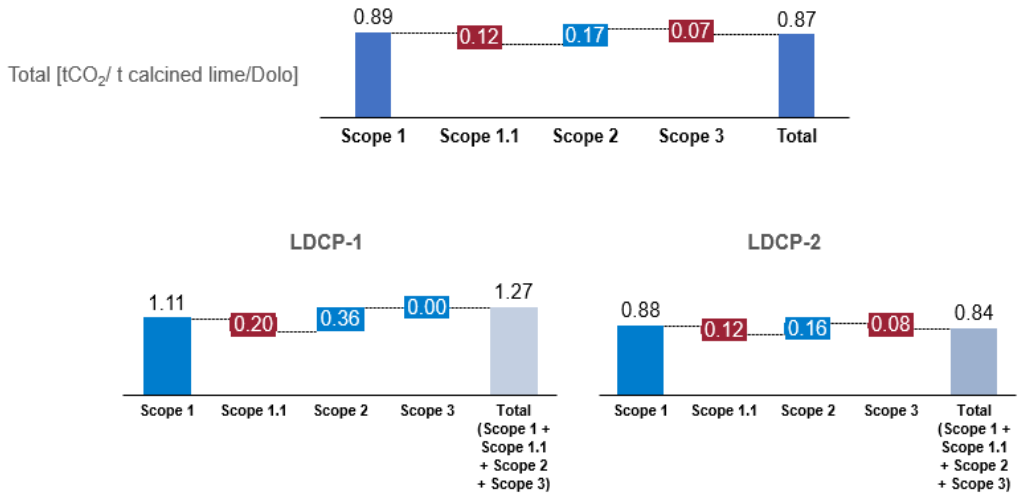
Plant Unit	Emission Intensity				
	Scope 1 emission intensity (t CO_2 / t Calcined Lime/Dolo)	Scope 1.1 emission intensity (t CO_2 / t Calcined Lime/Dolo)	Scope 2 emission intensity (t CO_2 / t Calcined Lime/Dolo)	Scope 3 emission intensity (t CO2 / t Calcined Lime/Dolo)	Total
LDCP-I	1.11	(0.20)	0.36	0.00	**1.27**
LDCP-II	0.88	(0.12)	0.16	(0.08)	**0.84**
LDCP (Total)	0.89	(0.12)	0.17	(0.07)	**0.87**

As Per Dastur database Scope-1 CO_2 emission per ton of Calcined Lime/dolo should be around 1.2 for an efficient Calcining Plant. In RSP it is around 0.89, so it's under the benchmark value.

It is observed that in LDCP-1, the limestone required per ton of burnt lime is significantly higher than that of LDCP-2. Moreover, In LDCP-1 COG consumption per ton of product is higher than that of LDCP-2 leading to high CO_2 emission.

The Kiln wise comparison of emissions is shown graphically in Fig.-16.

Fig.-16 - Emission intensity (t CO_2/t calcined lime/dolo)



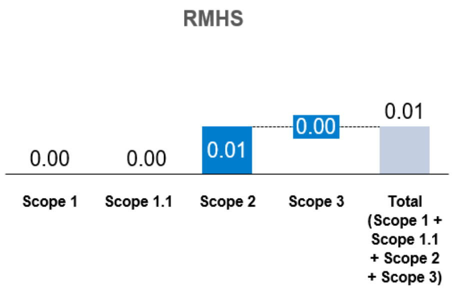
Auxiliaries

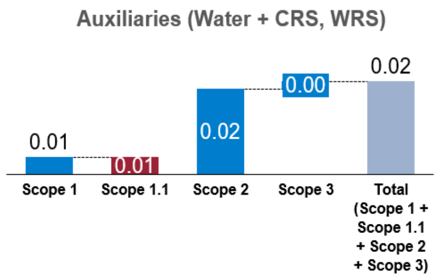
The scope wise emission for auxiliary units is shown in Table 21.

Table-21 - Auxiliaries - Scope-wise Emissions/ tonne of Crude Steel

Plant Unit Plant Unit	Scope 1 emissions (t CO_2)	Scope 1.1 emissions (t CO2)	Scope 2 emissions (t CO_2)	Scope 3 emissions (t CO_2)	Emission Intensity			
					Scope 1 emission intensity (t CO_2 / t Crude Steel)	Scope 1.1 emission intensity (t CO_2 / t Crude Steel)	Scope 2 emission intensity (t CO_2 / t Crude Steel)	Scope 3 emission intensity (t CO_2 / t Crude Steel)
RMHS+Yard	-	-	24,127	-	0.00	0.00	0.01	0.00
CRS+TOP+WRS	44,214	(44,214)	65,126	16,756	0.01	(0.01)	0.02	0.00

Fig. 17 - Emission intensity (t CO_2/t CS)





Unit-wise/Scope-wise emissions

The plant unit wise emissions under various scopes are shown in Table 22.

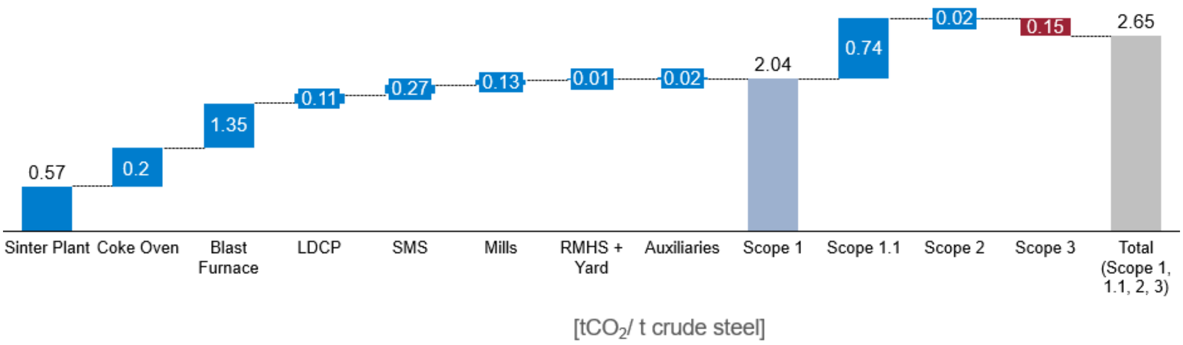
Table-22 - Scope-wise Emissions of Each Plant Unit

Plant Unit	Emission Intensity				
	Scope 1 emission intensity (t CO_2 / t Crude Steel)	Scope 1.1 emission intensity (t CO_2 / t Crude Steel)	Scope 2 emission intensity (t CO_2 / t Crude Steel)	Scope 3 emission intensity (t CO_2 / t Crude Steel)	Total emission intensity (t CO_2 / t Crude Steel)
Sinter Plant	0.54	(0.01)	0.04	(0.00)	0.57
Coke Oven Battery	0.54	(0.24)	(0.09)	(0.00)	0.20
Blast Furnace	0.65	1.04	(0.15)	(0.20)	1.35
SMS	0.13	0.04	0.04	0.06	0.27
LDCP	0.11	(0.01)	0.02	(0.01)	0.11
Plate Mill	0.01	(0.01)	0.03	0.00	0.03
New Plate Mill	0.02	(0.02)	0.02	0.00	0.02
HSM-1	0.03	(0.03)	0.06	0.00	0.06
HSM-II	0.00	0.00	0.01	0.00	0.01
ERW Pipe Plant	0.00	0.00	0.00	0.00	0.0
SW Pipe Plant	0.00	0.00	0.00	0.00	0.0
Silicon Steel Mill	0.00	0.00	0.01	0.00	0.01
CRM	0.00	0.00	0.01	0.00	0.01
Auxiliaries	0.01	(0.01)	0.02	0.00	0.02
RMHS	0.00	0.00	0.01	0.00	0.01
Total	**2.04**	**0.74**	**0.02**	**(0.15)**	**2.65**

NOTE:The sum of Scope 1, Scope 1.1, Scope 2, and Scope 3 values is calculated with rounding to two decimal places for each scope. This rounding precision can lead to a slight discrepancy between the aggregated total and the sum obtained by directly adding the individual scope values, resulting in a minor variance or parity from the exact arithmetic summation.

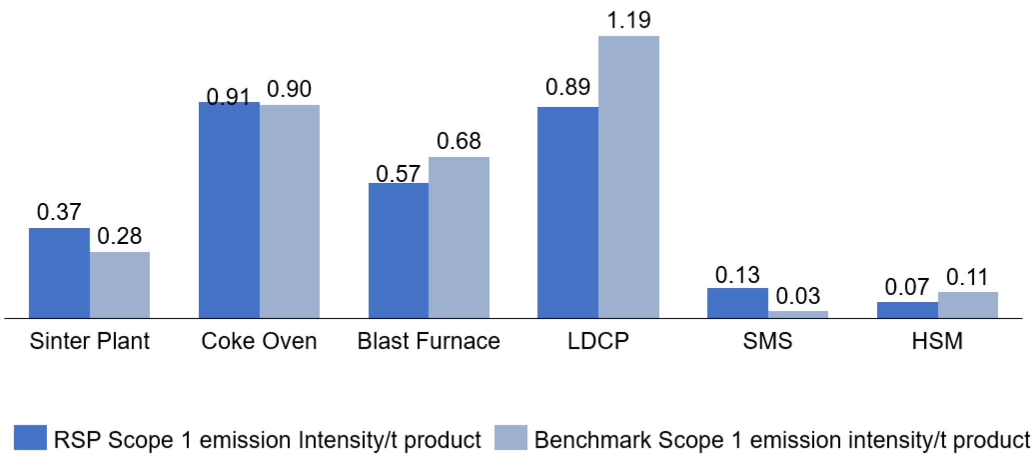
The overall emissions of SAIL-RSP stood at 2.65 for FY21-22. The scope wise emissions across all plant units of SAIL-RSP is shown graphically in Fig.-17.

Fig.-18 – CO_2 Emission (Scope 1 + Scope 1.1 + Scope 2 + Scope 3) for SAIL – RSP



The emission intensity of each plant unit in terms of tCO_2/t of product and their comparison with benchmarks are presented in Fig.-19.

Fig.-19 Specific Scope-1 Emissions for different intermediate products vis-à-vis benchmarks



A significant deviation from Indian benchmark figures is observed in

Sinter plant and SMS in all the other plants the emissions are within the benchmark values.

The unit wise CO_2 Inventorization sheets are enclosed as Annexure-I

Conclusion

The GHG inventorization of SAIL RSP sets the baseline for formulation of the mitigation measures to reduce the CO_2 emission to less than 2 tons per ton of crude steel by 2030. In the next stage of the study process improvement initiatives would be suggested based on feasibility, to reduce the CO_2 footprint. Further reduction, if required, would be taken up through implementation of Carbon Capture Utilization and Sequestration through technology as well as plantation of trees.

Sources

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Milestone – 2 Report

on

Comprehensive Plan for Reduction of Greenhouse Gas Emissions

to

SAIL - Rourkela Steel Plant

Submitted by
M. N. Dastur & Company (P) Ltd.
January 2025

Comprehensive plan for reduction of GHG emission

2.1 Introduction

2.1.1 Iron & Steel Industry Emissions: Global & Indian

Iron & Steel making is an energy-intensive sector and is responsible for about 8 - 10% of global anthropogenic CO_2 emissions i.e., 2.8 GT (2023). The top 5 countries crude steel production and their emission intensity have been given in Table 2-1.

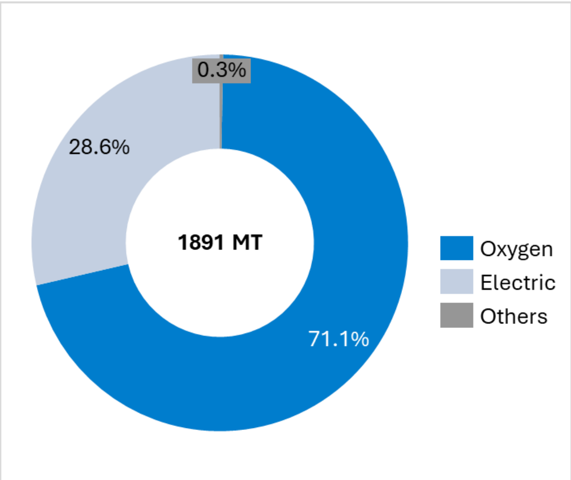
Table 2-1: Crude Steel Production and CO_2 Emission Intensity for Top 5 Steel Producers

Country	Total crude steel production in 2023 (MT)	CO_2 Emission Intensity (T_{CO2}/T_{CS})
China	1019.10	2.01
India	140.80	2.54
Japan	87.00	1.61
USA	81.40	0.79
Russia	76.00	1.65

Source: MoS (GSI Report 2024)

The distribution of crude steel production by route has been given in Figure 2-1.

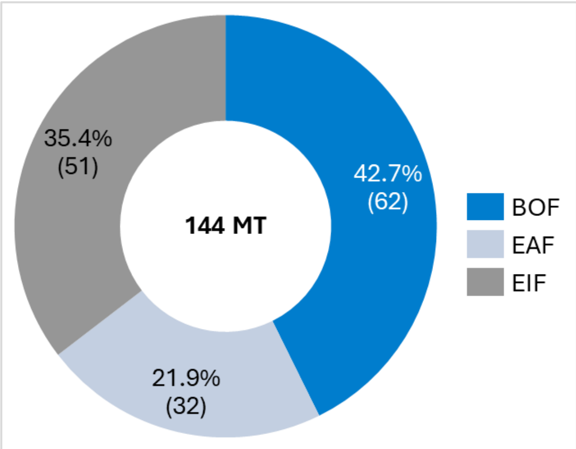
Fig. 2-1: Global Crude Steel Production by Route (2023)



Source: MoS (GSI Report 2024)

India is the world's second-largest producer of crude steel, producing 144 MT of crude steel annually (MoS, FY2023 - 2024). It is also the largest producer of sponge iron in the world with a production of about 52 MT in FY 23-24. Steel is produced in India mainly through three distinct routes, namely BF-BOF route, DRI-EAF route and DRI-IF route. The route-wise distribution of crude steel production has been given in Figure 2-2.

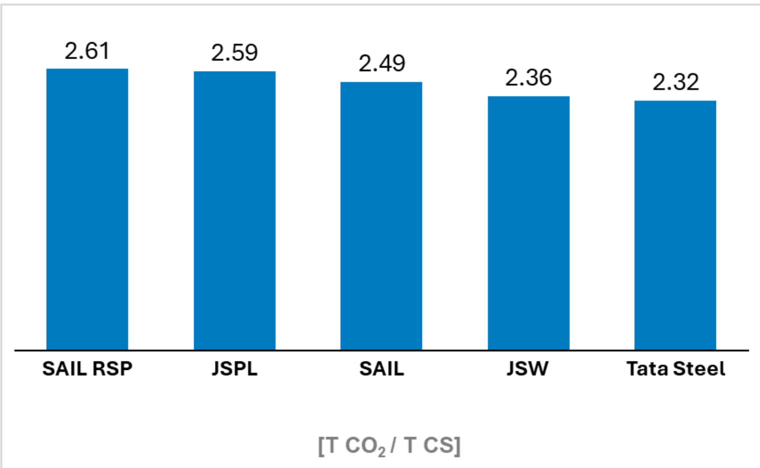
Fig. 2-2 – Indian Crude Steel Production by Route (MTPA)



Source: MoS (GSI Report 2024)

The Indian steel industry contributes approximately 8 - 10% to the total CO_2 emissions. The average CO_2 emission intensity of Indian iron and steel producers is relatively higher than their global counterparts as the majority of the crude steel is produced through the BF-BOF based route which is heavily reliant on coal and coke for iron production. The comparison of CO_2 emission intensity of SAIL RSP with other iron & steel producers has been given in Figure 2-3.

Fig. 2-3: CO_2 Emission Intensity of Indian Steel Producers



Source: MoS (GSI Report 2024), Dastur Analysis

2.1.2 GOI Initiatives to Reduce CO_2 Emissions from Iron & Steel Industry

The government of India has implemented several policies to reduce the carbon footprint of the country's economy. Some of the major initiatives which are relevant to the steel industry have been discussed below.

a) **Renewable Energy:** India has a huge potential for generating renewable energies like solar and wind energy. The government has been actively pushing renewable energy, beginning with laws like the Electricity Act 2003 and continuing through the National Electricity Policy 2005, Tariff Policy 2006, and Tariff Policy 2016. All these measures have helped to reduce the capital cost of renewable energy projects and boosted renewable energy deployment in India.

b) **Perform Achieve and Trade (PAT):** Introduced in 2012, the PAT (Perform, Achieve and Trade) scheme by the Government of India is a crucial effort to encourage energy efficiency and decrease carbon emissions within the industrial sector. Under this scheme, companies complying with Specific Energy Consumption targets, are awarded tradable Energy Saving Certificates (ECerts). It has significantly helped in achieving emission reduction in the Indian Iron & Steel sector.

c) **MoS-UNDP project for upscaling Energy-efficient Production in the Secondary Steel Sector in India (2013-2015):** There are many small-scale re-rolling mills in India which create high levels of pollution. The United Nations Development Programme (UNDP) and the Ministry of Steel came together for a project through which Energy Efficiency Technologies were implemented across 355 Mini Steel Mills (Re-rolling Mills & Induction Furnaces). This initiative reduced specific energy consumption by 20% - 30% and reduced CO_2 emissions by approximately 400,000 tonnes annually.

d) **National Steel Policy (NSP), 2017:** The NSP (2017) offers a detailed strategy to achieve 300 MTPA steel production by 2030 in India. It emphasizes growth of Micro, Small, and Medium Enterprise (MSME) sector, improving raw material security and R&D activities, reducing import dependency. The NSP also included several measures for the reduction of CO_2 emissions from the iron & steel sector such as increased scrap usage, enhanced fuel efficiency etc.

e) **Steel Scrap Recycling Policy (2019 - present):** The steel scrap recycling policy aims to:

› Establish scrap yards and scrap processing centres across the country.
› Improve the quality and availability of steel scrap for the secondary steel sector.
› By increasing the supply of domestically sourced scrap, the aim is to eventually decrease reliance on imported coal and iron ore.

› Reducing overall energy consumption and GHG emissions.

f) **National Green Hydrogen Mission (NGHM):** The National Green Hydrogen Mission (NGHM) aims to accelerate green hydrogen adoption by incentivizing the entire value chain in relevant sectors. The mission aims to produce 5 MTPA of green hydrogen using 125 GW renewable energy capacity by 2030, reducing India's fossil fuel imports by INR 1 lakh crore. The budget includes INR 455 crore for installing pilot plants that produce and utilize hydrogen in the iron and steel making process. The green hydrogen can also be used in DRI production.

g) **Carbon Credit Trading Scheme (CCTS):** The Carbon Credit Trading Scheme (CCTS), introduced through the Energy Conservation (Amendment) Bill, of 2022, aims to establish the Indian Carbon Market (ICM). Based on the pre-existing PAT scheme, the ICM will allow local businesses to exchange carbon credits that signify the reduction or elimination of one ton of CO_2 equivalent. Industries exceeding targets can earn Carbon Credits, which can be traded with other consumers who are unable to meet their targets. The ICM will impact India's steel industry, requiring low-carbon technologies and practices to meet emission reduction targets and avoid penalties. The ICM will incentivize investment in advanced technologies like green hydrogen and carbon capture, utilization, and storage (CCUS), promoting decarbonisation of steel production.

2.1.3 Initiatives by Iron and Steel Industry: Indian & Global

To reduce the carbon footprint of steel production, various domestic as well as global players have announced their ‘Net-Zero’ targets and have also initiated several strategies to achieve these targets. The decarbonisation strategies of major iron and steel producers (domestic & global) and their impact on the respective CO_2 emissions/intensity has been reviewed in this section. The CO_2 abatement impact assessment of these strategies are based on secondary research as reported by these companies.

JSW Steel

JSW Steel is one of the largest crude steel manufacturers in India with a domestic capacity of about 27 MTPA and has an international presence with manufacturing facilities in the USA (Ohio, Baytown) and Italy (Piombino).

Implemented Decarbonisation Strategies

JSW Steel has taken a number of initiatives for abatement of CO_2 emissions from their integrated steel plants. As a result, the CO_2 emission intensity of JSW Steel has dropped consistently. A list of implemented decarbonisation strategies as reported by JSW Steel has been given in Table 2-2.

Table 2-2: Decarbonisation strategies implemented by JSW Steel

Sl. No.	Strategy	Outcome
Vijayanagar		
1.	Increased micro pellet and BF return fines in Sinter Plant resulting in reduction of solid fuel rate and flux rate.	Reduction of emissions by 7,150 tCO_2
2.	Increased hot charging percentage in HSM by ~6% resulting in reduction of gaseous fuel rate by ~11%.	Reduction of emissions by 1,00,289 tCO_2
3.	Replacement of old boilers resulting in an increase in steam generation rate by ~380%.	Reduction of emissions by 11,539 tCO_2
4.	Refractory brick lining replaced by plastic refractory in Reheating Furnace resulting in heat rate reduction by ~5%.	Reduction of emissions by 79,489 tCO_2
5.	Installation of Waste Gas Heat Recovery (WHRS) in Blast Furnace resulting in reduction of stove heat rate by ~18%.	Reduction of emissions by 1,78,910 tCO_2
6.	Increased PCI rate resulting in reduction of BF fuel rate.	Reduction of emissions by 78,051 tCO_2
7.	Reduced solid fuel rate in Corex by ~5%	Reduction of emissions by 1,74,250 tCO_2
Dolvi		
1.	Commissioning of Gas Based Captive Power Plant.	Optimisation of process gases and reduction of emissions by 5,33,290 tCO_2
2.	Optimising Centralised Gas Mixing Station's network to maximise in-house power generation.	Reduction of emissions by 28,020 tCO_2
3.	Increase in PCI rate in Blast Furnace up to 200 kg/thm	Reduction in BF solid fuel rate leading to decrease in emissions by ~0.22 tCO_2/tcs
4.	Maximising COG consumption in Sponge Iron Plant.	Replacement of purchased fuel with by-product Coke Oven Gas leading to reduction in emissions (not quantified)
Salem		
1.	Biomass usage in coal-based boiler to minimise coal consumption.	Maximised blending of biomass with steam coal power generation has resulted in a reduction of emissions by 11,926 tCO_2
2.	Installation of MV drive in CPP boiler feed water pump to reduce power consumption.	Reduction of emissions by 725 tCO_2

Sl. No.	Strategy	Outcome
3.	Reduction in power consumption through optimisation of EOF ID Fan drive speed.	Reduction of emissions by 966 tCO_2
4.	Installation of VVVF drive in Plant Makeup Water Pump to reduce power consumption.	Reduction of emissions by 347 tCO_2
5.	Power savings through high pressure pump operation in BF.	Reduction of emissions by 237 tCO_2
6.	Optimisation of STG auxiliary cooling water system operation to reduce power consumption.	Reduction of emissions by 160 tCO_2
7.	Catering instrument air requirement in CPP by running one compressor for all three units.	Reduction of emissions by 84 tCO_2
8.	Installation of VVVF drive in SGP cooling tower fan in BF.	Reduction of emissions by 27 tCO_2
Salav		
1.	Operating Carbon Capture Utilisation (CCU) plant at its Salav facility by utilizing captured carbon in beverage industry.	Reduction of emissions by 33,300 tCO_2

Source: JSW Steel Integrated Annual Reports

Current Status (FY 2022-23)

1. Absolute CO_2 emissions (Scope 1 + Scope 2) = 49.35 MTPA
2. Scope 3 CO_2 emissions = 5.99 MTPA
3. CO_2 emission intensity = 2.36 T_{CO2}/T_{CS}

Target

1. To reduce specific GHG emissions from the 3 ISPs in India to below 1.95 T_{CO2}/T_{CS} by 2030.
2. To achieve carbon neutrality at JSW Steel Coated Products within 2030.
3. Net-Zero GHG emissions by 2070.

Net-Zero Roadmap

JSW Steel has identified several decarbonisation levers and has chalked out a net zero road map for the integrated operations of JSW Steel which has been tabulated in Table 2-3.

Table 2-3: Net zero roadmap of JSW Steel

Year	Planned Initiatives
2030	**Emissions Reduction** › Process & energy efficiency improvement › Technology performance improvement with best practices › Internal monitoring and planning by Climate Action Group (CAG) › Risk assessment and mitigation via Taskforce for Climate Related Financial Disclosure (TCFD) alignment **Other Enablers** › Adoption of Best Available Technology (BAT) › Improvements in operation methodology

Year	Planned Initiatives
	o Iron ore beneficiation o Coke rate reduction o PCI & NG Utilisation in blast furnace › Increased usage of renewable energy › Exploring technology-aided carbon capture (CCUS) › Increased use of scrap › Carbon sink creation › Efficient logistics through pipe conveyor
2030 – 2050	**Deep Decarbonisation** › Scaled deployment of CCUS › Carbon avoidance – use of hydrogen for reduction of iron
2050 – 2070	**Offsetting and other interventions** › Direct electrolysis of iron ore › Development of green cover to act as a carbon sink

Source: JSW Steel Integrated Annual Reports

Arcelor Mittal

The review of decarbonisation strategy of ArcelorMittal group represents a global case net zero roadmap employed across its various facilities and various announced projects to achieve the net-zero target.

Current Status (2022)

1. Absolute CO_2 emissions (Scope 1 + Scope 2) = 110.4 MTPA
2. Scope 3 CO_2 emissions = 5.9 MTPA
3. CO_2 emission intensity = 1.98 T_{CO2}/T_{CS}

Target

1. The near-term (2030) decarbonisation target has been set considering the European facilities individually in one case and cumulative of all facilities as a separate target. This has been given below:
   a. Europe Target: 35% reduction in CO_2 emission intensity by 2030 i.e. reducing 1.67 T_{CO2}/T_{CS} to 1.11 T_{CO2}/T_{CS}.

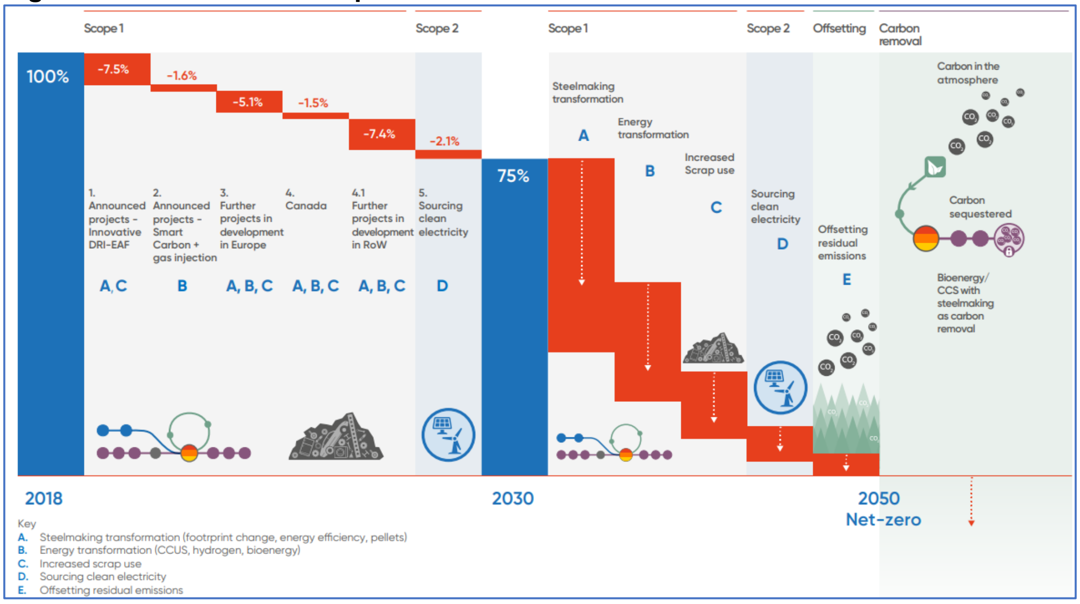
   b. Global Target: 25% reduction in CO_2 emission intensity by 2030 i.e. reducing 1.98 T_{CO2}/T_{CS} of steel to 1.52 T_{CO2}/T_{CS}.

2. Net-Zero GHG emissions by 2050.

Net-Zero Roadmap

ArcelorMittal has identified several decarbonisation levers and have chalked out a net zero road map to enable the production of carbon neutral steel by 2050. This roadmap has been illustrated in Figure 2-4.

Fig. 2-4: Net-zero roadmap of ArcelorMittal

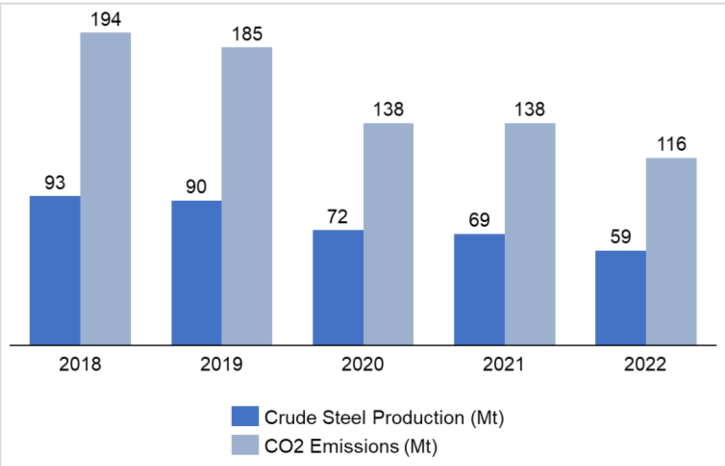


Source: ArcelorMittal Integrated annual report 2022

Implemented & Announced Decarbonisation Strategies / Projects

In terms of implemented decarbonisation strategies, a facility-wise list of all the activities performed to achieve decarbonisation is not available. The total crude steel production of the group has dropped significantly since 2007 which has led to a drop in other parameters such as energy consumption, raw material requirement (coke, coal, iron ore, lime, dolomite etc.) and therefore the CO_2 emissions from steel production operations have also dropped. A near-term trend (2018- 2022) of crude steel production and CO_2 emission has been illustrated in Figure 2-5. The crude steel production in 2022 has dropped by 36% as compared to 2018 leading to a 40% drop in the CO_2 emission.

Fig. 2-5: Crude Steel Production and CO_2 Emission Trend



Source: ArceloMittal factbook 2020 & 2022

The near-term (2021-2030) decarbonisation is envisioned to be achieved by implementation of 3 key strategies: Innovative DRI-EAF route capacity expansion, Smart carbon route, Increased use of scrap. Several of the announced projects to achieve the 2030 group target fall under the above 3 strategic pillars. A list of such projects and their impacts have been tabulated in Table 2-4.

Table 2-4: Decarbonisation initiatives/ Announced projects list by ArcelorMittal

Facility		Initiative/ Announced Projects
Innovative DRI-EAF Route		
1.	**ArcelorMittal Spain**	
i.	Gijon plant	○ Green hydrogen-powered DRI unit of ~2 million tonne DRI to be built to be constructed in Gijon plant. ○ Construction of a new hybrid EAF in Gijon plant will transition the Gijón plant away from BF-BOF steelmaking to DRI-EAF production
ii.	Sestao plant	○ To become world's first full scale zero carbon steel plant (scope 1 & 2). ○ Production of 1.6 million tonnes zero carbon-emissions steel from 2025. ○ Increasing scrap usage for steelmaking and using DRI produced in Gijon plant with green hydrogen. ○ Powering all steelmaking assets with renewable energy by establishing renewable energy power purchase agreements. ○ Introducing key technologies to replace remaining use of fossil fuel with carbon-neutral energy inputs (biomass, green hydrogen).
2.	**ArcelorMittal Germany**	
i.	Bremen and Eisenhüttenstadt plant	○ Industrial DRI-EAF plant under construction in Bremen. ○ Innovative pilot DRI plant and EAF plant under construction in Eisenhüttenstadt. ○ Both plants combined will produce 3.5 million tonnes of crude steel by 2030. ○ CO_2 abatement of more than 5 million tonnes will be possible.
ii.	Hamburg plant	○ The operational DRI-EAF facility is being tested for use of hydrogen for iron ore reduction as well as testing carbon-free DRI in the EAF steelmaking process. ○ The technology is expected to reach commercial maturity by 2025 and it is also expected to start producing 100 kt of DRI per year.

Facility		Initiative/ Announced Projects
iii.	Green Hydrogen Network	ArcelorMittal is collaborating with various companies to establish green hydrogen network in Germany to ensure hydrogen availability for steel production to enable decarbonisation.
3.	**ArcelorMittal France**	
	Dunkirk Plant	ArcelorMittal in collaboration with Air Liquide is studying an innovative solution to produce low-carbon steel in Dunkirk. ArcelorMittal shall combine DRI and submerged arc furnace technology for production of low carbon-emission steel while Air Liquide shall supply hydrogen and carbon capture solution for this project.
4.	**ArcelorMittal Canada**	
	Contrecoeur plant	Testing incremental use of hydrogen in existing DRI facilities.
Smart Carbon Route		
1.	**ArcelorMittal Belgium**	
	Ghent plant	o Torero- Industrial scale demonstration plant that converts wood into bio coal. At a scale of 40,000 tpa. o Steelanol- Utilizing Lanza Tech's technology to transform carbon-rich industrial gases into advanced bioethanol.
	Dunkirk plant	o 3D project: A CCS project of pilot scale of 4,400 tpa utilizing DMX Solvent to capture CO_2 from off gases and establish commercial viability of technology to be scaled up for industrial application.

Source: ArceloMittal Climate Action Report 2

Tata Steel

Tata Steel has a strong domestic and global presence with its manufacturing sites present in India, United Kingdom, Netherland, and Thailand. The group strategy to achieve net zero and various ongoing and announced projects have been reviewed in the section.

Current Status (FY 2022-2023)

1. Absolute CO_2 emissions (Scope 1+ Scope 2+ Scope 3) = 66.2 MT
2. CO_2 emission intensity = 2.21 T_{CO2}/T_{CS}.

Target

Tata steel has set a target of achieving net-zero across their global operations by 2045. They have also published a net-zero roadmap to achieve this target.

Net zero Roadmap

Table 2-5: Net zero roadmap of Tata Steel

Year	Planned Initiatives
Short-term (Up to 2025)	› Enter steel recycling business. › Increased scrap Utilisation. › Adoption of Best Available Technologies. › Improving raw material quality. › Increasing share of renewable energy in power mix.
Medium-term (2026 – 2030)	› Increasing scrap-based EAF route capacity in India. › Switching to lower CO_2 emissions intensity fuel such as natural gas or coal bed methane. › Upscaling pilots of CCUS and H2-based steelmaking. › Piloting low TRL technologies.
Long-term (2031 – 2045)	› Scaling up of HIsarna direct smelting technology. › Increased adoption of DRI-based route. › Sustainable production, storage, and use of Green Hydrogen across the steel value chain. › Increased adoption of CCUS. › Research on advanced materials. › Collaboration with technology companies and academia.

Source: Tata Steel Integrated report 2022-2023

Implemented & Announced Decarbonisation Strategies / Projects
Following the net zero roadmap, Tata Steel has implemented/ announced several projects to drive down the CO_2 footprint of their steel operations. A list of such initiatives/ projects has been tabulated in Table 2-6. These initiatives have been categorized on a region-wise basis.

Table 2-6: Decarbonisation initiatives/ Announced projects list by Tata Steel

Strategy	Outcome/Impact
India	
Agreement with Tata Power Renewable to set up solar & wind hybrid power to replace ~379 MW of Tata Steel's fossil fuel-based power.	Reduction of emissions by 2,000,000 tCO_2
Setting up a 0.5 MTPA scrap processing unit commissioned in FY 2020-21.	Increased usage of scrap in steel making, reducing CO_2 emission by reduction in raw material requirements.
Introducing scrap-based steel production facility: Setting up a 0.75MnTPA EAF capacity steel plant at Ludhiana, Punjab.	Significantly reduced CO_2 emission intensity as compared to BF-BOF route of production.
Commissioned a pilot 5 tonne per day Carbon Capture & Utilisation (CCU) plant in Jamshedpur to capture CO_2 from un-combusted blast furnace	Reduction of emissions by 1,670 tCO_2 annually.

Strategy	Outcome/Impact
gas and gaining crucial insights for scaling up the technology to industrial scale.	
6 kg/thm Hydrogen injection in blast furnace at Jamshedpur steel works on a continuous basis for 4 to 5 days.	Estimated fuel rate reduction by 10% and CO_2 emission intensity by 7-10%.
Continuous coal bed methane injection in blast furnace at Jamshedpur steel works.	Expected reduction in coke rate by ~10 kg/thm abating 33 kg of CO_2 per tonne of crude steel.
Evaluating the feasibility of investments in DRI production using either natural gas/ coal bed methane or syngas from coal gasification as a transitional technology until availability of green hydrogen.	Significantly reduced CO2 emission intensity as compared to BF-BOF route of production.
Netherland	
HIsarna demonstration plant of 60,000 tonnes of pig iron production capacity per annum has been used for commercial operation to establish the commercial viability of the project. It will further be scaled up to commercial level.	At least 20% reduction in energy intensity and CO_2 emission.
Public announcement of shifting to DRI-EAF based route of steel making and utilizing green hydrogen and renewable electricity at this facility. Existing blast furnaces and coke oven batteries to be phased out by 2045.	Significantly reduced CO_2 emission intensity as compared to BF-BOF route of production.
United Kingdom	
Improvement in blast furnaces at Port Talbot.	Estimated reduction in CO_2 emissions by 160,000 tpa
Investment in State-of the Art electric induction furnaces which will reduce emissions from one of its tube mills	Estimated reduction in CO_2 emissions by at least 2,000 tpa.
Secured a £500 million government subsidy to transition from coal-fired blast furnaces to EAF based route for steel making.	Significantly reduced CO_2 emission intensity as compared to BF-BOF route of production.

Source: Tata Steel Integrated report 2022-2023

Thyssenkrupp

Thyssenkrupp steel is one of the leading suppliers of high-grade flat steel and produces about 11 million tons of crude steel per year with its manufacturing sites in different countries of Europe and Asia Pacific. The group strategy to achieve net zero and various ongoing and announced projects have been reviewed in the section.

Current Status (FY 2022-2023)
Absolute CO_2 emission = 20 MT

Target

Thyssenkrupp steel Europe takes responsibility and has itself clear targets to reduce CO_2 emissions to >30% by the year 2030 and to attain net-zero CO_2 emissions by the year 2045.

Implemented & Announced Decarbonisation Strategies / Projects

Thyssenkrup Steel has implemented/ announced several projects to drive down the CO_2 footprint of their steel manufacturing operations. A list of such initiatives/ projects has been tabulated in Table 2-7. These initiatives have been categorized on a region-wise basis.

Table 2-7: Decarbonisation announcements made by ThyssenKrupp Steel Europe

Sl. No.	Strategy	Outcome/Impact
Duisburg		
1.	From 2026 onwards, transformation from Blast furnace and coking coal to direct reduction plants (with two melters) will be implemented where iron ore pellets will be reduced to sponge iron in the DR plant using green H_2.	Enable nearly 3.5 million metric tons of annual CO_2 savings in hot metal production when using H_2. Will produce two grades of Steel- Bluemint Pure and Bluemint Recycled with 70% and 64% reduction of CO_2 emission respectively.
2.	By 2025, the FlexHeat2Anneal Project will be implemented which will make use of H_2 as a fuel on continuous annealing lines and hot dip galvanizing lines for steel strip.	By 2045, 40000 MT of CO_2 emissions per year will be saved.
3.	By 2025, the H_2-DisTherPro Project will be implemented which will substitute carbon-containing fuel gases with hydrogen at discontinuous thermo-processing plants.	By 2045, the site will save 40,000 tpa of CO_2 emissions.
4.	Smelting of scrap products instead of the conventional hot strip in Blast Furnace.	Reduces 2.1 tCO_2/t of hot strip.

Source- Thyssenkurpp Steel Magazine 2022

Other Projects

Liberty Steel

Liberty is the largest integrated steel producer in Romania with a production capacity of 3 MT of steel/year. The company has ambitious plans to be the leading green steel supplier for Central and Eastern European countries.

Current Status (FY 2022-2023)
Absolute CO_2 emission 2.2 tonnes of CO_2 per tonne of crude steel (T_{CO2}/T_{CS}).

Target
Liberty Galati will invest upto 1 billion Euros in its Green Steel transformational plans as it aims to become a carbon neutral by FY 2030. They are aiming for their existing sites to achieve Carbon neutral Scope 1 and Scope 2 emissions by FY 2030.

Net Zero Roadmap

Fig. 2-6: Net-zero roadmap of Liberty Steel

Implemented & Announced Decarbonisation Strategies / Projects

Table 2-8: Decarbonisation announcements made by Liberty Galati Steel, Romania

Strategy	Outcome/Impact
Australia (Whyalla)	
Reshaping the operations by moving from a reliance on BFs and BOFs towards EAFs using DRI plants which will initially be fuelled with natural gas and, in time, transition to hydrogen. The DRI will be fitted with the latest EAF technology so that they can melt DRI as well as scrap.	Will reduce emissions from 2.2 CO_2/ts to 0.6 CO_2/ts by FY 2030.
Ostrava	
The installation of the two state-of-the art Danieli hybrid EAFs at the centre of Ostrava's GREENSTEEL transformation plan. The contracts for these were signed in July 2022.	Carbon emissions are expected to fall from 2.2 tonnes of CO_2 per tonne of crude steel (T_{CO2}/T_{CS}) to

Strategy	Outcome/Impact
	around 1.2 T_{CO2}/T_{CS} between 2022-2026.
The completion of a 400KV electricity line into the Ostrava Steelworks which will allow its new hybrid EAFs to melt 100% scrap by 2027.	Carbon intensity levels will fall by a further 75%, from around 1.2 T_{CO2}/T_{CS} to around 0.3 T_{CO2}/T_{CS} between 2027-2030.
Galati	
The installation of two new hybrid EAFs at the centre of Galati's GREENSTEEL transformation plan. The tender process has been launched. This will be supported by a 180MW on-site solar farm, of which the first 50MW is already being connected.	Carbon emissions are expected to fall from 2.2 tonnes of CO_2 per tonne of crude steel (T_{CO2}/T_{CS}) to around 1.2 tCO_2 /tCS between 2022-2026.
The installation of a DRI plant and a hydrogen electrolyser at Galati which will allow it to feed green DRI/HBI directly into its hybrid EAFs when hydrogen production in Europe becomes economically viable.	Carbon intensity levels will fall by a further 75%, from around 1.2 T_{CO2}/T_{CS} to around 0.3 T_{CO2}/T_{CS} between 2027-2030.

Source: Liberty Sustainability Report 2022

SSAB

SSAB is a global steel company with a leading position in high-strength steels and related services. We aim to be the first steel company in the world to offer fossil-free steel to the market and consolidated its leading position in the green transition in the steel industry.

Target

SSAB aims to be the first, in 2026, to offer fossil-free steel to the market. SSAB's environmental target for GHG emissions, which has been approved by the Science Based Targets initiative, stipulates a commitment to reduce their GHG emissions by 35% by 2032 (compared to 2018 and measured as CO_2e). The 2032 target applies both to direct and indirect emissions (Scope 1 and 2 GHG emissions).

Net Zero Roadmap

Table 2-9: Net zero Roadmap of SSAB

Scope 1&2 emissions	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Absolute emissions target (MT)	11.8	11.3	11.3	11.3	10.6	10	10	10	10	8.7	7.8	7.7

Implemented & Announced Decarbonisation Strategies / Projects

Table 2-10: Decarbonisation announcements made by SSAB

Strategy	Outcome/Impact
Through HYBRIT technology, SSAB intends to be the first steel company to launch fossil-free steel at a commercial scale and to replace blast furnaces and coke plants with electric arc furnaces in around 2030.	CO_2 emission will be reduced from 0.8 to 4.1 million tons from 2022 to 2032.

Source- SSAB Annual report 2022

Other Pilot Initiatives

Rio-Tinto

Rio-Tinto is an industrial startup establishing large scale production of green steel.It has developed a laboratory-proven process that combines the use of raw and sustainable biomass in place of coking coal with microwave technology to convert iron ore to metallic iron during steel making process.

Current Status (FY 2022-2023)
Absolute CO_2 emissions- Scope 1 and Scope 2 emissions were 30.3MT CO_2e in 2022.

Target
Rio-Tinto targets are to reduce Scope 1 and 2 emissions by 15% by 2025 and by 50% by 2030 (relative to 2018 levels), and to reach net zero by 2050.

Implemented & Announced Decarbonisation Strategies / Projects

Table 2-11: Decarbonisation announcements made by Rio-Tinto

Strategy	Outcome/Impact
Pilbara	
Blast furnace optimisation: Extended our collaboration with over 20 customers, such as Bouw, POSCO, Nippon Steel Corporation and Shou gang.	Potential Carbon Emission reductions up to 30%.
Bio Iron: Successfully piloted an innovative, low-carbon iron-making process on Pilbara iron ore with a capacity of one tonne per hour.	CO_2 emissions will be reduced by 30%.
Hydrogen-based DRI2: Collaborated with BlueScope and Salzgitter Flachstahl to test direct reduction of our products using green hydrogen and develop cleaner processing options.	CO_2 emissions by green hydrogen instead of coal will be reduced by up to 95%.

Source- Rio-Tinto Annual Report 2022

Primetals Technologies

Primetals Technologies has developed a Hydrogen-based fine-ore reduction (HYFOR) pilot plant. It was commissioned at the Voestalpine site in Danowitz, Austria. The HYFOR pilot plant employs the world´s first direct reduction process for iron ore fines concentrates from ore beneficiation, not requiring any agglomeration like sintering or pelletizing.

Target

The aim of this plant is to use this new technology to cut primary energy consumption by 20% and CO_2 emissions by up to 100% shrinking the carbon footprint of crude steel production by 80% in two years.

Implemented & Announced Decarbonisation Strategies / Projects

Table 2-12: Decarbonisation technologies made by Primetals Technologies

Sl. No.	Strategy	Outcome/Impact
Austria		
1.	In 2021, the scale of one test run is in the range of processing of 800 kg iron ore. As primary reduction agent, the new process uses 100% H_2 from renewable energy or alternatively H_2-rich gases from other gas sources like natural gas pyrolysis or conventional steam reformers. s. The product is hot DRI for direct hot transport and feed to the downstream melting like EAF or Hot Briquetted Iron (HBI) for being sold to the market. Smooth operation assumed; a hot briquetting unit will be added to verify the hot briquetting step as well as the HBI quality to be expected from the HYFOR technology.	Use of 100% Hydrogen as reduction agent lowers CO_2 footprint close to zero.

Source- Primetals Technologies HYFOR Pilot Plant Report 2021

Metso Outotec

Metso Outotec will convert its existing 700 mm Circulating Fluidized Bed (CFB) pilot plant in Frankfurt, Germany for hydrogen based direct reduction of fine ore applying the proven Planet Positive Circored technology.

Target

The commissioning of the plant is expected to take place in December 2023, which will be used for the reduction of low-grade iron concentrate fines in large quantities using 100% hydrogen as the sole reducing agent making it almost a zero-carbon emission plant.

Implemented & Announced Decarbonisation Strategies / Projects

Table 2-13: Decarbonisation announcements made by Metso Outotec

Sl. No.	Strategy	Outcome/Impact
Frankfurt		
1.	By December 2023, the 700 mm pilot plant will produce 150-200 kg/hr of direct reduced iron using 100% hydrogen as the sole reducing agent. The plant will also include integrated preheating and reduction section followed by gas cleaning and recirculation facility.	Use of 100% hydrogen as the sole reducing agent will offer the lowest possible carbon footprint or even a net-zero carbon emission.

Source- Metso Outotec Press Release (December 9, 2022)

2.2 Challenges of Carbon Abatement & Green Steel Production

While the reduction of CO_2 emission intensity of crude steel production has been made possible through technological interventions, the pathway to green steel production still entails numerous challenges few of which have been discussed below.

a. **Availability of renewables and green hydrogen:** Green hydrogen is produced through electrolysis and the electricity required for electrolysis must come from renewable sources. Renewable energy is not sufficiently available to replace fossil-based fuels.

b. **High cost of production:** Renewable energy and green hydrogen are two prominent drivers for low-carbon iron and steel production. One of the most prominent challenges that comes with transitioning into low carbon is the high cost of producing renewable power. Cost of renewable energy is responsible for 60-70% of cost of green hydrogen production. Green hydrogen is still an evolving market in India thus the technology is not yet established at a commercial scale leading to higher initial capital investment. Using renewable energy and green hydrogen at the current stage could significantly increase the cost of production of steel.

c. **Technology challenges:** The current blast furnace technology is reliant on coal and coke for iron making. This cannot be completely replaced with green hydrogen as coke functions as a fuel for melting the ore as well as charge burden support. Thus, the current technology cannot be completely decarbonized by using green hydrogen.

d. **Dependence on Coal-based Processes:** It's difficult to reach net-zero emissions goal with current technologies which are being used for steel production in India. Most of the Indian Steel manufacturers use coal-based processes due to limited access to natural gas at competitive prices and insufficient scrap availability. The decarbonization of these coal-based production routes can only be achieved through carbon capture, utilisation and storage (CCUS) and the CCUS ecosystem is still developing in India. As a result, achieving near-zero emissions with the present steel production routes will face considerable technical and cost-related challenges.

e. **CCUS Challenges**: While a large share of the CO_2 being emitted from Iron & steel plants could be captured using carbon capture technology, a very small fraction of the captured CO_2 can be utilized for downstream chemicals production. The CO_2 sequestration potential in India has not been mapped sufficiently to support the development of the infrastructure required for CO_2 sequestration.

f. **CO_2 Emissions Monitoring & Verification:** Monitoring of scope-3 emissions for upstream and downstream of a iron and steel production plant is complex activity due to complex network of supply chain for both raw materials and products. This aspect requires more transparency in terms of the network partners and the specific emissions data for the calculation of CO_2 emissions. More transparency shall enable a robust CO_2 monitoring and verification system for the Indian iron & steel industry.

2.3 GHG Inventorization of SAIL RSP (FY 22-23)

Based on the GHG inventory prepared for the existing plant for FY 22-23, the absolute CO_2 emission for 4 MTPA crude steel production is 10.52 MTPA and the resulting total CO_2 emission intensity came out to be 2.61 T_{CO2}/T_{CS}.

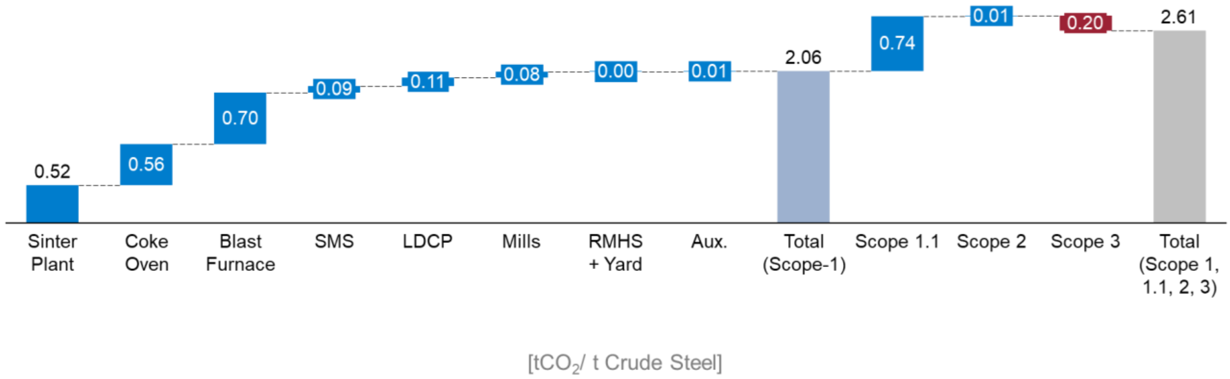
The unit-wise distribution of CO_2 emission intensity is listed in Table 2-14.

Table 2-14: Unit-wise distribution of CO_2 emission intensity for FY 22-23

Units	Scope 1	Scope 1.1	Scope 2	Scope 3	Total
Total SP	0.52	-0.01	0.04	0.00	0.55
Total COB	0.56	-0.25	-0.09	0.00	0.22
Total BF	0.70	1.03	-0.18	-0.25	1.29
Total SMS	0.09	0.07	0.03	0.05	0.24
Total LDCP	0.11	-0.02	0.02	-0.01	0.11
Rolling Mills	0.08	-0.08	0.16	0.00	0.17
RMHS+Marsh yard	0	0	0.01	0	0.01

Units	Scope 1	Scope 1.1	Scope 2	Scope 3	Total
CRS+WRS+TOP	0.01	-0.01	0.02	0.00	0.02
Total	**2.06**	**0.74**	**0.01**	**-0.20**	**2.61**

Fig. 2-7: CO_2 emission intensity for FY 22-23.



Based on the data received from RSP, the CO_2 emission intensity for FY 23-24 for 4.16 MTPA crude steel production was about 2.61 T_{CO2}/T_{CS}. The CO_2 mitigation strategies have been studied with FY 23-24 as the baseline year.

2.4 GHG Emission Reduction Plan for SAIL RSP (up to FY31)

2.4.1 Decarbonization strategies

By 2026-27, SAIL has a target to reach CO_2 emissions intensity below 2.15 T_{CO2}/T_{CS} and below 2.05 T_{CO2}/T_{CS} by 2030. In order to bring down the emission intensity of crude steel production certain initiatives are being considered. A brief summary of the initiatives is provided below. The base figure is considered as 2.61 T_{CO2}/T_{CS} in FY 23-24.

1. **Energy Efficiency:** This strategy aims to identify, evaluate, and promote the use of the best available technologies (BAT) in the steel sector to enhance efficiency and reduce emission intensity.

2. **Renewable energy transition:** This strategy evaluates the steel industry's power requirements, studies the adoption of renewable energy (RE), and identifies challenges in its implementation. It then creates an action plan to accelerate RE uptake in the steel sector without altering the existing production process.

3. **Material Efficiency:** This strategy evaluates the role of material efficiency measures in mitigating emissions from the steel sector. It identifies the current

levels of beneficiation and pellet uptake, assesses their impact on carbon emissions, and prepares a roadmap to increase the use of beneficiated ore, pellets, and scrap in the steel sector.

4. **Green hydrogen:** Green hydrogen is the fuel of the future. This strategy assesses the global status of green hydrogen in the steel industry, evaluates its potential in India, analyzes its techno-economic implications and emissions reduction benefits, and explores international cooperation for its adoption.

5. **Alternate Iron & Steel Making Route:** Shifting from the established BF-BOF route which is heavily reliant on coal & coke to an alternative route of iron and steel production like gas-based DRI-EAF route (NG/H_2 based) can lead to a significant reduction of CO_2 emissions from the crude steel production.

2.4.2 Decarbonization Strategies for RSP

In line with the decarbonization target of SAIL RSP, a few measures have been finalized in discussion with the plant in-charges of various units to ensure their feasibility and alignment with the overall operational objectives of RSP. These measures have been tabulated in Table 2-15.

Table 2-15: Unit-wise CO_2 mitigation measures

Sl. No.	Strategy
Sinter Plant	
1.	New set of pallet cars in SP-2
2.	Introduction of MEROS technology in SP -2
3.	Hot water mixing in SP-3
4.	Rubber seal in circular coolers in SP-3
5.	Pallet car width expansion in SP-3
6.	Maximum heat recovery from cooler onto sinter machine strand in SP-3
Coke Ovens	
1.	Blending of 90% imported & 10 % Indigenous coal
2.	COB-5 with CDCP
Blast Furnace	
1.	Increasing pellet to 30% in BF charge mix
2.	Injection of NG in BFs
3.	Increasing BF-1 Top pressure
4.	Installation of 4th stove in BF -5
5.	HBI / Scrap addition in BF-5
SMS	
1.	Increase scrap in charge-mix by 5 kg in SMS-2
Renewables	
1.	100 MW solar panel and 10MW hydropower
2.	660 Million Units of RE power by Purchase Power Agreement

Sl. No.	Strategy
New Facilities	
1.	Oxygen plant 1000 TPD and 1.8 MTPA Micro-Pellet Plant
2.	Stamp Charge COB -7
3.	330 MW Solar PV

I. Sinter Plants

Overall energy requirement in iron ore sintering process is roughly in the range of 500,000 – 550,000 KCal/t of Gross - sinter (GS) from gaseous, electrical and solid fuel as given below, which is about one-tenth that of BF iron making:

- Gaseous energy: 15000 -18000 KCal
- Electrical: 35 kWh (~30,200 KCal)
- Coke breeze characteristics: 0.45 – 0.5 GCal depending on ore

Considering the current health level of each sinter plant and future sustainability, the following measures have been adopted by RSP (as emerged during discussion with the operation and maintenance teams of the respective sinter plants) most of which are unlikely to impact CO_2 emission abatement appreciably but result in into smart plant operation and sustained sinter production for a long time to come.

New set of pallet cars in SP-2

The sealing assemblies of the existing pallet cars are significantly worn out due to prolonged use over decades resulting into appreciable leakage on the sealing track with attendant heat loss and a sharp fall in under grate suction level. This jeopardizes downward movement of the flame front thereby directly affecting sinter quality and plant productivity.

Introducing a new set of pallet cars with new sealing assemblies would restore the desired suction level by arresting undesirable air leakage on the track and hence the efficiency of the sintering process, vis-a vis heat utilisation, productivity, sinter quality and specific power consumption of exhaust fan.

In view of above, it is strongly advised to replace the existing pallet cars in SP-2 with new ones.

Introduction of MEROS technology in SP -2

MEROS (Maximized Emission Reduction of Sintering) system is an off-gas cleaning technology incorporated in a few sinter plants to effectively reduce dust load, harmful constituents etc from the off-gas. The possibility of incorporation may be explored for overall environmental benefits. In this regard, suitable interaction with technology suppliers like Primetals may be contemplated.

Hot Water mixing in SP-3

Hot water (at ~ 80°C) may be used instead of water at room temperature for mixing of proportioned materials in the mixer to derive some thermal benefits in terms of reduced coke breeze consumption. It was discussed with the Sinter Plant team that necessary heat exchanging facilities can be created by RSP to utilize recovered heat from the cooler without affecting regular plant operation. This strategy is already implemented.

Based on our analysis around 74,500 tons of CO_2 emission can be reduced by adopting this suggestion.

Rubber Seal in Circular Coolers in SP-3

Hot sinter at ~ 800 °C cools down in the circular cooler to < 100 °C. The heat recovered at cooler feed end is utilized in the process thereby resulting in energy saving.

Due to the poor condition of the rubber seals at present between the rotating structure and the static part of the cooler , there is air leakage being reported with attendant heat losses and reduced cooling efficiency. This warrants replacement of the existing damaged rubber seals at the earliest for improved functioning of the cooler.

Pallet car width expansion in SP-3

This may be favorably considered for incremental production benefits to the tune of 10-15 % in line with many existing sinter machines.

II. Coke Oven and Blast Furnace

Increasing pellet charge to 30% of total burden mix

In FY 23-24, RSP's blast furnace (BF) charge mix consisted of approximately 6% pellets, 70% sinter, and 24% iron ore. Due to the absence of LOI in pellet, increasing pellet charge instead of lump ore will be beneficial for coke rate reduction and, consequently, CO_2 emissions reduction, additionally, the surplus coke, which is not utilized, can be sold, generating Scope 3 CO_2 emissions credits.

A thorough analysis of the present BF condition, raw material quality and product specifications indicated that by increasing the pellet percentage to 30% in the BF charge mix, a significant reduction in coke rate can be achieved moreover, the surplus coke can be sold generating scope-3 credit. This strategy can be implemented by FY 25-26.

Based on our analysis around 183,450 tpa of CO_2 emission can be reduced by adopting this suggestion.

Injection of Natural Gas in BF-1 & BF-5

Natural gas (NG) injection is a potential replacement for Pulverized Coal Injection (PCI) in Blast furnaces. The PCI to NG replacement ratio is around 1.3 - 1.4 t PCI/ t NG. NG has lower carbon content than coal thus resulting in lower CO_2 emissions upon combustion. This strategy can be implemented by FY 26-27.

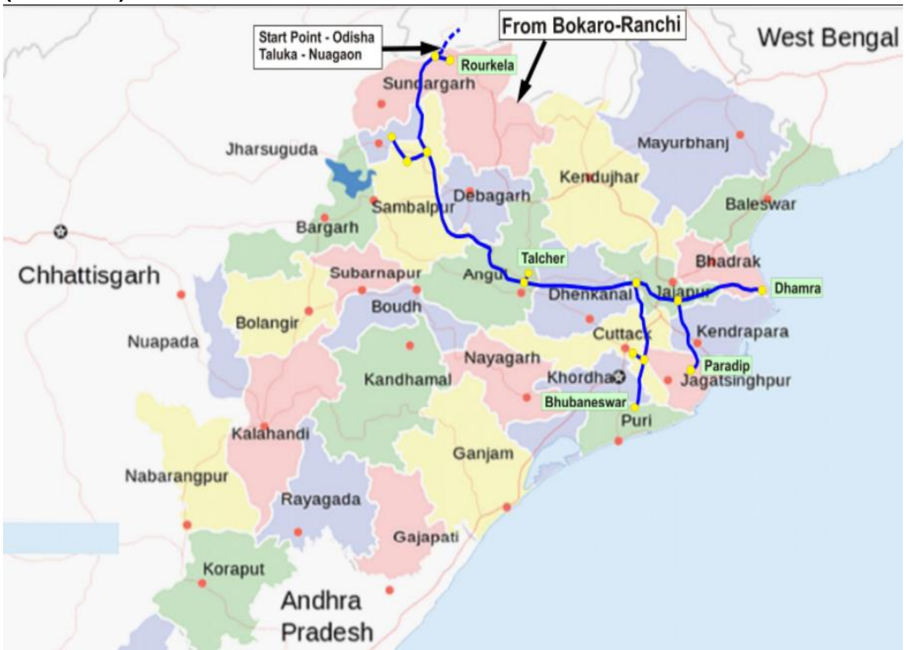
As per our study, around 17kg NG/ tHM can be injected safely in a blast furnace without any considerable change in the current BF operation.

In RSP, only BF 1 and BF 5 are operating as of FY 23-24. By replacing PCI with NG in BF 1 and BF 5 a substantial reduction of around 82,200 tons of CO_2 emissions can be achieved.

The proximity of GAIL's Jagdishpur-Haldia & Bokaro-Dhamra pipeline to RSP ensures a reliable and efficient supply of NG.

The outline of GAIL's Jagdishpur-Haldia & Bokaro-Dhamra pipeline passing through Rourkela has been illustrated in Fig. 2-8.

Fig. 2-8: GAIL'S JAGDISHPUR-HALDIA & BOKARO-DHAMRA Natural Gas Pipeline (JHBDPL) in Odisha.



Increasing BF-1 Top pressure

BF-1 has 1.71 kg/cm^2 of top pressure at present. After discussion with the plant in-charge of BF-1, it was concluded that the top pressure of BF-1 can be further increased up to 2kg/cm^2 without any considerable change in the BF operation. With an increase in the top pressure, a significant reduction in the coke rate is observed in BF-1, leading to lower CO_2 emissions. Additionally, the installation of a Top recovery turbine (TRT) can utilize the increased top pressure of BF-1 to generate electricity, further reducing the CO_2 emission by lowering the scope 2 emissions. This strategy can be implemented by FY 26-27.

As per our analysis, it was observed that a TRT of 2.7 MW capacity can be installed at BF 1 but the installation of TRT is not economically viable thus, TRT installation at BF-1 is not recommended. With increased pressure, a significant coke rate reduction is achieved.

As per our analysis, around 40,000 tpa of CO_2 emissions can be reduced by adopting this measure.

Installation of 4th stove in BF-5.

At present BF-5 has 3 stoves. The hot blast temperature is around 1100°C. After discussing with the BF-5 plant in charge it was decided that the hot blast temperature of BF-5 can be further increased up to 1200°C without any considerable change in BF operation. The installation of the 4th stove in BF-5 would result in an increase in the hot blast temperature by about 100°C. As we increase the hot blast temperature, a significant reduction in the coke rate is observed in BF-5 thus reducing CO_2 emissions, additionally, the surplus coke, which is not utilized, can be sold, generating Scope 3 CO_2 emissions credits.This strategy can be implemented by FY 25-26.

As per our analysis, around 171,900 tpa of CO_2 emissions can be reduced by adopting this measure.

HBI/Scrap addition in BF-5.

Replacing the pellet in the BF charge mix with Hot Briquetted Iron (HBI)/Scrap as per availibility offers significant metallurgical and operational benefits. Cleveland-Cliffs, an American Steel Manufactuter has already added HBI into their BFs, the HBI to pellet replacement ratio was around 1.3-1.4, for our calculation the same ratio has been taken here.

Approximately 300 kg of HBI/scrap per ton of hot metal, equating to 0.98 MTPA of HBI/scrap sourced from the market can be charged into BF-5. Consequently, 1.34 MTPA of pellets would be replaced by 0.98 MTPA of HBI, leading to a notable reduction in coke consumption due to HBI’s superior reducibility and lower gangue levels. This substitution not only enhances furnace productivity through improved gas permeability and stable operation but also leads to energy savings and lower CO_2 emissions. Additionally, the surplus coke, which is not utilized, can be sold, generating Scope 3 CO_2 emissions credits.This strategy can be implemented by FY 26-27.

As per our analysis, around 782,800 tpa of CO_2 emissions can be reduced by adopting this measure.

Coal quality improvement in COB 1-6

At present, RSP utilizes coal with an average ash content of 12.5%.The coke ovens use a blend of 10% indigenous coal with 27% ash content, 63% imported HCC (ash content - 12%), and 27% imported SCC (ash content - 7%). Coal from the Tasra mine, which has 17 % ash content is expected to be procured by RSP by FY 2026-2027. Incorporating 10% indigenous coal from the Tasra mines will reduce the average ash content to 11.15%. Consequently, the resultant coke ash quality will decrease from 16.2% to 14.9% thus, a significant coke rate reduction is achieved.Additionally, the surplus coke, which is not utilized, can be sold, generating Scope 3 CO_2 emissions credits.This strategy can be implemented by FY 26-27.

As per our analysis, around 2,47,900 tons of CO_2 emissions can be reduced by adopting this measure.

III. SMS

Scrap addition in SMS-2

Currently, the total solid charge in SMS-2 is about 8% in RSP.

There are certain advantages to increasing the scrap addition to BOF. Adding more scrap shall lead to a reduction in the hot metal requirement of BOF. This substituted hot metal can be sold to the market as pig iron which shall result in credit in the scope-3 emission intensity of the SMS unit thus decreasing the overall CO_2 emission intensity. After discussion with the plant in-charge of SMS-2, it was decided that around 5 kg/T_{CS} extra Scrap can be added to BOF-2 without much change in any parameters. This strategy can be implemented by FY 25-26.

As per our analysis, around 80,000 tpa of CO_2 emission can be reduced by adding 5 kg Scrap /T_{CS}.

IV. Renewable Power

RSP is planning to install 100 MW of solar facility and 10 MW of hydroelectric power. This will help to lower the scope-2 emission intensity. The electricity generation from solar PV and hydro power have been considered at 20% and 80% plant load factor (PLF) respectively. This strategy can be implemented by FY 26-27.

As per our analysis, around 123,621 tpa of CO_2 emission can be reduced by adopting this measure.

Increasing the share of renewable energy

As the electricity generated from solar and hydroelectric is on the lower side. Another strategy to increase the share of renewable power is to collaborate with green energy companies that set up large renewable energy facilities and sign power purchase agreements (PPA). As a part of these agreements RSP would receive renewable energy certificates from the power producer and the power producer shall set up the renewable energy generation facilities for the agreed capacity.

As per our analysis, around 333,000 tpa of CO_2 emission can be reduced by adding 660 Million Units of RE Power by Purchase Power Agreement.

V. New facilities

Stamp charge COB-7 addition

The stamp charge COB-7, with a capacity of 0.8 MTPA, is projected to be commissioned by FY 2029-30. During this period, COB-6 (0.8 MTPA) will undergo capital repairs. The stamp charge battery can accommodate a higher proportion of SCC (70%) than the top charge battery thus, the average coal ash quantity in COB-7 is about 9.75 %.The overall ash content in COB-1-5 & 7 comes out to be 10.69%.The resultant coke ash quality further reduces to 14.2% from 14.9% thus, a significant coke rate reduction is achieved. This strategy can be implemented by FY 29-30.

As per our analysis, around 49,400 tpa of CO_2 emissions can be reduced by adopting this measure.

Micropellet Plant & Oxygen Plant

1.8 MTPA Micropellet Plant and a 300 TPD oxygen plant are planned to be installed which would cater for RSP's pellet and additional oxygen requirements. These would be built on Built Own Basis (BOO) so it has been considered out of the plant boundary.

Solar PV

An additional 330 MW solar PV can be installed on the water body, barren land and built-up area of RSP. The total power drawn would be about 66 MW. This strategy would lower the scope-2 emission significantly. This strategy can be implemented by FY 29-30.

As per our analysis, around 269,700 tpa of CO_2 emissions can be reduced by adopting this measure.

The summary of each initiative and the respective estimated CO_2 emissions reduction have been given in the Table 2-16.

Table 2-16: Summary of Initiatives planned for till FY31 from FY 23-24 (2.61 T_{CO2}/T_{CS} for 4.16 MTPA CS)

Plant Unit / Initiative	Implementation Year	Initiative	Parameter	Unit	Original value	Final value	Change in Coke rate of BF-1	Change in Coke rate of BF-5	Wt. avg. coke rate (BF-1+BF-5)	Coke Sale (tpa)	CO2 reduction, tpa	Intensity reduction, tCO2/tCS
Sinter Plant-3	FY 25-26	Hot water mixing in mixing drum of SP-3	Coke breeze	kg/tSinter	72	69	-	-	-	11,160	-74,036	-0.02
BF & COBP	FY 25-26	BF-5 4th stove addition to reach blast temp above 1200 oC	Coke rate	kg/thm	416	410	458	390	410	25,913	-1,71,905	-0.04
SMS-2	FY 25-26	5 kg additional scrap addition to BOF of SMS-2	Pig iron sale	tpa	1,33,831	1,52,876					-83,240	-0.02
BF & COBP	FY 25-26	Pellet increase to 30% in BFs replacing lump ore	Coke rate	kg/thm	410	404	452	384	404	27,652	-1,83,441	-0.04
BF & COBP	FY 26-27	BF-1 top pressure increase	Coke rate	kg/thm	404	404	452*	384	404	1,885	-12,503	-0.01
BF & COBP	FY 26-27	Coal quality improvement - COB 1-6 (Coal Blend: 10% from Tasra Mines (17% ash) instead of present indigenous coal (27% ash), 63% HCC (12% ash) and 27% SCC (7% ash) - Resultant coke ash - 14.9% from 16.2%	Coke rate	kg/thm	404	396	443	376	396	37,285	-2,47,898	-0.06
BF & COBP	FY 26-27	Partial replacement of PCI with 17 kg/thm NG	PCI (NG)	kg/thm (kg/thm)	123(0)	99 (17)	-	-	-	-	-82,172	-0.02
HBI/Scrap Addition in BF-5	FY 26-27	About 300 kg HBI /Scrap per ton of HM charge in BF-5 to reduce coke rate	Coke rate	kg/thm	396	315	0	299	379	9,76,612	-7,82,753	-0.19
Renewable Power	FY 26-27	100 MW solar installation and 10 MW Hydroelectric power by RSP	Scope 2 reduction	MW	0	22	-	-	-	-	-1,23,621	-0.03
Renewable Power	FY 26-27	660 Million Units of RE Power by Purchase Power Agreement	Scope 2 reduction	Mill KWh	0	660	-	-	-	-	-3,32,960	-0.08
										Total reduction by FY 26-27	**-20,94,529**	**-0.51**
											tCO2 /tCS at FY 26-27	**2.10**
BF & COBP	FY 29-30	Stamp charge COB-7 addition and coal quality improvement in COB 7 with HCC-30%, SCC-70% - Resultant avg. Coke ash - 14.2% from 14.9%	Coke rate	kg/thm	379	378	443	297	378	9,248	-49,313	-0.01
Renewable Power	FY 29-30	330 MW Solar PV installation (rooftop + barren land + water body) in 155 Hactre. The final power drawn is 66 MW.	Scope 2 reduction	MW	0	66	-	-	-	-	-2,69,643	-0.06
										Reduction from FY 27-28 to FY 30-31	**-3,18,956**	**-0.08**
											tCO2 /tCS at FY 30-31	**2.03**

***Insignificant Change in Coke rate**

2.4.3 Cost Analysis for Suggested GHG Mitigation Strategies

The evaluation of the impact on CAPEX, OPEX, CO_2 abatement cost and cost of production of steel for the initiatives suggested in the near-term decarbonization strategy has been done based on the assumptions given in Table 2-17.

Table 2-17: Assumptions for cost impact analysis

Assumption	Value
Capex Assumptions	
Blast Furnace Stove (Rs. Crore)	110
Solar PV (Rs. Crore/MW)	4.5
Hydro Power (Rs. Crore/MW)	8.5
Weighted average cost of capital (WACC)	10%
Opex Assumptions	
Price of Coke Breeze (Rs./T)	15,000
Price of Coke (Rs./T)	25,000
Price of PCI (Rs./T)	20,000
Price of Natural Gas (Rs./MMBtu)	924
Price of Scrap (Rs. / T)	38,000
Price of Pig Iron (Rs. / T)	40,000
Price of Pellet (Rs./T)	8,000
Price of Lump Ore (Rs./T)	6,500
Price premium of renewable energy over grid power (Rs./kWh)	2

Based on these assumptions, the cost impact for the selected near-term decarbonization strategies has been given in Table 2-18.

Table 2-18: Cost of CO_2 Abatement and Impact on cost of Crude Steel Production

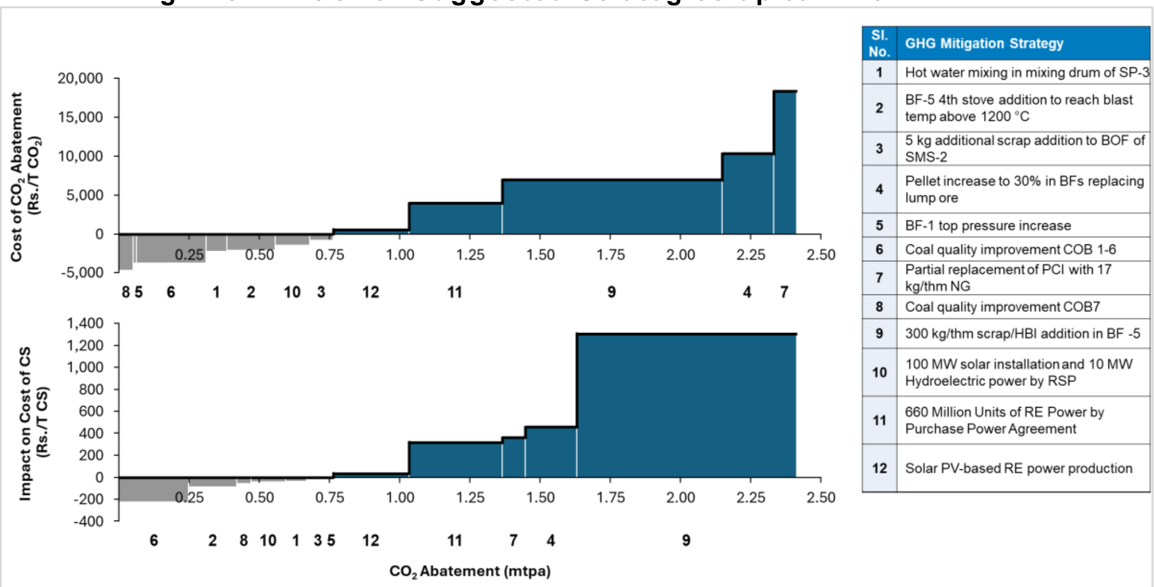
Sl. No.	Initiative	CO_2 abated (MTPA)	Impact on cost of CS (Rs. /T CS)	Cost of CO_2 abatement (Rs. /T CO_2)
1	Hot water mixing in the mixing drum of SP-3	0.07	-40	-2,261
2	BF-5 4th stove addition to reach blast temp above 1200 °C	0.17	-86	-2,076
3	5 kg additional scrap addition to BOF of SMS-2	0.08	-16	-792
4	Pellet increase to 30% in BFs replacing lump ore	0.18	455	10,329
5	BF-1 top pressure increase	0.01	-11	-3,768
6	Coal quality improvement COB 1-6	0.25	-224	-3,760

7	Partial replacement of PCI with 17 kg/thm NG	0.08	363	18,367
8	Coal quality improvement COB7	0.05	-56	-4,688
9	300 kg/tHM Scrap/HBI addition in BF-5 to replace pellet (90% pellet replacement).	0.78	1,306	6,943
10	100 MW solar installation and 10 MW Hydroelectric power by RSP	0.12	-44	-1,483
11	660 million Units of RE Power by Purchase Power Agreement	0.33	317	3,964
12	Solar PV-based RE power production	0.27	35	547

The marginal abatement cost curve (MACC) and the impact on the cost of crude steel production for the suggested strategies has been given in Figure 2-9.

It is to be noted that, for all the calculations, it was considered that the plant facilities will be operating at stabilized manner. Accordingly, when coke rate of BF is reduced due to any intervention, the coke sale is considered (comes under scope-3) instead of lesser coke production. This dual effect on CO_2 footprint reduction reduces the per-ton cost of crude steel from its present level for a few cases.

Fig. 2-9: MACC for Suggested Strategies up to FY 31



2.5 Net Zero Roadmap for SAIL RSP

In line with the RSP's target of achieving net zero, a pathway has been formulated. The strategies and the respective timelines are given in Table 2-19.

Table 2-19: Net zero roadmap of SAIL RSP

Years	Strategies	Hot Metal& DRI (MTPA)	Crude Steel (MTPA)	CO_2 Intensity
FY 31-40	**Facilities added** COB-6 NG based DRI (2X 2 MTPA) New SMS-1 (2.8 MTPA EAF Based) **Facilities de-functionalized** COB-4 COB-5 Old SMS -1	HM-4.7 DRI-4	6.4	1.94
FY 41-50	**Facilities added** H_2 based DRI (2x 2.5 MTPA) SMS-3 (4.5 MTPA EAF based) **Facilities de-functionalized** SP-1,2 & 3 BF-1 BF-5 COB-1,2,3,6,7 SMS -2	HM-0 DRI-9	7.3	1.0
FY 51-60	**Facilities added** Replacing NG based to H_2-based DRI in (2x 2 MTPA) DRI Modules and using hydrogen as fuel in reheating furnace & H_2 preheater in DRI	DRI-9	7.3	0.6
FY 61-70	Green power replacing coal-based electricity. Addition of biochar in SMS instead of pet coke	DRI-9	7.3	0.0

2.6 Net Zero Pathway for SAIL RSP

Decarbonization Strategies: FY 31-40

In the period 2031 – 2040, the addition of two NG–based DRI modules of 2.0 MTPA capacity must be targeted. The old SMS-1, which has 0.5 MTPA capacity, has been envisaged to be replaced by a new EAF-based SMS-1 with a capacity of 2.8 MTPA.

Capital repair of COB-6 (0.8 MTPA) is expected to be completed by FY 33-34, COB-4 (0.4 MTPA) and COB-5(0.4 MTPA) shall be de-functionalized accordingly as production of COB-6 restarts.

The Crude Steel production capacity shall increase to 6.4 MTPA and the net CO_2 emission intensity shall be reduced to 1.94 T_{CO2}/T_{CS} by 2040.

Decarbonization Strategies: FY 41 – 50

In the period 2041 – 2050, the addition of another 2 modules of H_2-based DRI of 2.5 MTPA capacity each and 4.5 MTPA EAF-based SMS-3 must be targeted. Accordingly, sinter plants need to be de-functionalized. The remaining 2 BFs (BF-1 and BF-5) and remaining coke ovens (1,2,3,6,7) shall also be de-functionalized. The crude steel capacity increases to 7.3 MTPA. Post 2050, the crude steel capacity shall remain constant at 7.3 MTPA. The net CO_2 emission intensity shall be reduced to 1.0 T_{CO2}/T_{CS} by 2050.

Decarbonization Strategies: FY 51 - 60

Post 2050, it has been assumed that green hydrogen shall be readily available for commercial utilisation. According to TERI projection, under conservative scenario the national grid emission intensity shall be 0.22 T CO_2/ MWh. All the DRI units shall be operated with 100% green hydrogen and the fuel for reheating furnace and other areas shall be replaced with green hydrogen. In line with these projections and assumptions, the net CO_2 emission intensity of RSP shall be reduced to 0.6 T_{CO2}/T_{CS} by 2060.

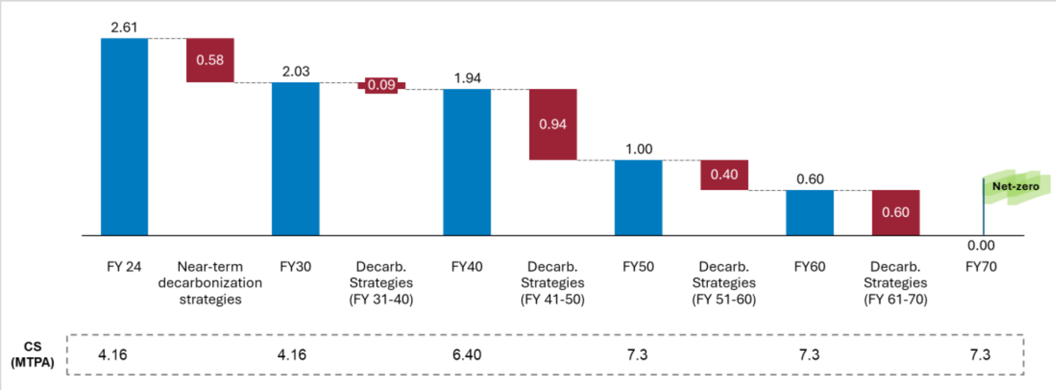
Decarbonization Strategies: FY 61 - 70

In line with the net-zero target of India by 2070, it has been assumed that the power available from the grid shall be 100% green power post 2060. This would eliminate the remaining scope-2 emissions, and the emission intensity shall be reduced to 0.2 T_{CO2}/T_{CS} by 2070.

With the availability of carbon-neutral fuels like bio-char carbonaceous material in EAF operation will slowly be replaced. This would lead to a reduction of residual emissions from the plant and thus bring down the CO_2 emission intensity to near zero. As the bio-char shall be derived from biomass, it is considered to be a net-neutral fuel thus there is no additional emission for combustion of bio-char.

The overall CO_2 emissions intensity reduction to achieve SAIL's target of net zero by 2070 has been illustrated in Figure 2-11.

Fig 2-10: CO_2 Emission Intensity Reduction to achieve net-zero for SAIL RSP



2.5 CO_2 Sequestration Options

The CO_2 sequestration for SAIL RSP can be done by two pathways, i.e.,

i) **Sequestration by Trees**

The sequestration of carbon dioxide (CO_2) by trees is a complex process deeply intertwined with the mechanisms of photosynthesis and carbon cycling. Through photosynthesis, trees absorb CO_2 from the atmosphere using sunlight, water, and nutrients drawn from the soil. Within the chloroplasts of their leaves, CO_2 is converted into carbohydrates such as glucose, which serve as energy sources for the tree's growth and maintenance. While oxygen is released as a byproduct, the carbon is incorporated into the tree's biomass, including its roots, stems, branches, and leaves. Furthermore, trees play a crucial role in carbon storage beyond their aboveground biomass. A significant portion of carbon is also stored in the soil through root systems and organic matter decomposition. Mycorrhizal fungi associated with tree roots facilitate this process, forming symbiotic relationships that enhance nutrient uptake and carbon sequestration in the soil. The effectiveness of trees in sequestering CO_2 depends on various factors, including species, age, and environmental conditions. Fast-growing species tend to sequester carbon more rapidly during periods of active growth.

ii) **Geological Sequestration**

The geological sequestration of CO_2 can be done by four pathways, i.e., Enhanced Oil Recovery (EOR), Enhanced Coalbed Methane Recovery (ECBMR), Storage in saline aquifers and storage in Basalt formations. Each of these mechanisms have been explained below:

Enhanced Oil Recovery (EOR): This is a tertiary technique of oil extraction from aged wells where extraction through primary techniques is not possible. These help in the production of 30-60% of the original oil in place. Injection of CO_2 for EOR has been studied and applied for years, especially in North America. CO_2 is miscible with crude oil which helps in recovering oil not possible by secondary methods. This also helps in permanently storing CO_2 in oil reservoirs, thus making CO_2 EOR a sustainable option for abating CO_2.

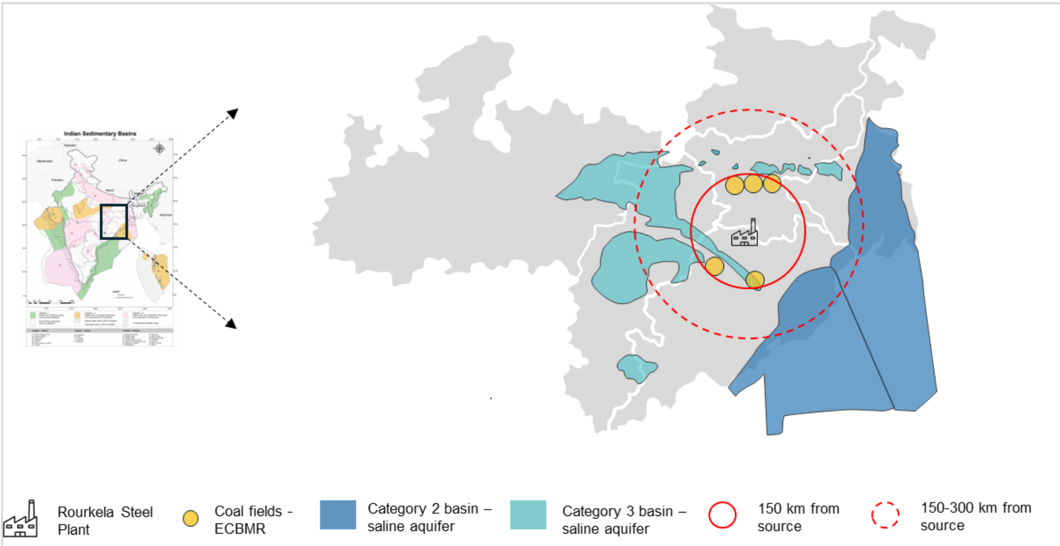
Enhanced Coalbed Methane Recovery (ECBMR): Coal bed methane (CBM) can be produced from coal seams and can contribute to the energy security of countries with rich coal resources. In ECBMR, CO_2 is injected into un-mineable coal seams under supercritical conditions. The coal seams present at a certain depth (more than the mining depth) can be considered a suitable option for the storage of CO_2. The injected CO_2 is accumulated in the coal cleats in a dense gas phase. This CO_2 is adsorbed on and absorbed in the coal. Since CO_2 has a higher affinity for coal than CBM, it pushes the coal bed methane toward production wells, thus enhancing its primary recovery.

Storage in Deep Saline Aquifers: Captured CO_2 can be permanently stored in deep saline aquifers. Unlike EOR and ECBMR, injection of CO_2 in deep saline aquifers has no economic benefit. Deep saline aquifers are spread across very large areas and, thus, have the potential to store very high quantities of CO_2. Supercritical CO_2 can be injected into saline aquifers. Brine water has a higher density compared to the injected CO_2; thus, CO_2 rises towards the caprock and is trapped in the saline aquifer. This is also termed physical/ structural/ stratigraphic trapping. While injecting, some CO_2 might occupy the pore spaces by displacing the previously present fluid (residual trapping). Some of the injected CO_2 also dissolves into the brine. This mixture is denser than the surrounding brine and settles down (dissolution trapping). CO_2 dissolves into water to form a weak carbonic acid that can react with minerals over time to form solid carbonate minerals. This leads to the storage of some portion of CO_2 through the mineral trapping mechanism.

Storage in Basalt Formations: Basaltic rocks are formed from the rapid cooling of basaltic lava from the interior of the earth's crust and are at a depth closer to the surface of the earth. These rocks exhibit high porosity and permeability. Basaltic rocks contain divalent cations of Ca, Mg, and Fe, which react with the CO_2 dissolved in water to form stable carbonate minerals (mineral trapping mechanism) and thus can offer a safe CO_2 sequestration method for an extended period. As a result of the high porosity and permeability, the reactivity of basaltic rocks with CO_2 is high, which makes them an area of interest for research related to CCUS.

The cluster potential has been analyzed for the five regions of India: North, South, East, West, and North-East. By identifying the nearest state/UT to the storage locations mentioned, the storage sites can be classified and mapped to the various regions. A similar practice has been carried out with the emission sources. The estimation of region-wise emissions for the year 2030 was considered for analyzing the CO_2 volume emitted for the duration 2030 - 2050. The cluster potential data for Eastern region of India has been given in the figure 2-11.

Fig.2-11: **Storage clusters in Eastern Region in India**



Our primary focus is on the eastern region of India. The sequestration potential of the eastern region has been given in the table below.

Table 2-20: Sequestration potential of the eastern region

Storage Pathways	Theoretical Storage Capacity (Gt)
EOR	0.0
ECBMR	2.4
Deep Saline Aquifers	67.2
Basalts	11.0
Total	**80.6**

Due to the absence of oil fields, there is no scope for EOR in the eastern region. While there is scope for ECBMR, there is no reference for this sequestration mechanism. The sequestration of CO_2 in saline aquifers and basaltic formations presents a good opportunity for the sequestration of captured CO_2.

Milestone – 3 Report
on
Reduction of Greenhouse Gas Emissions
to
SAIL - Rourkela Steel Plant

Submitted by

M. N. Dastur & Co (P) Ltd.

January 2025

Reduction of GHG Emissions through Sequestration by trees and CCUS technologies

3. Introduction

This chapter of the report provides a comprehensive analysis of carbon sequestration by trees. It also details both emerging and existing decarbonisation technologies. It explores the drivers and challenges associated with these technologies, examines carbon offset standards and procurement mechanisms, and includes a sensitivity analysis with respect to decarbonisation levers required to achieve net-zero emissions

3.1. Soil characteristics, Agro Climatic zone and Ecological condition of land

The region surrounding the Rourkela Steel Plant (RSP) exhibits typical characteristics of a tropical climate, influencing vegetation growth and regeneration. The region falls in the Tropical wet and dry climatic zone of Koppen Climate Classification and under Eastern Plateau & hill regions in Agro-climatic Zone of India Planning Commission.

The key highlights of the region's ecological condition & climatic factors are:

1. **Temperature:**
    - Summer: Extremely high temperatures, reaching 45°C to 46°C.
    - Winter: Cooler, with temperatures reaching 6°C to 7.5°C.
2. **Rainfall:**
    - Annual precipitation varies from 1000 mm to 1900 mm.
    - The rainfall is predominantly influenced by the Southwest monsoon.
3. **Humidity and Soil Moisture:**
    - The tropical environment contributes to significant humidity levels, which, along with soil moisture, plays a crucial role in supporting vegetation growth.

4. **Sunlight and Wind:**
    - High levels of sunlight during most of the year aid in photosynthesis, while wind patterns impact evapotranspiration rates.

5. **Soil Characteristics:**
    - Nutrient Content: Availability of more than sufficient nutrients having nitrogen in the range of 890 mg/kg to 1285 mg/kg, phosphate in the range of 680 mg/kg to 1235 mg/kg & potassium in the range of 850 mg/kg to 1290 mg/kg, promotes suitable growth of vegetations and promoted species richness.

    - Water Retention: Sandy loam soils of the region characterized by moderate level water-holding capacity with porosity in the range of 46.0 - 55%, that favouring tropical vegetations.

    - pH Levels: The soil is neutral to very slightly alkaline in nature with pH value ranging from 7.16 to 7.42 that favouring nutrient availability for vegetation growth.

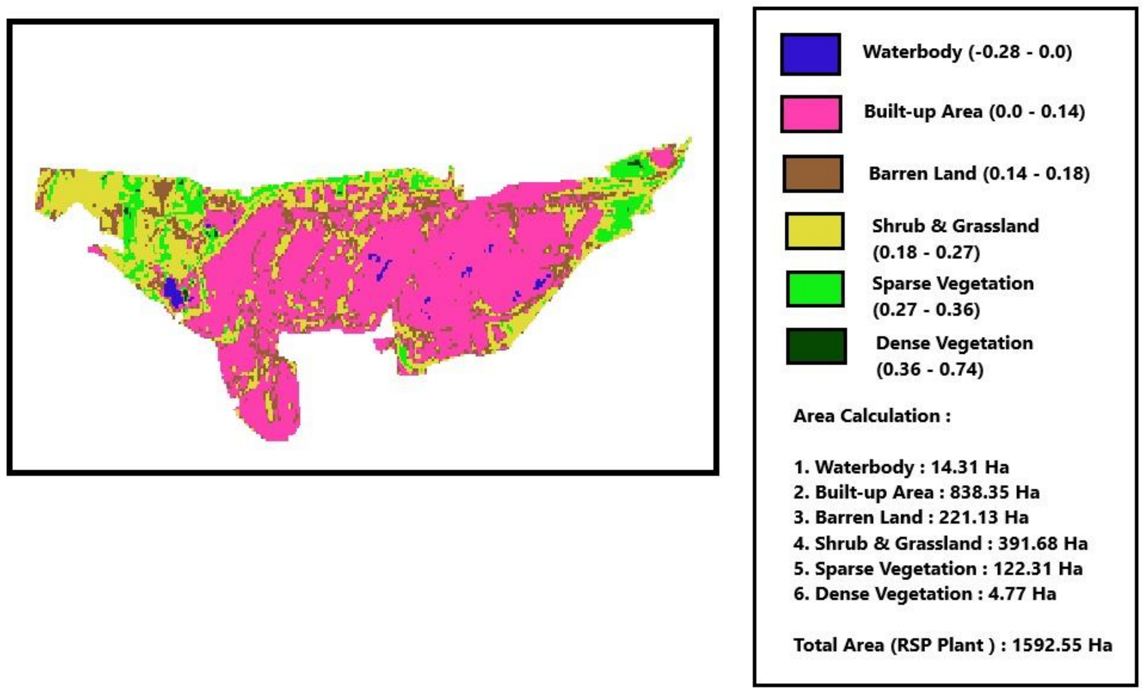
    - These factors collectively determine the type of vegetation, the regeneration of rootstocks, and the ecological balance in the area. The tropical climatic conditions in the Rourkela Steel Plant region create a supportive environment for the natural regeneration and growth of several native and economically significant plant species.

3.2. Relevant Species of trees for Carbon Sequestration

At present, out of 1592.55 Ha of land of Rourkela Steel Plant, about 519.33 Ha of land i.e. 32.6% of the area covered by greenery. The greenery mainly has been developed along the periphery of the plant boundary, around waste dump area and other vacant spaces in various patches within the plant.

The area distribution for shrubs/grasses, sparse vegetation and the dense one is identified through NDVI (Normalized Difference Vegetation Index) assessment of satellite imagery.

Fig. 1: Area Distribution of RSP



A 3-tier greenbelt has been developed along the periphery of the plant boundary with the tree density of 2500 tress/ha. The objective of this programme is not only enhancement of green cover area but also create an industrial sink for CO2 sequestration. The key tree species thriving in the region are as follows:

1. **Natural Regenerators:**
    - Sal (Shorea robusta): Dominant Forest species, valued for durable timber.
    - Sagun (Tectona grandis): Known for high-quality teakwood.
    - Kendu (Diospyros melanoxylon): Produces leaves for traditional bidi making.
    - Char (Buchanania lanzan): Source of edible seeds (Chironji).
    - Palash (Butea monosperma): Vibrant flowering tree, also used for lac production

2. **Other Native Species:**
    - Banyan (Ficus benghalensis) and Pipal (Ficus religiosa): Sacred trees with ecological and cultural importance.
    - Jamun (Syzygium cumini): Fruit-bearing species with medicinal properties.
    - Mahua (Madhuca indica): Source of flowers for food, fodder, and traditional liquor.
    - Mango (Mangifera indica): Renowned for its fruit and cultural significance.
    - Neem (Azadirachta indica): Known for its medicinal and pest-repellent properties.
    - Siris (Albizia procera) and Sissoo (Dalbergia sissoo): Useful timber species.
    - Semal (Bombax ceiba): Produces softwood and cotton-like fibers.
    - Sajna (Moringa oleifera): Multi-purpose tree valued for its edible leaves and pods.

3. **Introduced or Secondary Species:**
    - Nilgiri (Eucalyptus citriodora): Cultivated for essential oils and fast-growing timber.
    - Akashmoni tree (Acacia auriculiformis): A fast-growing evergreen tree widely planted in tropical and subtropical regions. It is valued for its versatility and ecological benefits.
    - Cassia (Cassia siamea): Often used in avenue plantations.

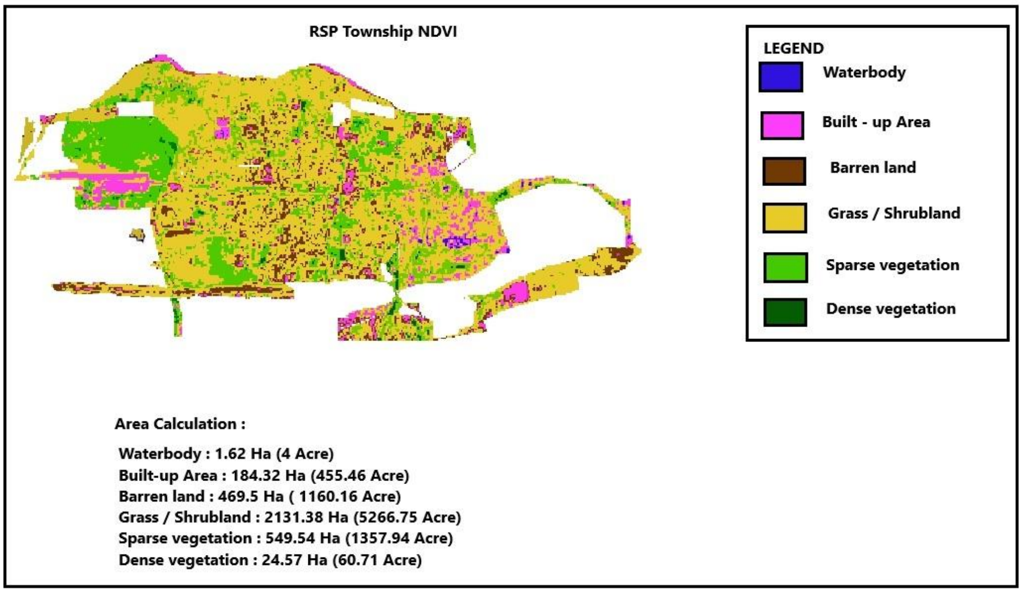
Radhachura (Peltophorum pterocarpum): Ornamental tree known for its yellow flowers.

3.3. Plan for harvesting of plants and use of harvested wood as biomass

The Barren /Vacant land indicated in the Steel Plant area which is about 221.13 hectare; can converted into a potential vegetation cover.
The native species in these regions are Ckakhundi, Dedadaru, Dhala Siris, Jamum, Neem, Palas, Aam, Arjuna, Amla, Sisoo, Subabool, Bat, Aswatha, Tentul, Ashok, Bougainvillea, Ber, Karanja, Ashok, Akashmoni, Kadamba, Segun, Jarul, Gulmohor, Rain tree, Karabi, Champa, Chatim, Guava, Sal, Simul, Mahua, Kusum, Bakul etc. This plant can be harvested in vacant space and the grass/ bushes covered area. The patches of

barren land and grass/shrub is already indicated in the above NDVI map of Rourkela Steel Plant. The grass/ shrub area which is about 391.68 Hectare can also be converted into Dense vegetation cover and harvested wood can be used as a fuel and feedstock in paper mill or any other alternative use.

Fig. 2: RSP Township NDVI



Rourkela township area is also under possession of SAIL-RSP. Hence, the vacant/barren land which is about 469.5 Hectare (1160.16 Acre) available in this township area can be used for tree plantation. The local/native species that can grow easily has already mentioned above, which should be harvested effectively.

3.4. Carbon Sequestration by Trees

Trees are capable of effective sequestration and storage of atmospheric carbon in their above-ground (shoot system) as well as in their below-ground biomass (root system) by way of processes of photosynthesis and tree growth.
The process of carbon cycle in the trees is broadly constituted by three processes, they are-

i. Carbon uptake and assimilation, including immediate respiratory losses which detract from previously fixed carbon in the plant cell.

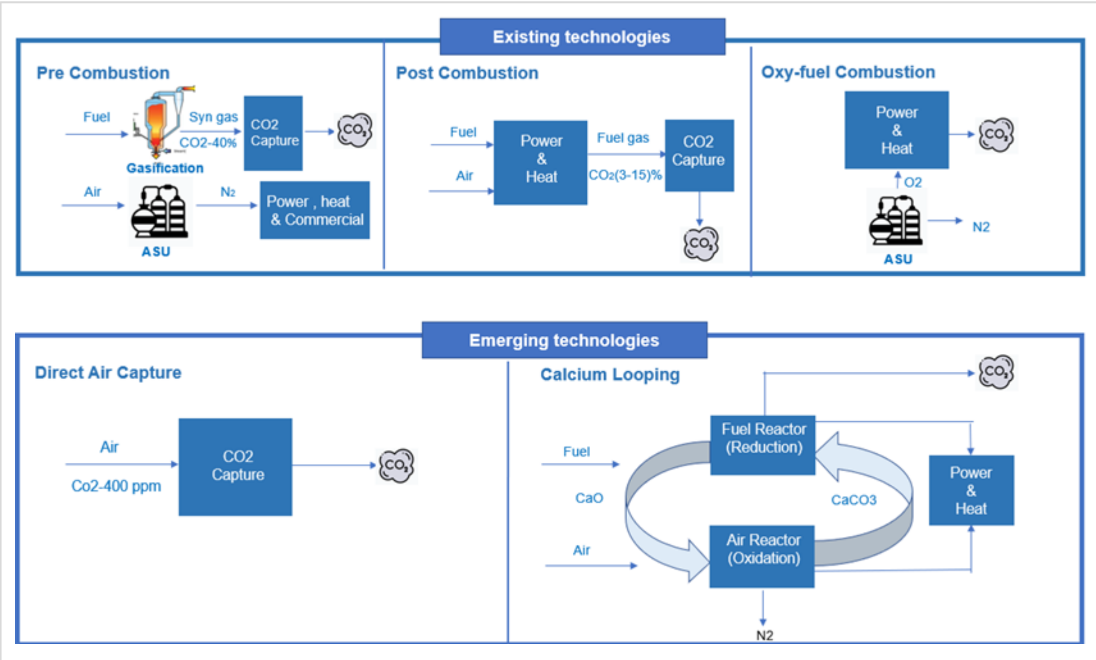
ii. Carbon transport, allocation and partitioning of carbon for storage, structural and metabolic use in the above ground and below ground parts of the tree.
Return of carbon to the atmosphere through oxidative pathways, biological decay and combustion of tree biomass and their product.

The species wise CO2 sequestration potential of trees would be covered in the subsequent milestone.

3.5. Existing and emerging technology trends

The CCUS (Carbon Capture, Utilization, and Storage) value chain's initial phase entails capturing CO_2 from gas streams. This process involves the separation of carbon dioxide from emissions generated by various industrial processes such as steelmaking. This section focuses primarily on existing and emerging carbon capture technologies. Figure 3 depicts different types of existing and emerging carbon capture technologies

Fig. 3: Existing and Emerging Carbon Capture Technologies



3.5.1. Classification of Carbon Capture Technologies

Carbon capture technologies can be broadly classified into three categories based on their combustion operating principle:

- **Pre-combustion capture**
- **Post-combustion capture**
- **Oxyfuel combustion**

Pre-combustion capture: Pre-combustion carbon capture technologies focus on capturing carbon dioxide (CO_2) from fossil fuels or biomass fuels before they are burned to generate energy. These technologies are particularly effective when the gas stream contains a high concentration of CO_2 (30%-90%) and operates at high pressure, as seen in processes like fossil fuel gasification, natural gas-based hydrogen production or sour gas processing.

In pre-combustion carbon capture, the CO_2 is separated from the gas stream using a physical solvent that selectively absorbs the CO_2 due to its elevated partial pressure. The regeneration of the physical solvent is achieved mainly by reducing pressure. This results in lower thermal energy requirements.

Post-combustion capture: Post-combustion capture technology focuses on separating CO_2 from exhaust gases generated through the combustion of fossil fuels. The exhaust gas is first pretreated to remove particulate matter, nitrogen oxides, and sulfur oxides. Subsequently, the treated exhaust gases come into contact with a liquid solvent, commonly an aqueous amine solution.

In this process, the solvent selectively absorbs the CO_2 in an absorber column, capturing over 85% of the CO_2 while allowing the nitrogen-rich flue gas to be released into the atmosphere or sent for further treatment. The CO_2-rich solvent is then regenerated through steam stripping, which separates the CO_2 from the solvent. This regeneration step enables the lean solvent to be recycled back to the absorber while producing a concentrated CO_2 stream. Due to the low partial pressure of CO_2 in the flue gas, post-combustion capture requires a significant volume of chemical solvents, such as amine, for effective CO_2 capture.

Chemical solvent-based CO_2 capture technology is the most commercially mature for carbon capture applications. However, post-combustion technologies face challenges in terms of energy and cost intensity. The high regeneration energy for the solvent makes the process highly energy-intensive.

Oxy-fuel combustion capture: Oxyfuel combustion involves burning coal in an oxygen-enriched environment, resulting in a flue gas stream primarily composed of CO_2 and water vapour. This process allows for easier condensation of CO_2. Challenges of implementing oxyfuel combustion in existing power plants include the cost of the air separation unit (ASU) and potential air leakage into the flue gas stream. However, this technology is still in development and has not been widely deployed in commercial applications.

3.5.2. Categorization of commercially proven carbon capture technologies

Commercially proven carbon capture technologies can be categorized based on the capture process as follows:

- Solvent-based absorption
  - Physical solvent-based absorption
  - Chemical solvent-based absorption
- Adsorption
- Cryogenic separation

These carbon capture technologies can be employed in all three stages: pre-combustion, post-combustion, and oxyfuel combustion capture. The most suitable carbon capture technologies for the pre-combustion stage include physical solvent-based absorption, adsorption, and cryogenic separation due to the high partial pressure of CO_2 at the pre-combustion stage.

In contrast, most post-combustion capture scenarios rely on chemical solvent-based absorption. Post-combustion gas streams, typically have low CO_2 concentration and partial pressure due to the significant presence of nitrogen resulting from complete combustion. Chemical solvents are well-suited for such gas streams as they exhibit high absorption capacity at low partial pressures of CO_2, mainly due to the strong chemical affinity between CO_2 and amine-/carbonate-based chemical solvents, along with faster kinetics.

However, under specific circumstances involving CO_2 concentration adjustment and pressure augmentation through appropriate gas conditioning, post-combustion capture scenarios can also utilize physical solvent absorption, adsorption, or cryogenic separation technologies. The choice of technology depends on factors such as the availability and cost of utilities required for gas conditioning (such as steam) and pressure augmentation (such as power), as well as the pressure, temperature, and purity requirements of the captured CO_2. It is worth noting that initially, the application of physical solvents, adsorbents, or cryogenic technologies in a post-combustion capture setting, or the use of chemical solvents for pre-combustion carbon capture, may have adverse effects on the economics of carbon capture.

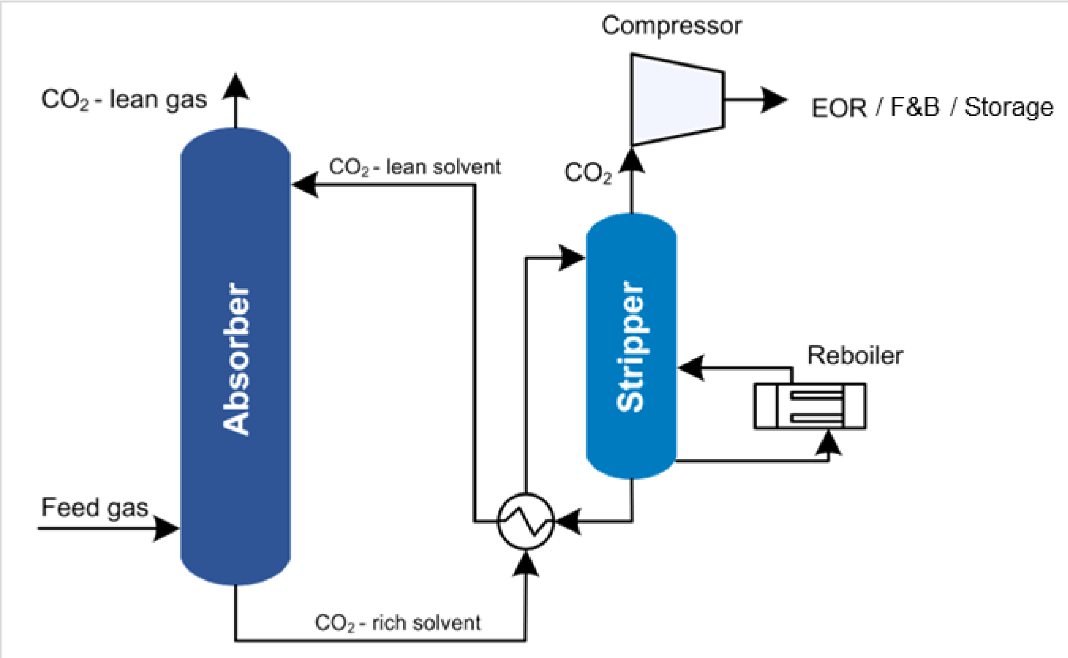
3.5.3. Existing CO_2 Capture Technologies

Solvent-Based Absorption Process

Solvent-based CO_2 capture Process is a mature technology used for over half a century to process natural (sour) gas, combustion flue gas and Fischer-Tropsch (FT) synthesis products. The fundamental principle on which solvent-based CO_2 capture technologies work is the “selective absorption” of CO_2 over the other gaseous constituents. The working principle of solvent-based CO_2 capture has been depicted in Figure 4.

The CO_2 in the feed/process gas is selectively absorbed in an absorber using a solvent (physical or chemical); the CO_2 lean gas then leaves the absorber. The CO_2-rich solvent is then passed through a stripper column, where the CO_2 is removed from the solvent and the lean solvent is regenerated for reuse.

Fig. 4: Schematic Representation of Working Principle of solvent-based CO_2 Capture



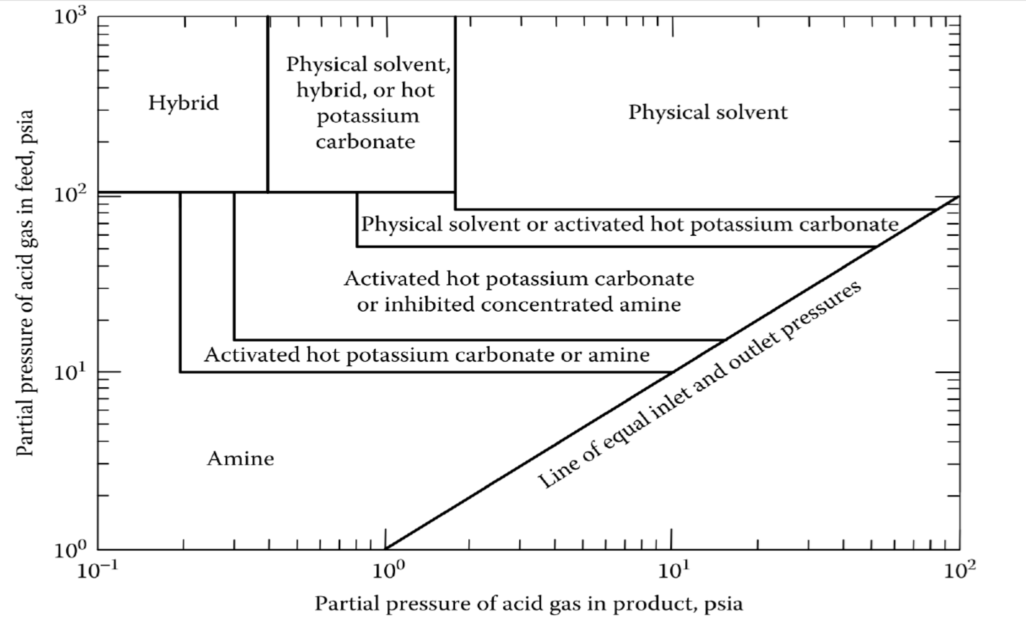
Solvent-based CO_2 capture technologies are further categorized based on whether the CO_2 reacts with the solvent chemically (chemical solvents and chemical absorption) or dissolved physically (physical solvents and physical absorption).

Chemical absorption-based CO_2 capture is better suited for gas streams with low CO_2 concentrations and partial pressures due to the high chemical affinity of CO_2 for amine-/carbonate-based chemical solvents as well as quicker rate kinetics.

While chemical solvents have a high absorption capacity at low partial pressures of CO_2, a non-reactive or physical solvent works well at greater partial pressures of CO_2.

Figure 5 displays the working ranges of several CO_2 capture solvents and serves as the foundation for selecting appropriate CO_2 solvents. Because of the low CO_2 partial pressures in coal-fired power stations' flue gas, amine-based chemical absorption is the recommended technology/solvent. However, at relatively higher gas stream pressure and CO_2 concentrations, such as in syngas in gasifiers and SMR, physical absorption-based capture is preferable.

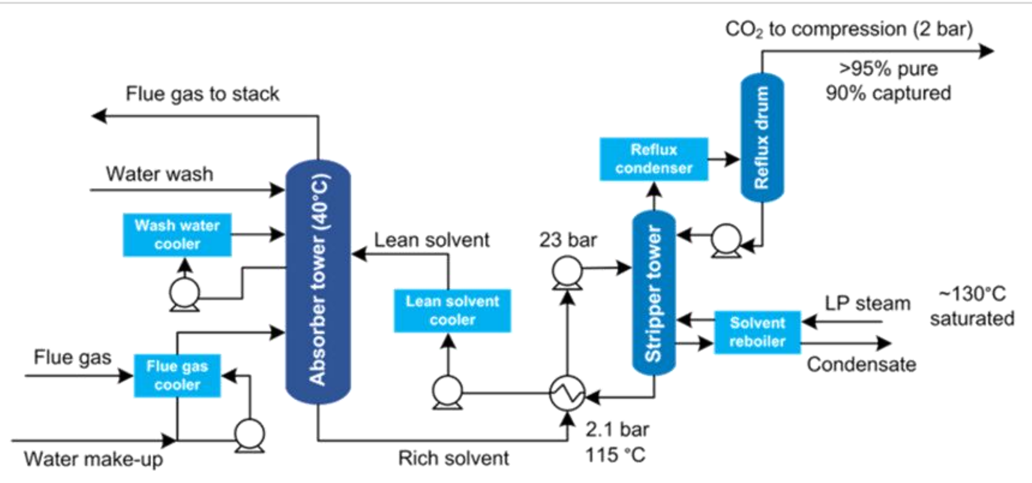
Fig. 5: Operating Regimes of Various Solvents for CO_2 Capture



a) Chemical Solvent-Based Absorption Process

The chemical reaction between CO_2 and the chemical solvent is an exothermic reaction and hence favored at lower temperatures. Hence it is necessary to pre-cool the feed gas. During the cooling of the feed gas, water condenses out of the wet gas. A block flow diagram for a chemical solvent-based CO_2 capture is depicted in Figure 6.

Fig. 6: Typical Flow Diagram of a Chemical Solvent Based CO_2 Capture



The low-temperature gas stream reacts with the amine-based solvent at 40-60°C via a counter-current flow reaction within the absorber column, resulting in:

a) CO_2-free gas stream
b) Solvent with chemically bound CO_2

The Important Process units are:

Absorber: Multiple stages of structured packing in the absorber columns maximize the contacting surface area and mass transfer rate of CO_2 in the solvent during the counter-current flow. While the CO_2 lean gas stream leaves the absorber from its top stage, the CO_2-rich solvent stream exits the absorber column from its bottom stage and is pumped to the stripper/regenerator.

Stripper/Regenerator: It is where the application of higher temperatures (100-140°C) results in the regeneration of the solvent by breaking the chemical bonds between CO_2 and the chemical solvent. The heat required for the regeneration of the solvent is provided by a reboiler, supplied with steam extracted from captive CHPs/CGPs. Such a heat and strip operation for the regeneration of the solvent leads to a high thermal energy penalty. Depending on the solvent used and system configuration, the steam consumption for solvent regeneration can range from 1.1 to 1.5 t/tCO_2.

While the dense CO_2 stream exits the stripper from its top stage, the CO_2 lean solution is cooled and recirculated to the absorber. Typically, the absorber and stripper's operating pressures for chemical solvent-based capture are low, ranging from 1 – 4 bar(a).

While primary and secondary amines (such as MEA, DGA, AEE, DEA) have higher reaction rates and lower CO_2 carrying capacities, tertiary, and polyamines (such as MDEA and piperazine) have lower reaction kinetics and higher CO_2 carrying capacities. Due to competing characteristics, often blends of varying solvent compositions are used to exploit high reaction rates and CO_2 carrying capacity along with lower regeneration loads. Specifically, for MEA-based systems, the steam (LP steam at ~3 bar(a)) energy requirement for solvent regeneration can range from 3.6 to 7 GJ/t CO_2, depending on the system configuration and heat integration. A few of the proven and emerging solvent-based technologies are tabulated below:

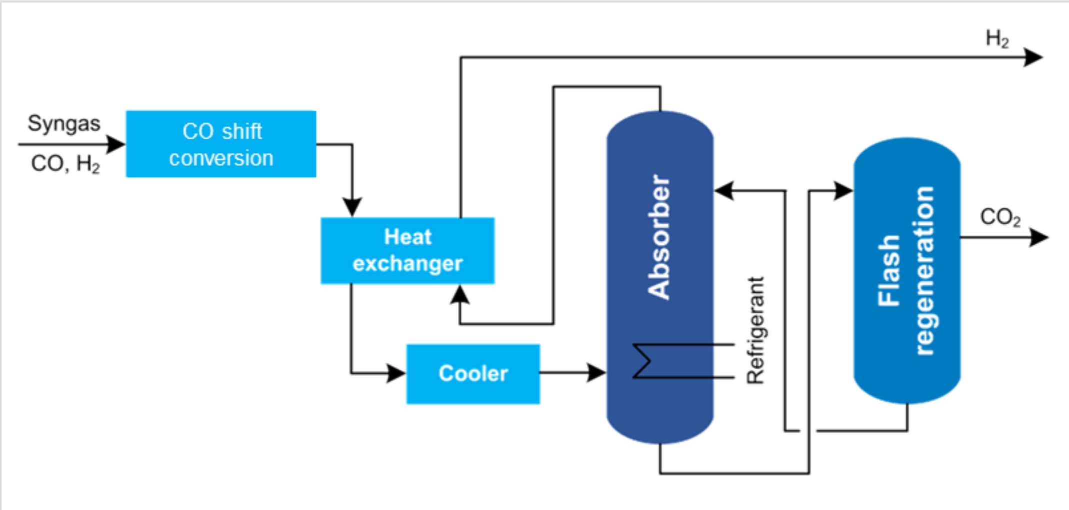
Table 1: Commercially Proven Chemical Solvent-Based Capture Technologies

Sl. No.	Technology Supplier	Solvent	Special Features	TRL
1	Air Liquide	Proprietary blends of amines (primary/secondary/tertiary/hindered) and activators (heterocycles, primary or secondary alkanolamines, alkylenediamines or polyamines) having higher stability than MEA	Low energy requirement of 2.6 to 2.5 GJ/t CO_2	9
2	ION Clean Energy	Proprietary ICE-21 solvent which is amine with an organic solvent; low water content	Low energy requirement of 2.6 to 2.5 GJ/t CO2	6
3	Kansai Mitsubishi	KM CDR KS-21TM solvent having proprietary composition: sterically hindered amine, low volatility,	Capture with 99.9% purity	5 – 6
4	Carbon Clean Solutions	Proprietary solvent CDRMax®	Lowers solvent degradation and solvent emissions	8
5	Honeywell UOP	Several types of proprietary solvents viz. Amine GuardTM FS, BenfieldTM and SeparALLTM.Amine Guard is most popular.	High thermal and chemical stability	9
6	Baker Hughes	An ammonia-based solvent, ammonium carbonate solution	High pressure stripping possible.	7

b) Physical Solvent-Based Absorption Process

The main distinction between chemical and physical solvent-based capture is that the latter is preferred when the gas stream has a greater partial pressure of CO_2, such as in gasification, sour gas processing, or syngas from SMRs. There is no chemical reaction, and the capture process is entirely regulated by physisorption. The thermal energy penalty is substantially lower since no chemical bonds must be broken for solvent regeneration. The regeneration of the physical solvent is mostly accomplished by lowering the pressure. However, as compared to chemisorption-based capture, the operating temperatures of physical solvent-based capture methods are substantially lower (varying from -70 °C to +20 °C), necessitating considerable power consumption. The typical process flow diagram is depicted in Figure below.

Fig. 7: Basic Process Flow diagram of the Physical Solvent Based Absorption Process



The two major commercially available physical absorption-based technologies are:

- **Rectisol®** (offered by Linde and Air Liquide) - the physical solvent used for CO_2 absorption is chilled methanol (at subzero temperatures).

- **Selexol™** (offered by Honeywell UOP)- the physical solvent used for CO_2 absorption uses a mixture of dimethyl ether of polyethene glycols (DEPG).

Adsorption Process

In the adsorption-based CO_2 capture process, the CO_2 molecules selectively adhere to the surface of the adsorbent material and form a film. This is possible because of the difference in diffusivities and heat of adsorption values for the feed gas stream components.

The working principle of adsorption-based CO_2 capture can be described in three primary steps:

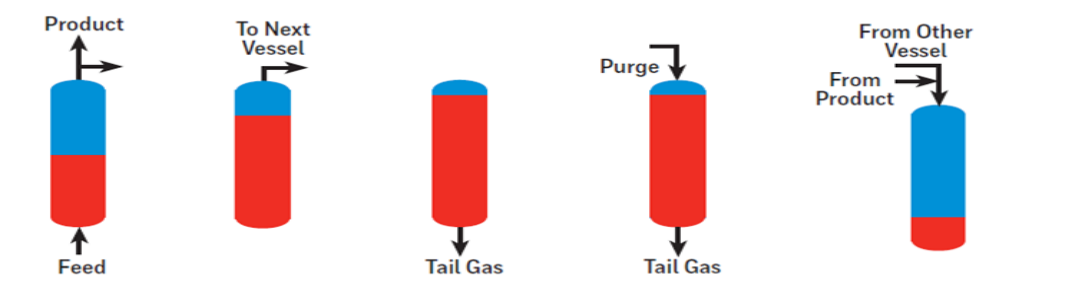
- CO_2 adsorption on the surface of the adsorbent material
- Diffusion of other gaseous molecules through the adsorbent material and exit from the system

- CO_2 desorption by either decreasing pressure or increasing temperature.

While the former is known as Pressure Swing Adsorption (PSA), the latter is called Temperature Swing Adsorption (TSA). TSA operations involve high temperatures, which may lead to the degradation of the desirable products and reduce the life of the adsorbent material. In the PSA route, there is no need for heating/cooling and hence the cycle time is significantly reduced to the order of a few minutes. Hence, adsorption through the PSA route is the preferred choice, allowing the economical removal of a large number of impurities. The typical process flow of the PSA technology is depicted in Figure 8.

The PSA route comprises timed cycles of adsorption, pressure equalization, depressurization, blowdown, purge, and re-pressurization across multiple fixed beds. These beds consist of different types of adsorbent materials, such as activated alumina, silica gel, activated carbon or molecular sieves. Air Products and Honeywell UOP both offer the PSA carbon capture technology.

Fig. 8: Five-step Pressure-swing Cycle of UOP's PolybedTM PSA Systems



Red: impurity | Blue: product

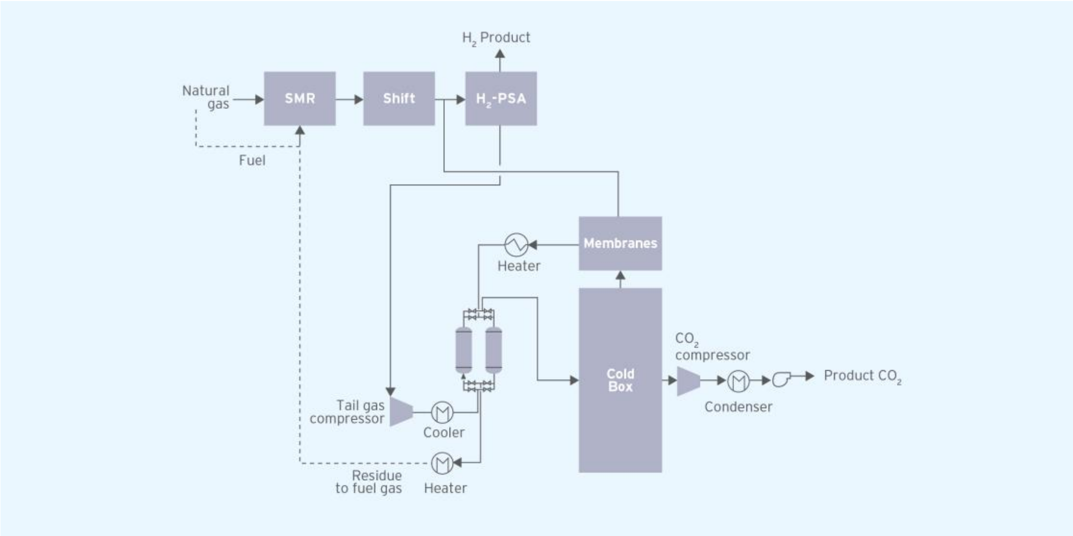
Step 1: Adsorption	**Step 2:** Co-current depressurization	**Step 3:** Counter current depressurization	**Step 4:** Purge	**Step 5:** Re-pressurization

Source: UOP White Paper

Cryogenic Separation Process

Cryogenic separation for CO_2 capture is a process closely analogous to conventional distillation, with the primary distinction lies in the nature of the mixture being separated. While conventional distillation typically involves the separation of components from a liquid mixture, cryogenic separation deals with the separation of components from a gaseous mixture based on the differences in their boiling points. The process relies on the principle that gases exhibit distinct condensation behaviours at varying temperatures and pressures. A simple schematic illustration (based on the cryogenic capture technology offered by Air Liquide) is provided in Figure 9.

Fig. 9: Process Flow Diagram of the Cryogenic Separation by Air Liquide (CryocapTM H2 Technology)



The cryogenic separation process typically involves the following steps:

Compression and drying: The first step of the process is to compress and dehydrate the feed gas. The feed gas is compressed to about 10 bar(a). Feed gas is cooled with chilled water before drying to reduce the size of the dehydration unit. There are two parallelly placed dryers – one operates in an adsorption mode and the other in a regeneration mode. The dry gas from the regeneration gas separator is rich in CO and CH4 and is transferred back to the SMR.

Cold Box: After drying and purification, the gas is again compressed to about 40 bar(a) pressure before entering the cold box. The cold box section aims to separate CO_2 from the remaining components. The gas is cooled down in the main heat exchanger to perform the first separation after partial condensation. The vapour phase of the 1st separator is then sent back to the main heat exchanger and then to the membrane skid for further processing. The liquid phase from the first separator containing the majority

of CO_2 is sent to a distillation column to purify the CO_2 from the remaining CH4 and CO. The first membrane system aims at separating the bulk of the hydrogen from the rest of the components. The hydrogen-rich stream is recycled back to the SMR. The second membrane system will allow the recovery of a rich CO_2 stream.
This stream is recycled to the feed compressor. The remaining stream, rich in CO and CH4, is regenerated in the dryers before sending to the SMR. The final CO_2 compression aims to achieve the required pressure for CO_2 based on the downstream product CO_2 requirements and specifications. Due to the extreme operating conditions of high pressure and low temperature, it is an energy-intensive process. The energy consumption can range from 600-660 kWh/tonne of CO_2 recovered in liquid form. Both Air Liquide and Honeywell UOP offer cryogenic carbon capture technology with different names.

Comparative Analysis of Various Commercial Scale CO_2 Capture Technologies

A comparative analysis for the different types of technologies discussed, i.e., Solvent based capture (chemical solvent, physical solvent), adsorption and cryogenic separation has been given in the table below.

Table 2: Comparative Analysis of Various Commercial Scale CO_2 Capture Technologies

Process	Working Principle	Advantages	Limitations	Examples
Chemical Solvent	○ Chemical reaction between CO_2 and solvent ○ Governed by rate kinetics & thermodynamics	○ High absorption at a low partial pressure of CO_2 ○ Selective capture and high-purity CO_2 product	High energy (steam) requirements for solvent regeneration	○ BASF / OASE® ○ ICE-21, ICE-31 ○ KS-1™, KS-21™ ○ UCARSOL™ ○ CAP
Physical Solvent	○ Absorption due to CO_2 solubility in the solvent ○ Governed by Henry's Law	○ Suitable for gas streams with high partial pressure of CO_2 ○ Regeneration through low-temperature flashing or pressure reduction	○ Low energy efficiency for low partial pressure of CO_2 ○ High compression requirement for low-	○ Rectisol™ ○ Selexol™

Process	Working Principle	Advantages	Limitations	Examples
		○ High absorption capacity & lower solvent recirculation rates	pressure feed gas ○ H_2S is often absorbed more effectively than CO_2	
Adsorption	○ Selective adsorption due to difference in diffusivity & heat of adsorption ○ Governed by pressure change	○ Selective capture ○ Can be performed at normal temperatures	○ Batch process ○ Complex pressure balancing management system ○ High electrical energy consumption	○ PSA ○ VSA ○ TSA
Cryogenic Separation	○ Low-temperature separation through liquefaction ○ Governed by temperature change	○ Selective capture ○ Generates high purity CO_2 ○ Liquefied CO_2 product can be used for F&B grade CO_2 ○ Almost no steam consumption ○ Low area footprint	○ High energy requirement ○ High operating pressure	○ Cryocap™ ○ Ortloff Dual Refrigerant CO_2 Fractionation (DRCF)

The applicability of the various CO_2 capture technologies viz., physical solvent, chemical solvent, adsorption and cryogenic, also depends on the project objectives and the project-specific and gas stream characteristics, including:

- CO_2 capture volumes targeted/desired.
- CO_2 end usages and CO_2 purity required.
- Source gas characteristics (CO_2 concentration, pressure, and volumes)
- Availability and cost of utilities such as steam, power, water, fuel, etc.
- Plot availability and space constraints.

3.5.4. Emerging Carbon Capture Technologies

The commercially established capture technologies have significant steam and power duties, leading to significant regeneration energy requirements and secondary emissions. Thus, there is ample opportunity for further research and development of newer carbon capture technologies and even deploying a hybrid of traditional and emerging methods of carbon capture. The evolving carbon capture technologies have challenges with respect to selectivity, absorbing capacity, energy, new material development, demonstrability, and scalability, but they still offer significant potential with respect to their decarbonization impact. CO_2 capture technologies differ widely; apart from pre-combustion and post-combustion-based technologies, there exists the potential to use ionic liquids for carbon capture from power plants and industrial facilities while enhancing the CO_2 capture ability and simultaneously reducing the carbon capture costs and energy requirements.

The most promising newer/evolving carbon capture technologies are DAC and calcium looping which have been discussed below.

a) Direct Air Capture

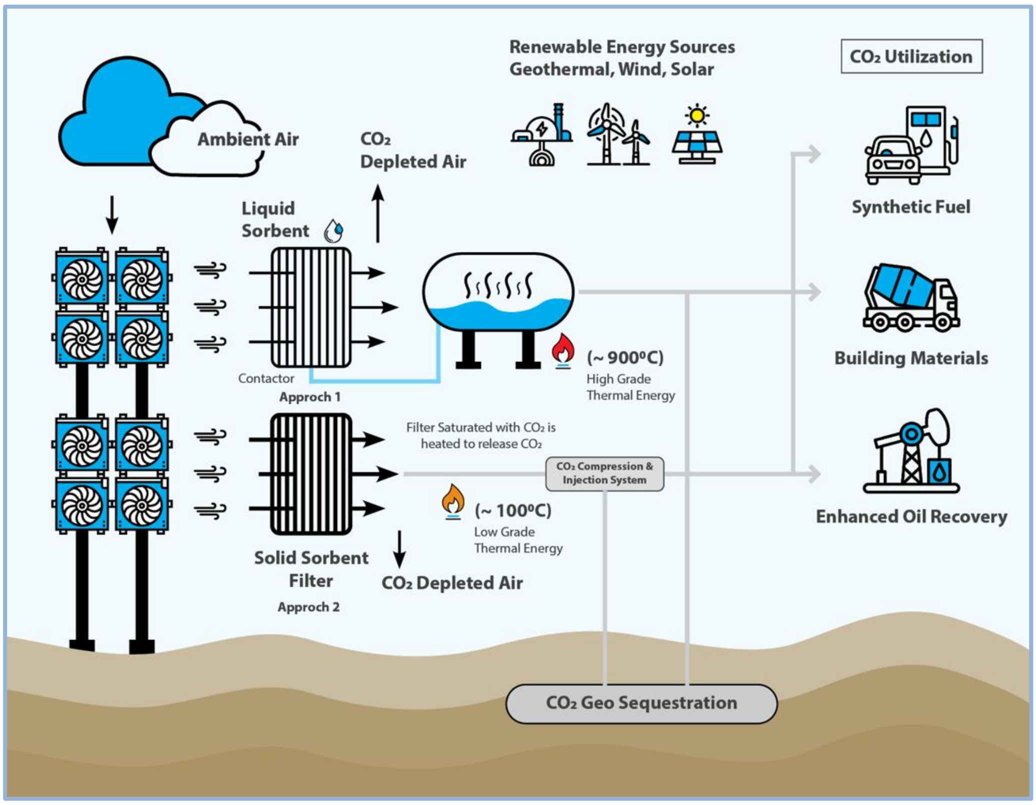
Over 175 nations of the world are signatories of the Paris Climate Agreement, which calls for formulating strategies for deep decarbonization and long-term net zero targets. Against this backdrop, Carbon Dioxide Removal (CDR) from the atmosphere is likely to play a major role as a component of global climate strategies. CDR refers to a range of approaches for the removal of CO_2 from the atmosphere using biological, engineered or hybrid approaches. CDR can play an important role in climate change mitigation and thus supplement existing carbon capture technologies, which reduce and prevent emissions of carbon dioxide from the source points.

CO_2 removal from the atmosphere can be done using chemicals, refrigeration, or membranes. These approaches are similar to industrial applications such as air separation units for producing oxygen and CO_2 as a by-product for the food & beverage industry or atmospheric CO_2 scrubbers which are used in submarines and spaceships. Direct Air Capture (DAC) can play a vital role in emission reduction using decentralized mobile units for capturing low-concentration CO_2 from the atmosphere. DAC needs a large flow of air and hence requires significant mechanical and thermal energy for the air to pass through the capture system and the separation of CO_2 from the capture medium, making the DAC process very energy and cost intensive. Figure 10 shows two technological approaches:

a) Passing air through solutions (hydroxide solution /amine /amino acid)

b) Use of solid sorbent filters to reduce the cost.

Fig. 10: Basic Technical Schematic of Direct Air Capture Technology



The minimum energy required for capturing CO_2 from the atmospheric air at 400 ppm has been reported as 19-22 kJ/mol CO2, which is almost four times than the energy requirements of the post-combustion process (4.6-5.6 kJ/molCO2). DAC is distinct from "point-source" carbon capture technologies because it removes CO_2 from ambient air, not from the flue gases, through physical or chemical separation processes. There are three categories of approaches towards the separation of CO_2 from the air.

Table 3: Various Types of Approaches for DAC

Approach of Separation	Description
Chemical	In this category of separation, CO_2 in the air reacts with liquid solvents or solid sorbents, temporarily binding to them. The solvent or sorbent is then heated or subjected to a vacuum, releasing the CO_2 for further concentration. This approach is similar to point-source carbon capture systems that remove CO_2 from flue gas. The solvents/sorbents used are aqueous hydroxides, solid-supported amines and solid alkali carbonates etc.
Membranes	CO_2 can be separated from air and seawater using membranes, including ionic exchange and reverse osmosis membranes. This mimics the way plants and animals separate CO_2.
Cryogenic	CO_2 has a relatively high freezing temperature among gases and can be frozen out of the air. Currently, CO_2 is recovered from the air by freezing it as a by-product of cryogenic oxygen separation.

Most companies developing DAC projects prefer the chemical approach, using either liquid solvents or solid sorbents, as the heat and power required to regenerate the key chemical reagents are easy to handle and manage. Hence mainstream DAC technologies are based on reversible chemical sorbents that can be recycled multiple times to capture and release CO_2. This process tends to degrade the material, reducing CO_2 capture capacity and making its replacement necessary from time to time. The choice of the appropriate chemical materials is an important part of DAC system design since it determines the overall system design. There is also ongoing research in the development of various physio-sorbent materials, such as zeolites and metal-organic frameworks (MOFs), which typically bind CO_2 much more weakly than chemical sorbents. So far, the experimental results are not very encouraging as they perform inefficiently at the very low CO_2 concentrations of ambient air and are also inhibited by the presence of atmospheric moisture. Therefore, no company or developmental group has yet used these physio-sorbent materials as primary capture materials for any DAC project. The major design challenges for the efficient and economical operation of DAC plants and possible suggested mechanisms to address the same are summarized in the table given below.

Table 4: Design & Operational Issues of DAC Plants

Sl. No.	Design and Operational Issues	Possible Suggested Solutions
1	Minimize exhaustion of the sorbent-liquid/solid materials	Use of a combinational process of TSA [heating the sorbent material, whether solid or liquid], Moisture-Swing Adsorption (MSA)

Sl. No.	Design and Operational Issues	Possible Suggested Solutions
	while being regenerated, releasing the adsorbed CO_2.	[by changing the amount of ambient moisture/humidity] and PSA [changing the ambient pressure of the air], depending on the properties of the sorbent material.
2	Maximization of the area & contact timing of the air with the sorbent	Better designing of the air contactor - designed to handle both large volumes of air throughput and also the flow of a liquid sorbent or the structural support of a solid sorbent, taking the structural materials, geometric design, pressure drop and other features into consideration.
3	Minimization of the thermal and electrical energy requirement for regeneration of sorbent and pushing air through the system	Usage of waste heat and renewable energy to compensate for the thermal and electrical energy load. Use blended sorbents to achieve the desired level of thermal performance.

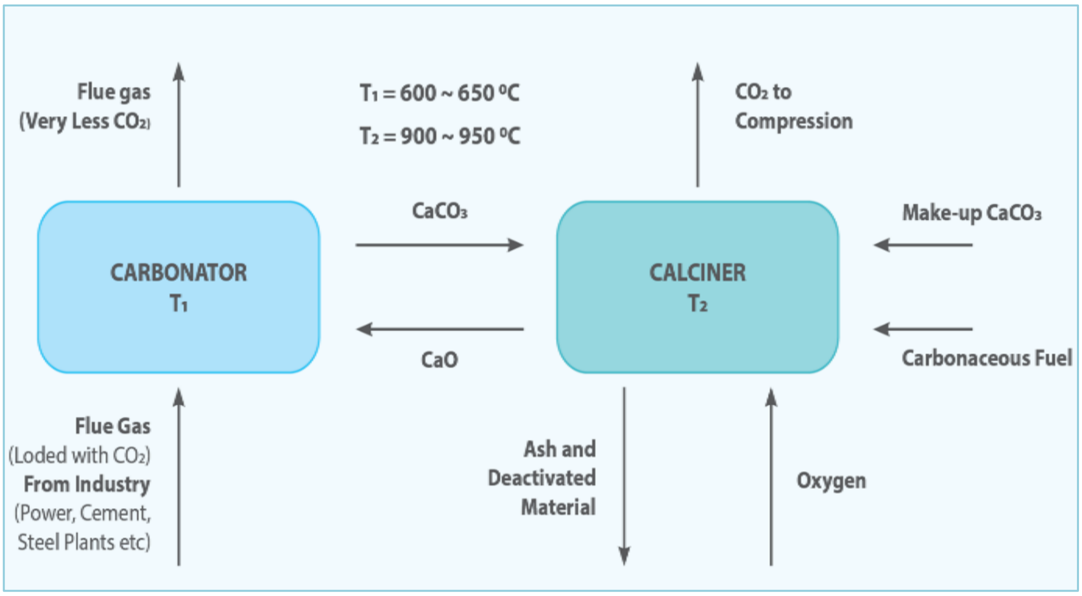
b) Calcium Looping

Calcium Looping (CaL) capture can either be classified as a pre-combustion method or as an alternative to the emerging & cost-cutting early-stage oxyfuel combustion technology. The CaL process is based on the multicyclic calcination–carbonation of CaCO3, which can be obtained from limestone, a cheap and abundantly available material. Th reactions taking place at the calciner and the carbonator are as follows:

Calciner Reaction: $CaCO3 \rightarrow CaO + CO_2$, $\Delta H = 182.1$ kJ/mol (1)
Carbonator Reaction: $CaO + CO_2 \rightarrow CaCO3$, $\Delta H = -182.1$ kJ/mol (2)

The CaL process was first introduced in the 19th century in the context of sorption-enhanced hydrogen production. However, the first instance of using the CaL process as a carbon capture scheme in power generation systems was introduced by Shimizu, who proposed two interconnected circulating fluidized bed (CFB) reactors for the carbonation and calcination reactions (Figure 11).

Fig. 11: Schematic of Calcination and Carbonation Reaction in Calcium Looping



The CaL process is based on the reversible gas-solid reaction between CaO and CO2 to form CaCO3. The carbonation reaction involves the reaction of sorbents with CO_2 in the flue gas.

The typical CO_2 concentration varies in the range of 3–30 vol.% depending on the flue gas source. The forward reaction occurs in the carbonator exothermically at a temperature range of 600°C - 700 °C at which the equilibrium CO_2 partial pressure is below 0.001 bar, such that most of the CO_2 in the gas stream can be captured by the sorbent. Then, the sorbent is regenerated by the reverse endothermic reaction, which includes the decomposition of calcium carbonate. Noting that the goal of the CaL process is to produce a pure stream of CO_2, the calciner must be purged with either pure CO_2 or the CO_2 has to be diluted with steam, which can be readily separated by condensation. With these restrictions, thermodynamic limitations require the calciner reactor to be operated above 900°C, which is the equilibrium temperature of equation (2) at a CO_2 partial pressure of about 1 bar. Calcination can be achieved at a temperature lower than 900°C, provided that the purge gas is diluted with steam.

The high-operating temperature of the calciner usually requires oxyfuel combustion in the calciner, which necessitates an air separation unit (ASU). However, the size of the ASU for this process is estimated to be one-third of the size of the ASU required for an oxyfuel fired power plant. Moreover, the energy penalty of the ASU is partially recuperated by the recovery of the high-grade heat available in the CaL process.

The techno-economic aspects of the CaL process have been reviewed by several researchers, and it is reported that CaL offers significant advantages over conventional amine processes with respect to the cost per tonne of CO2 captured - less than US$ 20 per tonne CO2 for CaL, compared with approximately US$ 30 per tonne CO2 for amine-based processes. The CO2 capture process accounts for 2%–3% of the efficiency penalty, which is comparable to the penalty of a desulphurization unit (0.5%–4%).

3.5.5. CO2 Sequestration Pathways

The geological sequestration of CO2 can be done by four pathways, i.e., Enhanced Oil Recovery (EOR), Enhanced Coalbed Methane Recovery (ECBMR), Storage in saline aquifers and storage in Basalt formations. Each of these mechanisms have been explained below:

Enhanced Oil Recovery (EOR): This is a tertiary technique of oil extraction from aged wells where extraction through primary techniques is not possible. These help in the production of 30-60% of the original oil in place. Injection of CO2 for EOR has been studied and applied for years, especially in North America. CO2 is miscible with crude oil which helps in recovering oil not possible by secondary methods. This also helps in permanently storing CO2 in oil reservoirs, thus making CO2 EOR a sustainable option for abating CO2.

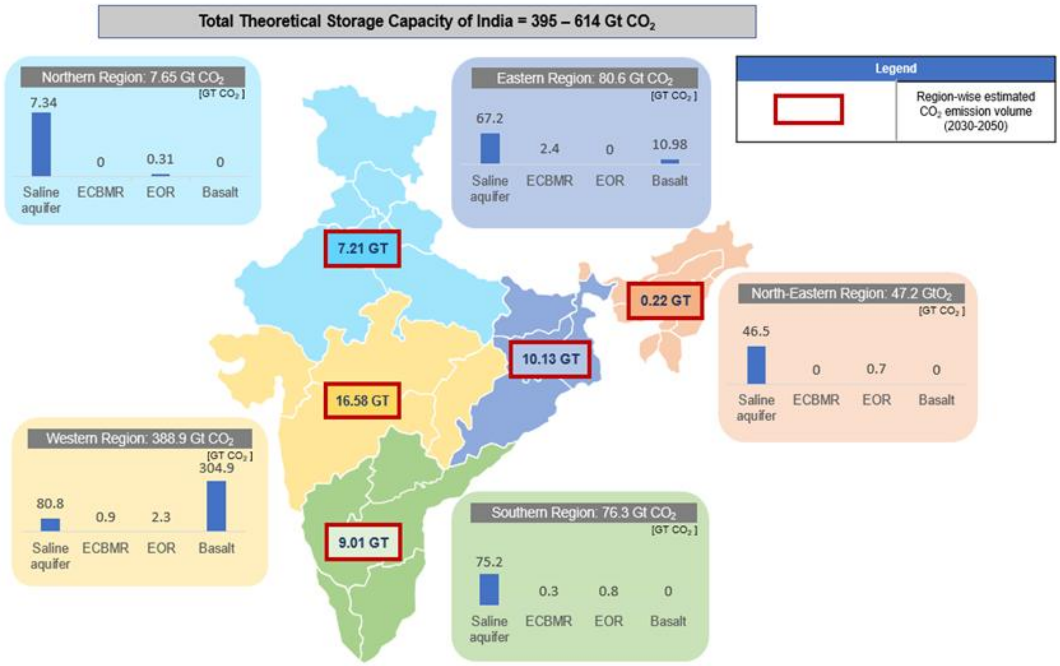
Enhanced Coalbed Methane Recovery (ECBMR): Coal bed methane (CBM) can be produced from coal seams and can contribute to the energy security of countries with rich coal resources. In ECBMR, CO2 is injected into un-mineable coal seams under supercritical conditions. The coal seams present at a certain depth (more than the mining depth) can be considered a suitable option for the storage of CO2. The injected CO2 is accumulated in the coal cleats in a dense gas phase. This CO2 is adsorbed on and absorbed in the coal. Since CO2 has a higher affinity for coal than CBM, it pushes the coal bed methane toward production wells, thus enhancing its primary recovery

Storage in Deep Saline Aquifers: Captured CO_2 can be permanently stored in deep saline aquifers. t. Deep saline aquifers are spread across very large areas and, thus, have the potential to store very high quantities of CO_2. Deep saline aquifers consist of porous rock formations that contain high quantities of unusable salt water. The salt/mineral content is very high in this water rendering it unusable for human use. The brine water is called formation liquid, and it is trapped by an impermeable rock called the caprock. Supercritical CO_2 can be injected into saline aquifers. Brine water has a higher density compared to the injected CO_2; thus, CO_2 rises towards the caprock and is trapped in the saline aquifer. This is also termed physical/ structural/ stratigraphic trapping. While injecting, some CO_2 might occupy the pore spaces by displacing the previously present fluid (residual trapping). Some of the injected CO_2 also dissolves into the brine. This mixture is denser than the surrounding brine and settles down (dissolution trapping). CO_2 dissolves into water to form a weak carbonic acid that can react with minerals over time to form solid carbonate minerals. This leads to the storage of some portion of CO_2 through the mineral trapping mechanism.

CO_2 Storage in Basalts: Basaltic rocks are formed from the rapid cooling of basaltic lava from the interior of the earth's crust and are at a depth closer to the surface of the earth. These rocks exhibit high porosity and permeability. Basaltic rocks contain divalent cations of Ca, Mg, and Fe, which react with the CO_2 dissolved in water to form stable carbonate minerals (mineral trapping mechanism) and thus can offer a safe CO_2 sequestration method for an extended period. As a result of the high porosity and permeability, the reactivity of basaltic rocks with CO_2 is high, which makes them an area of interest for research related to CCS.

The cluster potential has been analyzed for the five regions of India: North, South, East, West, and North-East. By identifying the nearest state/UT to the storage locations mentioned, the storage sites can be classified and mapped to the various regions. A similar practice has been carried out with the emission sources. The estimation of region-wise emission for the year 2030 was considered for analyzing the CO2 volume emitted for the duration 2030 - 2050. The region-wise cluster potential data for India has been given in the figure below.

Fig. 12: Region-wise cluster potential data for India



Our primary focus is on the eastern region of India. The sequestration potential of the eastern region has been given in the table below.

Table 5: Sequestration potential

Storage Pathways	Theoretical Storage Capacity (Gt)
EOR	0.0
ECBMR	2.4
Deep Saline Aquifers	67.2
Basalts	11.0
Total	**80.6**

Due to the absence of oil fields, there is no scope for EOR in the eastern region. While there is scope for ECBMR, there is no reference for this sequestration mechanism. The sequestration of CO2 in saline aquifers and basaltic formations presents a good opportunity for the sequestration of captured CO2.

3.6. Drivers and challenges for uptake of technologies

The key drivers for the growth of CCS are as follows:

a) **Policy framework and Government support:** Favourable policies have the ability to channel private sector investments in CCUS by either creating sufficient incentives for CCUS projects or conversely by penalizing inaction. The policy framework may be either credit/incentives based or based on taxation of emissions. Along with policy support, Governments also need to create a positive signaling effect by committing investments and risk capital to early stage or demonstration CCUS projects, as well as the creation of shared infrastructure, which will subsequently attract and de-risk private sector investments, thus enabling CCUS to reach scale.

b) **Development of CO_2 utilization technologies:** Carbon utilization technologies have an important role to play in providing a pathway for the disposition of CO_2 by converting captured CO_2 emissions to marketable value-added products such as methanol, DME. As markets become more carbon conscious and ascribe a carbon price to CO_2 unabated products, CO_2 utilization products will eventually become competitive compared to the hitherto conventional fossil fuel based production routes.

c) **Hub and cluster frameworks:** CCUS hubs and clusters lower the costs and risks for parties associated with CCUS value chain. The development of CCUS hubs and clusters can drive CO_2 capture, transport and disposition at scale by enabling emitters and disposition sites to seamlessly connect through shared transportation hubs/ infrastructure.

d) **Facilitating CCUS-enabled projects:** The process for acquiring permits and clearances for projects where CCUS has been integrated for the reduction of carbon emissions of the project should be streamlined for fast-tracking the process.

The key challenges to the growth of CCS are as follows:

a) **Financial aspect of CCS**: The expense of capturing CO_2, particularly in the context of post-combustion CO_2 capture from flue gases that have a low CO_2 concentration, is significant. This high cost of capture results in a substantial overall cost for CO_2

reduction, calculated either per tonne of CO_2 or per unit of the final product, for the steel industry. This Industry operates in highly competitive markets, making it challenging to pass on these additional costs to consumers.

While it is anticipated that costs will decrease as the scale of deployment increases and technology continues to advance, there is an immediate necessity for supportive policies to encourage investment in CCS. Policies such as CCS credits or preferential procurement for products manufactured with reduced carbon emissions are essential to incentivize businesses to invest in and adopt CCS technologies, thereby accelerating the transition to a low-carbon economy.

b) **Absence of downstream CO2 infrastructure:** The infrastructure for the downstream transportation and storage of captured carbon is still in its early stages of development. This means that emitters are not only required to invest in carbon capture technologies but also to invest across the entire Carbon Capture and Storage (CCS) value chain. To facilitate the growth and efficiency of CCS, there is a crucial need for policy interventions aimed at establishing CCS clusters equipped with large-scale CO_2 storage facilities. These clusters should be designed to connect emitters and storage sites through well-provisioned and shared transportation infrastructure. By proactively developing such downstream infrastructure, the risks and costs associated with CCS adoption can be significantly reduced, making it more attractive for new emitters to join the cluster and contribute to the broader effort of reducing carbon emissions.

c) **Lack of pore space and natural resources mapping:** Whilst various CO_2 capture technologies are in development, CCS at scale is only possible through the geological storage of CO_2. There is a need to focus and invest in pore space mapping to characterize promising CO_2 storage regions and basins.

d) **Risk management:** It is essential to establish comprehensive and resilient monitoring, verification, and accounting (MVA) systems, as well as effective risk management frameworks. These frameworks are crucial for managing and minimizing risks and liabilities throughout the entire CCS value chain and throughout the project's life cycle. By doing so, participants can better navigate potential challenges and uncertainties, ensuring the overall success and sustainability of CCS initiatives.

3.7. Adoption of Emerging Decarbonisation Technologies

In the pursuit of reducing the carbon emissions from iron and steel production and ultimately achieve a net zero emissions for iron and steel production, significant efforts have been made in R&D for developing novel production routes and modification of current routes. A few of these emerging technologies have been identified and are given in the table below.

Table 6: Emerging Technologies

Decarbonisation Technology	Estimated Year of Commercialization
Hydrogen injection in blast furnace	2030
COG injection in blast furnace	2030
Biomass as a reductant in blast furnace	2035
Flash ironmaking	2045
Plasma Direct Steel Production	2050

Technologies like H2 injection in BF and COG injection in BF have pilot references while others are nascent and are currently limited to lab scale. These initiatives have been discussed below:

Hydrogen injection in Blast furnace: Hydrogen is being explored as a potential alternative to carbon-based reductants in blast furnace technology. Iron ore is melted in BF in a reducing environment using coke and coal. Hydrogen can replace coal dust as an additional reducing agent, coal in BF is oxidized and CO2 is formed but hydrogen reacts in the blast furnace to form H2O. The purpose of hydrogen-rich smelting in a blast furnace is to increase the proportion of H2 reduction to reduce the consumption of carbon reductant.

This technology is in its pilot stage, trials have been conducted to inject H2 in BF by companies like ThyssenKrupp Steel and Tata Steel. Tata Steel initiated a trial for record-high hydrogen gas injection in a Blast Furnace at its Jamshedpur Works.

COG injection In Blast Furnace: The injection of coke oven gas (COG) into the modern blast furnace (BF) is one of the effective measures for the steel industry to achieve low carbon ironmaking, energy saving and emission reduction.

COG injection is a process that involves injecting large volumes of coke oven gas into the raceway of a BF. This provides not only a supplemental carbon source but also speeds up the production of hot metal besides reducing the need for coke for reactions in the blast furnace. The COG injection technology also aids in the reduction of CO2 emissions from the blast furnace.

Trials with COG gas injection into the blast furnace were done in the USA in the middle of the 1990s. In an effort to save energy and reduce costs, US Steels developed a system at their Mon Valley works, located just outside Pittsburgh, that enabled them to use COG in their blast furnaces. Although other steelmakers in North America have attempted this, US Steels is the first to use COG in blast furnaces successfully.

Biomass as a reductant in Blast Furnace: Biomass is being explored as a potential reducing agent in BF technology. Biomass, due to its high H2 content compared to coal, can contribute directly to lowering CO2 emissions from a blast furnace. Increasing H2 content in the shaft can also improve the reduction kinetics of descending iron oxide. Replacing fossil coal with renewable and carbon-neutral biomass is one of the potential measures to significantly decrease the fossil CO2 emission from the blast furnace.

Flash Ironmaking: Flash ironmaking is a novel technology developed to address two major issues faced by the steel industry: CO2 emissions and energy consumption. This technology aims at producing iron directly from iron ore concentrate using gaseous reductants/fuels such as natural gas or hydrogen. The Flash Ironmaking Process uses iron ore concentrates directly without further treatment. The fineness of the concentrate particles allows a very rapid reaction rate, thus requiring residence time measured in seconds instead of the minutes and hours it takes to reduce pellets and sinter.

The flash ironmaking process could provide steel plants with significantly more energy-efficient and customized iron production facilities than that of competing processes. The flash ironmaking process would reduce energy consumption to a considerable extent over competitive processes by eliminating pelletizing, briquetting, or sintering. CO_2 emissions could be significantly reduced by using natural gas or hydrogen as the reducing agent instead of coke.

Plasma Direct Steel Production: Hydrogen plasma is used to simultaneously reduce iron ore and smelt it into crude steel in a special direct current electric arc furnace. The advantage of using green electricity and hydrogen as the reducing agent is that water vapor is the only end product, completely avoiding carbon dioxide emissions.

Voestalpine, an international steel company, is currently the world’s only steel manufacturer conducting research into the use of hydrogen plasma in steelmaking. As part of the “sustainable steelmaking” (SuSteel) research project, the company is investigating the use of hydrogen plasma in a carbon-neutral steel production process.

3.8. Carbon Offset Requirement and Procurement Strategy

The principle of carbon offsetting lies in the idea of balancing out greenhouse gas emissions by funding projects that reduce or remove an equivalent amount of carbon from the atmosphere. The process begins with the measurement of the amount of carbon emissions produced by an individual or an organization. Once this carbon footprint is quantified, the equivalent volume of emissions can be offset through various environmental projects. The objective is to achieve a net zero carbon footprint by offsetting the quantity of carbon dioxide (or its equivalent) produced with an equal amount of reduction or removal elsewhere.

Based on the net zero analysis for SAIL RSP presented in Chapter 2, a negligible amount of CO_2 emissions remains after the implementation of suggested decarbonisation strategies assuming abundant availability of biochar, a transition of green power and availability of green hydrogen at a competitive price but in case any of these measures fails to be implemented some amount CO_2 emission would remain. The remaining emissions if any must be abated by procurement of carbon offsets. The procurement options for carbon offsets have been discussed below.

3.9. Various Carbon Offset Standards

Carbon credit standards are a set of guidelines and criteria used to measure, verify, and certify greenhouse gas (GHG) emissions reductions or removals achieved through carbon offset projects. These standards ensure that the carbon credits generated by these projects are real, additional, permanent, measurable, and verifiable. Currently, there is no such carbon offset standard regulating the Indian carbon market. A list of few global standards has been given in the table below.

Table 7: Global Carbon offset standards

Standard	Introduction Year	Project Types
Clean Development Mechanism (CDM)	1997	CDM accepts projects that mitigate any one of the six gases covered by the Kyoto Protocol (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) except nuclear energy projects, and sequestration projects other than afforestation and reforestation projects.
Gold Standard (GS)	2003	The GS accepts renewable energy (including methane-to-energy projects) and energy efficiency projects. It excludes large hydro projects above 15 MW capacity.
Verified Carbon Standard (VCS)	2005	All project types are allowed under the VCS Programme. Exceptions are projects that are “reasonably assumed” to have generated GHG emissions primarily for their subsequent reduction, removal, or destruction (e.g. new HCFC facilities) and projects that have created another form of environmental credit (e.g. Renewable Energy Certificate)

Different emissions trading schemes (ETS) may follow different standards for approving carbon offset projects and generating carbon credits through them. Although individual organizations may formulate their own internal carbon pricing (ICP), there is no ETS in India and as a result there is no price on carbon. Globally, several countries are conducting trials of ETS in the primary and secondary markets. The EU ETS and the Canadian output based pricing system (OPBS) are few of the robust operational ETS. The EU ETS has set a carbon price for procurement of an offset unit as €70 per metric tonne of CO2 as of 2024. Canada’s OPBS has set a price of CAD 50 per metric tonne of CO2 in

2022 and an annual increment of CAD 15 per metric tonne CO2 thereafter till 2030 when the price reaches CAD 170 per metric tonne of CO2.

Carbon Offset Procurement Options

Achieving net zero in hard to abate sector like iron and steel production is a challenging task as the process requires carbon for production of iron and steel. It is evident from the net zero scenario analysis that certain CO2 emissions would always be present as these are emissions from sources which are not a techno-economically viable carbon capture option. To abate these residual emissions, carbon offsets can be procured from different mechanisms/programmes. In India, SAIL RSP can explore the following options for procurement of carbon offsets:

a. **Carbon Credit Trading Scheme (CCTS):** This is an indigenously developed emissions trading scheme which aims at operating a carbon market in India. The GOI has planned implementation of the CCTS from 2026 onwards which would consist of components of compliance-based market as well as voluntary carbon market. Based on a pre-determined ceiling value for emission per unit product, the companies shall be mandated to procure carbon credits to offset their incremental emissions from the ceiling value. On the other hand, the companies can also voluntarily purchase credits to offset their emissions in order to achieve net zero emissions. The companies can also trade their surplus credits and generate additional revenue.

b. **Clean Development Mechanism (CDM):** CDM was established under the Kyoto protocol international treaty that commits state parties to reduce GHG emissions. India has been an active participant in the CDM. The CDM initiatives in India can be in energy efficiency, fuel switching, forestry, and renewable energy. RSP can develop/invest in projects which are eligible for earning credits according to the CDM standards.

c. **Perform, Achieve and Trade (PAT) Scheme:** Launched by BEE in 2008, this scheme mainly focussed on reducing the specific energy consumption of highly energy intensive industries. Based on the energy savings, Energy Saving Certificates (ESCerts) are received which can be used as an offset for carbon emissions based on the CO2 emission equivalent of energy.

d. **Renewable Energy Certificates (REC) and Renewable Purchase Obligations (RPO):** RECs are another market-based instrument that is tradable and represents the environmental benefits of 1 MWh of renewable energy generation. The RPO was implemented to tackle the drop in demand of REC. It mandates entities such as distribution licensees, open access consumers, and captive power producers to purchase a certain percentage of electricity from renewable energy sources as a percentage of the total consumption of electricity. These REC certificates can also be used to offset carbon emissions based on the CO2 equivalent for the renewable electricity generated.

3.10. Sensitivity Analysis for Net-Zero Scenario

Based on the net zero roadmap formulated for SAIL RSP, certain assumptions have been made for the period 2050 -2070 which are as follows:

- By the year 2060, green H_2 will be readily available at a low price
- The grid emission will be zero by 2070,
- Carbon capture technology will not be matured by 2050
- Biochar will be commercially available for use in ISP

This is an optimistic scenario for achieving SAIL RSP's net zero target. However, due to several unforeseen factors, the decarbonization levers envisaged for achieving the target may not materialise. This section has considered few of these scenarios and has suggested alternate pathways towards achieving the net zero target.

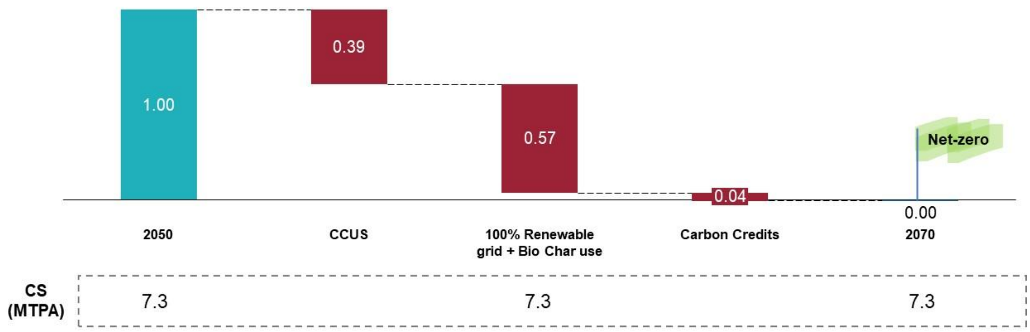
Net Zero Scenario 1

In this scenario, the following assumptions have been made:

- The green H_2 scenario doesn't get materialised by the year 2060.
- By 2050, carbon capture technology will be matured and commercially available for integrated steel plants.
- By 2070, the grid emission will be zero

If green hydrogen doesn't get materialised by 2070, the absolute CO_2 emissions are projected to be 3.17 MTPA. Here, if carbon capture, storage, and utilisation are assumed for NG-based DRI units considering 90% capture efficiency then 2.85 MTPA of absolute CO_2 emissions can be captured and disposed. The remaining 0.32 MTPA CO_2 emission intensity needs to be offset by procuring carbon credits through mechanisms mentioned in section 3.8 of this chapter. The intensities are represented in the figure below.

Fig. 13: CO_2 Emission Intensity Reduction in Net Zero Scenario 1



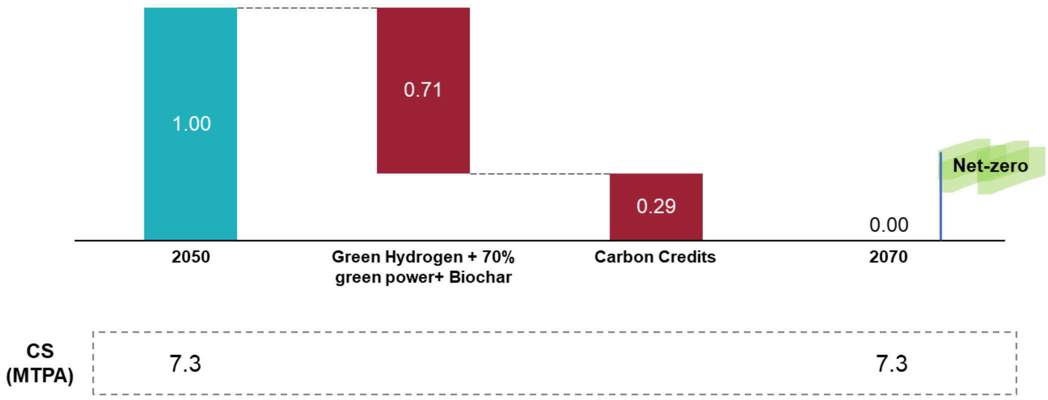
Net Zero Scenario 2

In this scenario, the following assumptions have been made:

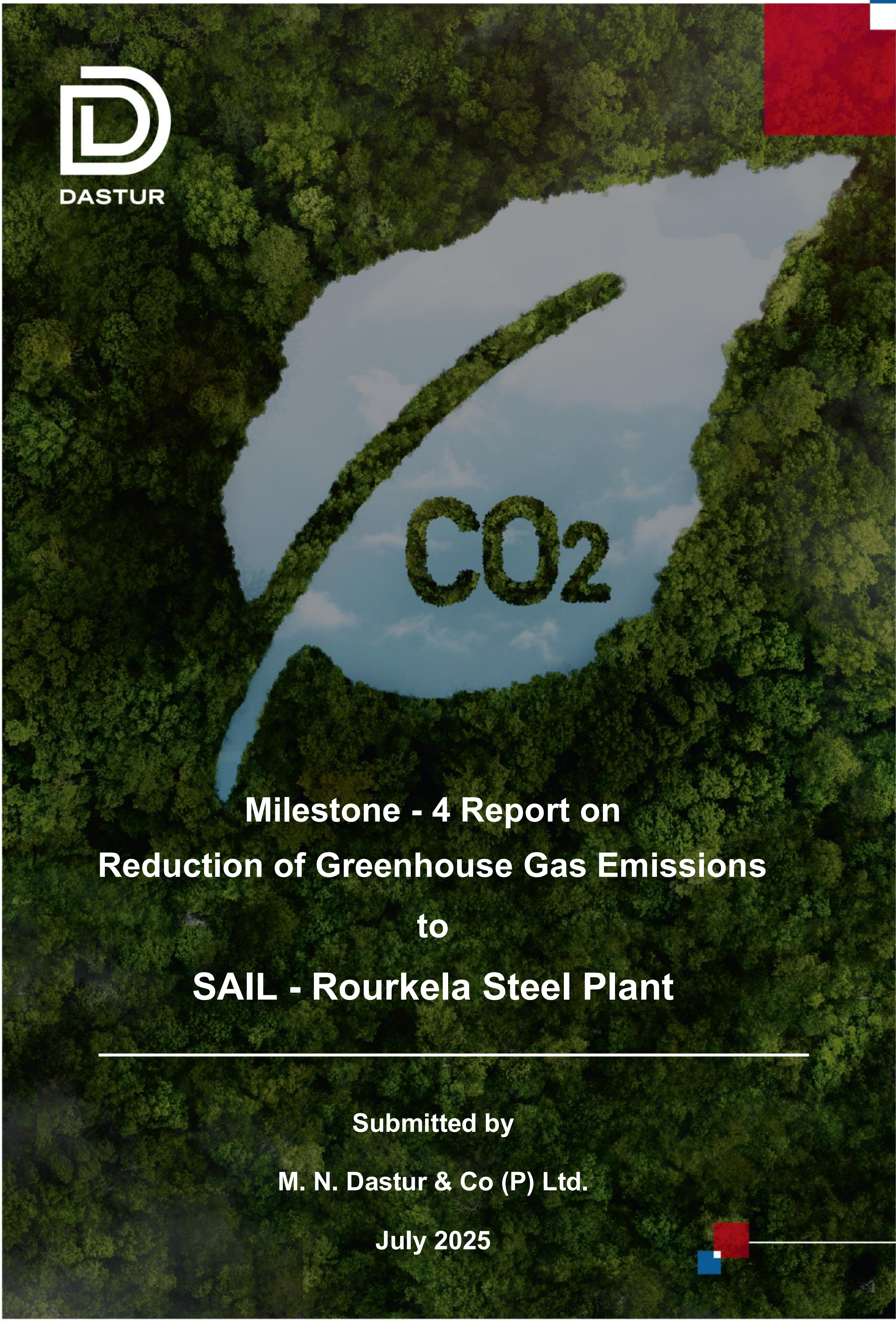
- Green H_2 will be available by 2060
- Grid emission has been considered 0.36 TCO_2/MWh assuming 70% of the grid electricity turns green by 2060
- Carbon capture technology is not matured by 2050

In this scenario by 2070, the absolute CO_2 emissions are projected to be 2.1 MTPA. These emissions fall entirely under Scope 2 emissions, which can only be reduced to zero through the procurement of carbon offsets/credits. Therefore, carbon offsets need to be procured for the entire 2.1 MTPA of CO_2 emissions. The intensities are represented in the figure below.

Fig. 14: CO_2 Emission Intensity Reduction in Net Zero Scenario 2



RSP may choose the appropriate net-zero scenario at a suitable timeframe (near 2050), based on the actual CO_2 footprint achieved, and availability of RE power, green hydrogen, biochar etc.



Milestone - 4 Report on Reduction of Greenhouse Gas Emissions to SAIL - Rourkela Steel Plant

Submitted by

M. N. Dastur & Co (P) Ltd.

July 2025

SURVEY OF GREEN BELT INSIDE AND OUTSIDE ROURKELA STEEL PLANT (RSP)

4.1 Introduction

The scope for potential greenery development at Rourkela Steel Plant (RSP) is significant, given its industrial landscape and surrounding areas. Enhance greenery at RSP would focus on mitigating environmental impacts, enhancing biodiversity, and contributing to sustainability goals. Rourkela Steel Plant (RSP) has demonstrated a strong commitment to environmental sustainability by maintaining a substantial green cover within total land under ownership of RSP including Plant area, Township, Mandira Dam area and other adjacent area to its premises. As per environmental guidelines, RSP ensures that 33% of its total area is covered with tree plantations. RSP aims to significantly increase its green cover beyond the current 33% through mass afforestation drives and eco-restoration initiatives. Increasing vegetation cover will enhance natural carbon absorption, contributing to offsetting emissions.

These efforts contribute significantly to the region's ecological balance, aligning with Sundargarh district's overall forest cover, which encompasses about 43% of its total area.

These initiatives will not only support RSP's commitment to achieving zero carbon emissions but also set a benchmark for sustainable industrial practices. Enhancing green cover alongside technological innovation will play a critical role in reducing the carbon footprint and aligning RSP with India's broader climate goals, such as achieving **net- zero emissions by 2070**.

In line with this initiatives, selection of plant species for plantation in prospective areas within ownership of RSP to enhance green cover area will require careful consideration to ensure that the plant species selected will contribute positively to the goals to achieving zero carbon emissions. Priority must be given to select the plant species with high potential carbon sequestration, native to local agro-climatic zone & ecological conditions, soil characteristics, pollution resistant and good lifespan.

4.2. The Ecological Condition and Climatic Factors That Influence on Vegetation in and around Rourkela Steel Plant (RSP)

The region surrounding the Rourkela Steel Plant (RSP) exhibits typical characteristics of a tropical climate, influencing vegetation growth and regeneration. The region falls in the Tropical wet and dry climatic zone of Koppen Climate Classification and under Eastern Plateau & hill regions in Agro-climatic Zone of India Planning Commission.

The key highlights of the region's ecological condition & climatic factors are:

4.2.1 Temperature:

- Summer: Extremely high temperatures, reaching 45°C to 46°C.
- Winter: Cooler, with temperatures reaching 6°C to 7.5°C.

4.2.2 Rainfall:

- Annual precipitation varies from 1000 mm to 1900 mm.
- The rainfall is predominantly influenced by the Southwest monsoon.

4.2.3 Humidity and Soil Moisture:

The tropical environment contributes to significant humidity levels, which, along with soil moisture, plays a crucial role in supporting vegetation growth.

4.2.4 Sunlight and Wind:

High levels of sunlight during most of the year aid in photosynthesis, while wind patterns impact evapotranspiration rates.

4.2.5 Soil Characteristics:

- Nutrient Content: Availability of more than sufficient nutrients having nitrogen in the range of 890 mg/kg to 1285 mg/kg, phosphate in the range of 680 mg/kg to 1235 mg/kg & potassium in the range of 850 mg/kg to 1290 mg/kg, promotes suitable growth of vegetations and promoted species richness.
- Water Retention: Sandy loam soils of the region characterized by moderate level water-holding capacity with porosity in the range of 46.0 - 55%, that favouring tropical vegetations.
- pH Levels: The soil is neutral to very slightly alkaline in nature with pH value ranging from 7.16 to 7.42 that favouring nutrient availability for vegetation growth.

These factors collectively determine the type of vegetation, the regeneration of rootstocks, and the ecological balance in the area. The tropical climatic conditions in the Rourkela Steel Plant region create a supportive environment for the natural regeneration and growth of several native and economically significant plant species. In line with these objectives selected tree species has been identified for future enhancement of greenery, listed in Table- 4.1.

Table-4.1. List of selected tree species for future greenery development

Plant species	Carbon Sequestration Potential CO2 eq./tree Sp./yr. (Kg)	Characteristics
Acacia auriculiformis (Akashmoni)	29.5	Fast growing, Dust tolerant
Acacia leucophloea (Safed Babul)	64.1	Fast growing, Evergreen, Dust Tolerant, Drought Tolerant
Albizzia lebbek (Siris)	77	Fast growing, wide-spreading dense canopy, resilient to drought.
Cassia siamea (Kassod/Chakundi)	34.7	Fast growing, dense canopy, resilient to drought. Avenue Plantation.
Eucalyptus citriodora (Nilgari)	64.1	Fast growing, resilient to drought.
Ficus religiosa (Peepal)	141.2	Evergreen, wide-spreading canopies, long lifespan.
Ficus variegate (Fig)	24.3	Moderate to fast growing, dense canopy, Evergreen, Dust tolerant
Gmelina arborea (Gamhar)	23.7	Evergreen, fast growing, dense canopy, dust, SO2 & NOx tolerant,
Syzygium cumini (Jamun)	21.3	Fast growing, Evergreen, Dust tolerant
Peltophorum pterocarpum (Radhachura)	65.3	Fast growing, dense canopy, resilient to drought. Avenue Plantation.
Mangifera indica (Aam/Mango)	33.8	Evergreen, wide-spreading canopies, long lifespan.
Azadirachta indica (Neem)	32.7	Moderate growing, dense canopy, resilient to drought.
Madhuca longifolia (Mahua)	43.7	Moderate growing, dense canopy, resilient to drought.
Artocarpus heterophylla (Kanthal)	42.7	Moderate growing, dense canopy, resilient to drought.
Pongamina pinnata (Karanja)	30.7	Moderate growing, dense canopy, resilient to drought.

4.3 GREENERY DEVELOPMENT POTENTIAL WITHIN TOTAL LAND OF RSP

It is necessary to find out the future greenery development potential in the total land under ownership of Rourkela Steel Plant. As estimated through GIS, Remote Sensing data through NDVI (Normalised Dense Vegetation Index) study of the total land under ownership of RSP.

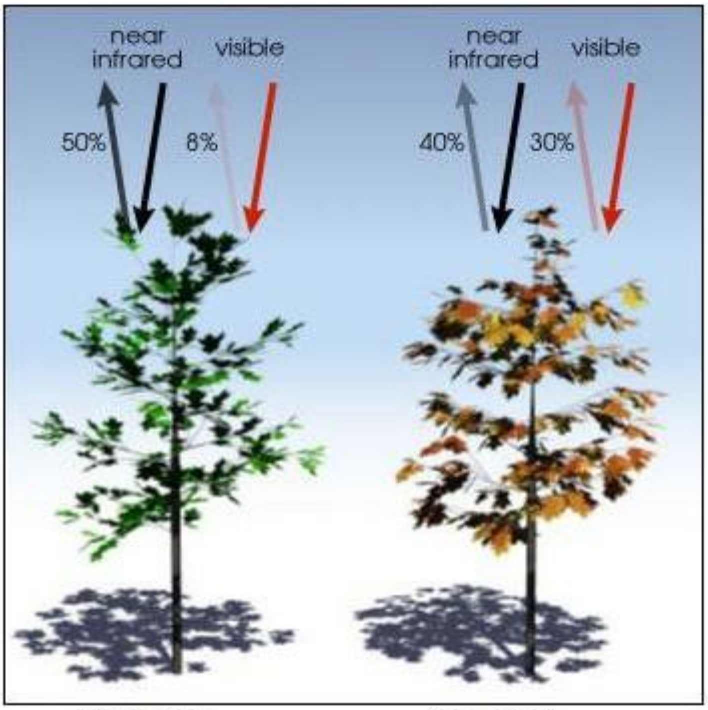
4.3.1 METHOD OF VEGETATION CALCULATION:

- **NDVI (Normalised Difference Vegetation Index) :** It is widely used metric for quantifying the health and density of the vegetation using satellite imagery. It is calculated from spectrometric data (sourced from remote sensors such as satellites) at two specific bands: red and near-infrared. Satellite sensors like ‘Landsat’ and ‘Sentinel-2’ both have the necessary bands with NIR and red.

  NDVI = (NIR – Red) / (NIR + Red)

  The Normalized Difference Vegetation Index (NDVI) is always within the range of -1 to +1. When NDVI displays a negative value, it typically signifies a waterbody. Conversely, a value close to +1 indicates dense vegetation cover, while a value near zero or zero itself suggests the absence of green leaves, often indicating an urbanized area. Healthy vegetation, rich in chlorophyll, reflects more near-infrared (NIR) and green light compared to other wavelengths. However, it absorbs more red and blue light, which is why our eyes perceive vegetation as green. The relationship between reflectance and NDVI is illustrated in the image below: objects with low reflectance (or low values) in the red channel and high reflectance in the NIR channel will yield a high NDVI value, and vice versa.

Fig. 4-1 : NDVI INDEX MEASURMENT



$$\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72 \qquad \frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14$$

Image courtesy of NASA.

The NDVI metric is popular in industries because of its accuracy. It has a high correlation with the true state of vegetation on the ground.

- It is suggested to study the status of all the green cover in the total land under ownership of SAIL-Rourkela Steel Plant, Rourkela, Odisha. The NDVI analysis was undertaken by utilising :

    1. Indian Remote Sensing Satellite Imageries ResourceSat 2 (RS2); LISS IV (Sensor) multispectral imageries has been procured from National Remote Sensing Centre (NRSC), Hyderabad.
    2. Map of total land area under ownership of SAIL-RSP.
    3. Validation of multispectral imageries by ground truthing.

For LISS IV (Sensor) ; Spectral Band B3 (0.62-0.68 μm) refers to Red band and Spectral band B4 (0.77-0.86 μm) refers to Near Infrared Band. Hence, NDVI is analysed in “QGIS” software (Version 3.28) by calculating the raster layers through the formula written below.

NDVI (Calculated in LISS IV Images) = (B4 – B3) / (B4 + B3)

4.3.2 Satellite Imagery Procurement :

Indian Remote Sensing Satellite Imageries Resourcesat 2 (RS2) LISS IV (BAND 2, BAND 3, BAND 4) , multispectral imageries has been procured from National Remote Sensing Centre (NRSC), Hyderabad for analysis of greenbelt in Rourkela plant & township area. The satellite imagery is shown in FIG 4.2 & FIG 4.3.

Fig. 4-2 : SATTELITE IMAGARY OF MANDIRA DAM ALONG WITH SAIL- RSP

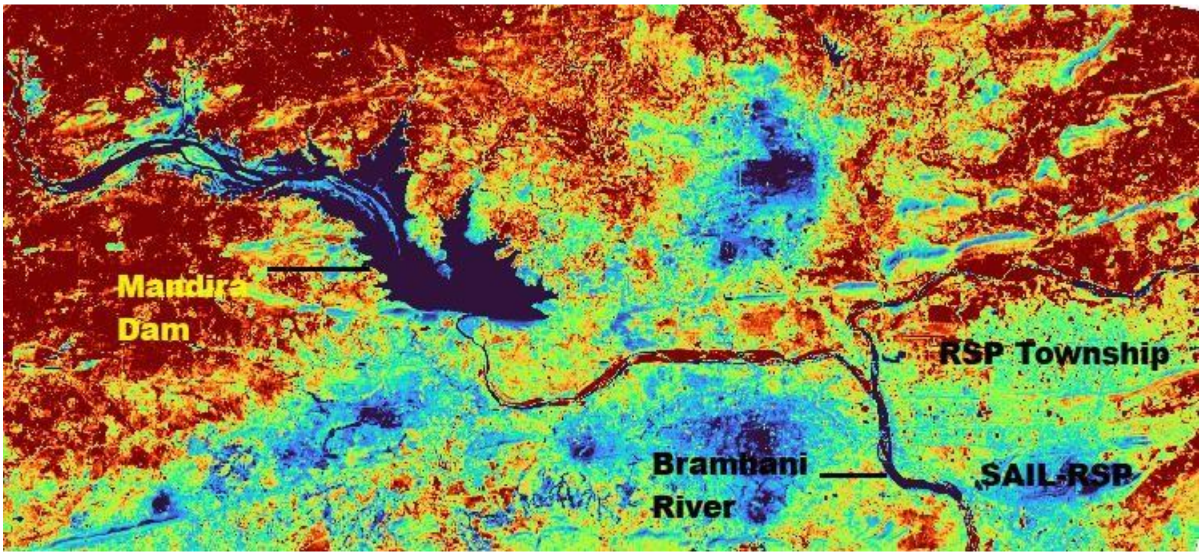
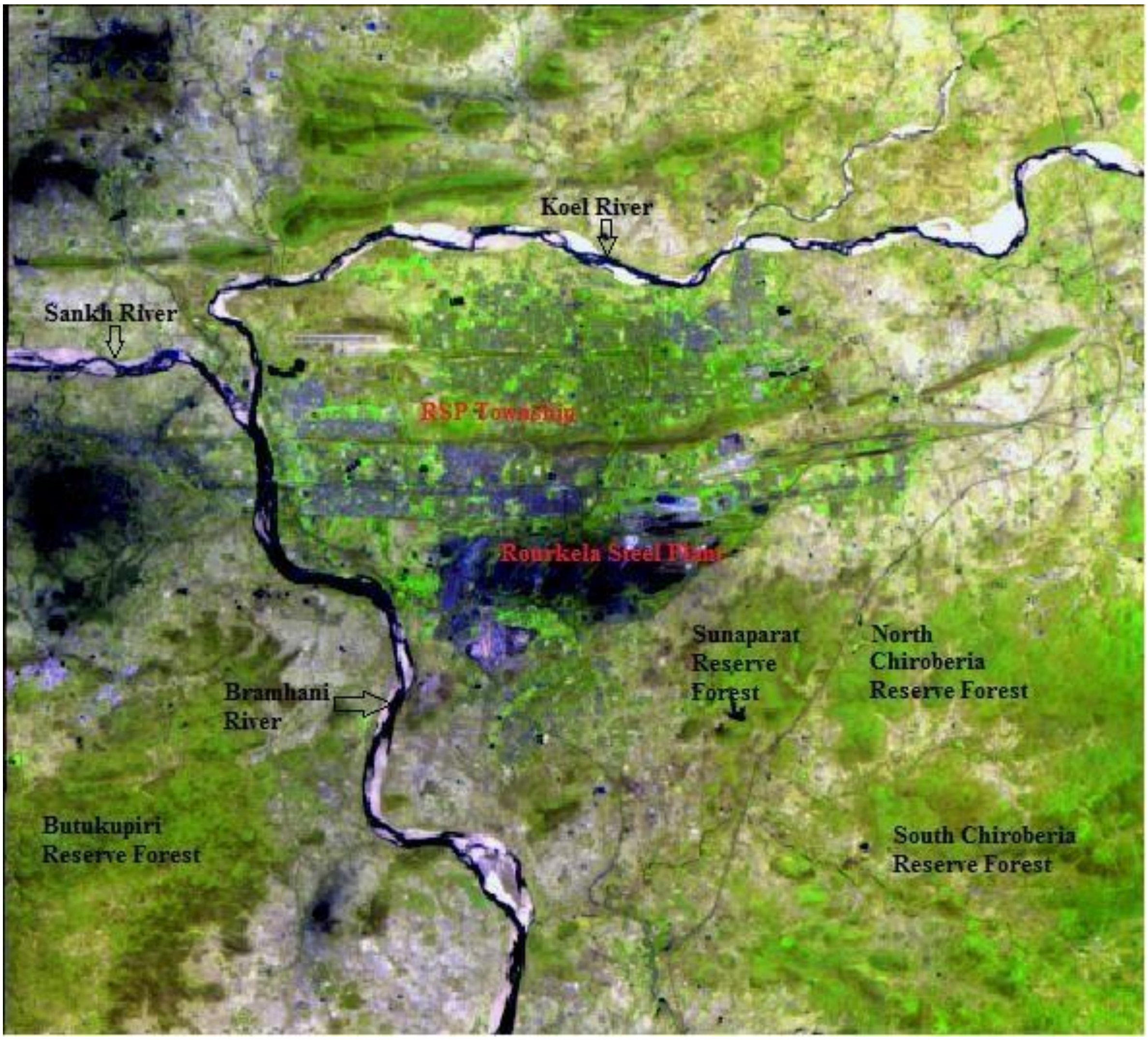


Fig. 4-3 : SATELLITE IMAGARY OF THE RSP PLANT & TOWNSHIP AREA



The land parcels that are kept vacant/barren or covered by small shrubs and grasses can be easily converted into semi-dense or dense vegetation cover. Additionally, there are scope of plantation through gap filling within the 1654.2 hectare of sparsely vegetative cover area to develop into densely vegetative cover area. Primarily, the land parcels identified for barren land / shrub & grassland category are marked in Brown and yellow colour boundary respectively, in the NDVI Image. The marked NDVI image presented in Fig. 4.4, Fig 4.5, Fig 4.6 & Fig 4.7 and the status of the land parcels, and their respective location is narrated in the Table-4.2.

Fig. 4-4 : NDVI Image of Plant Area under ownership of RSP

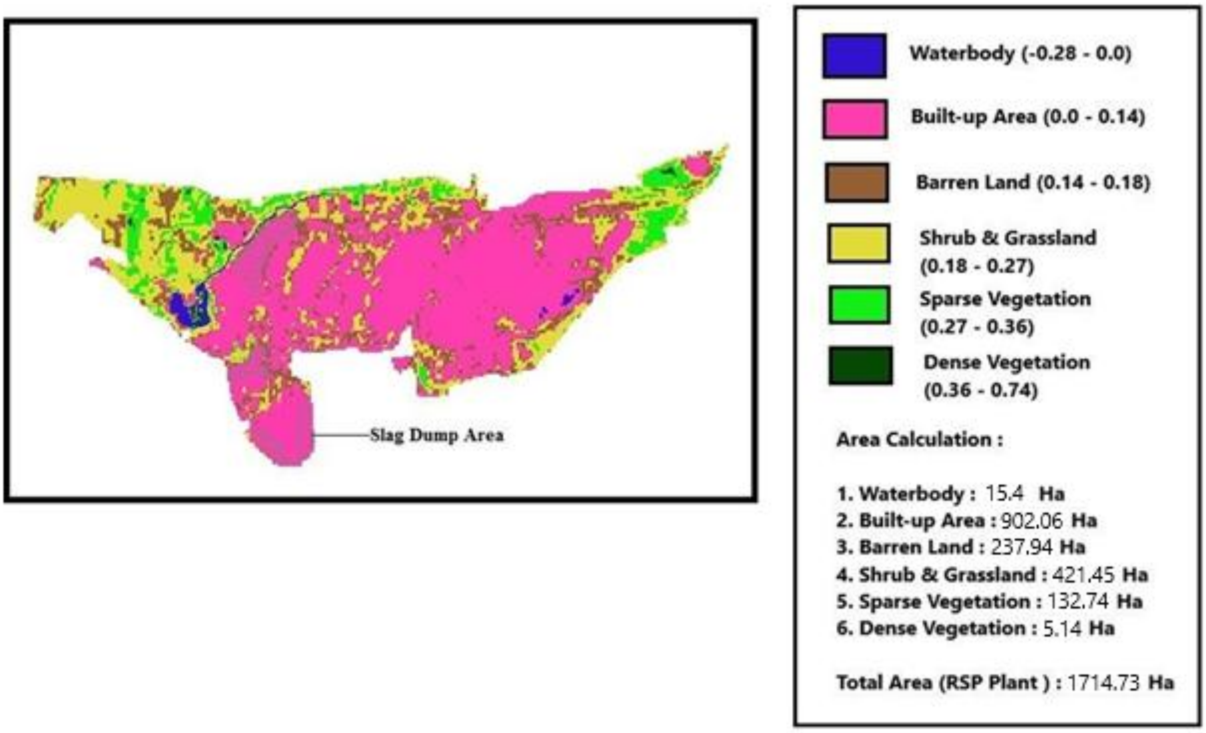


Fig 4-5 : NDVI Image of SAIL-RSP Township Area

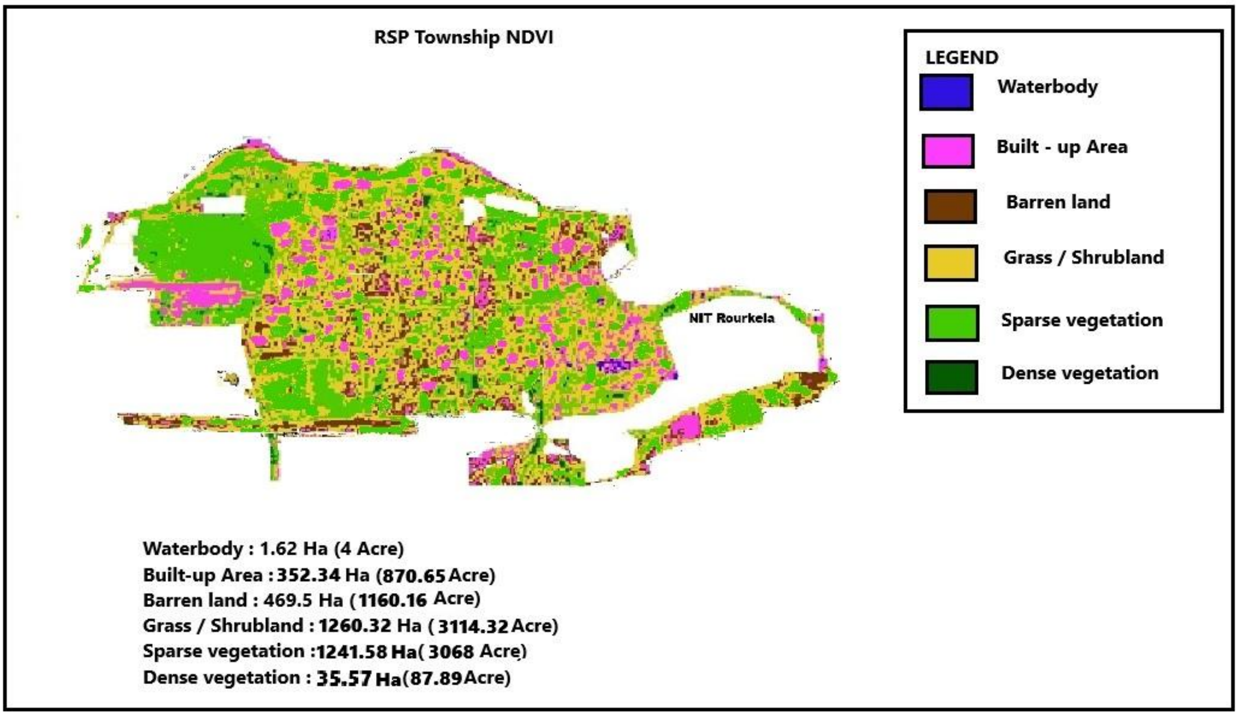


Fig. 4-6: NDVI Image of Mandira Dam Area under ownership of RSP.

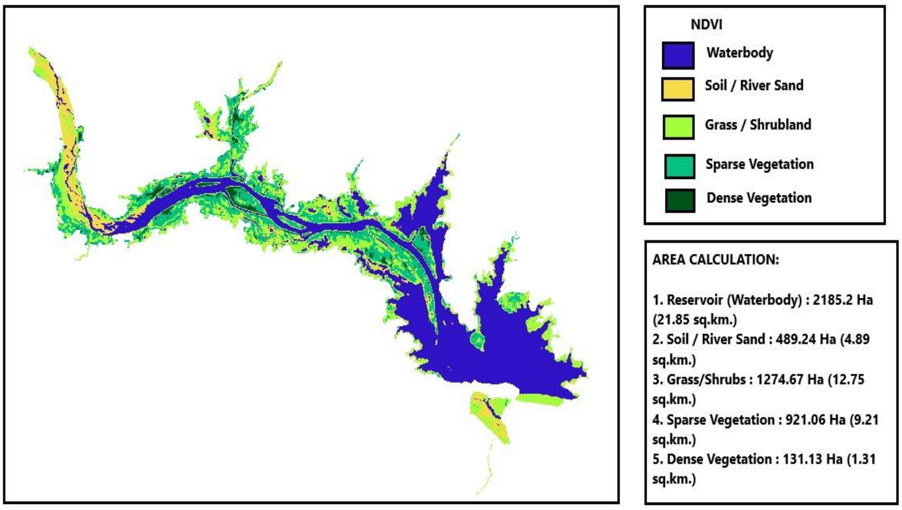


Fig. 4-7: NDVI OF RSP Land outside Boundary

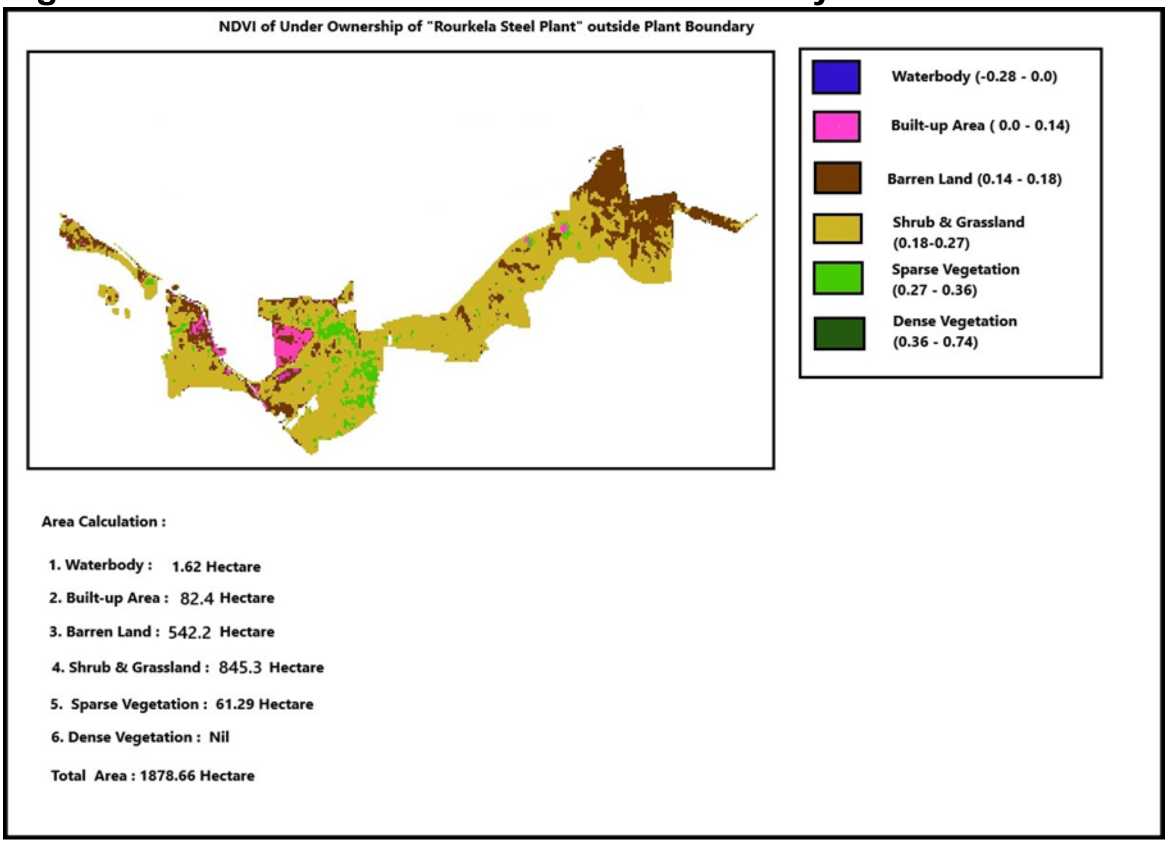


Table-4.2: Details of land classification under ownership of RSP at Plant area, Township area, Mandira Dam area and adjacent land parcels towards southern side of Plant Boundary.

Barren Land Parcels		
Location	**Area (Hectare)**	**Remarks**
RSP Plant Area	237.94	Mostly scattered shrubs and grasses within vacant land
RSP Township Area	469.50	
Mandira Dam Area	489.24	
Adjacent Land Parcel toward Southern Side of the Plant Boundary	542.2	
Total	**1738.88**	
Shrub & Grassland Parcel		
Location	**Area (Hectare)**	**Remarks**
RSP Plant Area	421.45	Areas covered with bushes of grasses / agricultural land in Township area
RSP Township Area	1260.32	
Mandira Dam Area	1274.67	
Adjacent Land Parcel toward South of the RSP Plant Area	845.3	
Total	**3801.74**	
Sparsely Vegetation Cover Area		
Location	**Area (Hectare)**	**Remarks**
RSP Plant Area	132.74	Mostly covered with dense shrubs and scattered trees
RSP Township Area	1241.58	
Mandira Dam Area	921.06	
Adjacent Land Parcel toward South of the RSP Plant Area	61.29	
Total	**2356.67**	
Densely Vegetation Cover Area		
Location	**Area (Hectare)**	**Remarks**
RSP Plant Area	5.14	Vegetation cover with dense tree plantation at matured stage and diverse tree species with varied heights.
RSP Township Area	35.57	
Mandira Dam Area	131.13	
Adjacent Land Parcel toward South of the RSP Plant Area	0.00	
Total	**171.84**	

Build up Area		
Location	**Area (Hectare)**	**Remarks**
RSP Plant Area	902.06	RSP Plant Facilities
RSP Township Area	352.34	Residencial Buildings and Administrative office buildings
Mandira Dam Area	0.14	Pump house buildings
Adjacent Land Parcel toward South of the RSP Plant Area	82.4	-
Total	**1336.94**	
Water Bodies		
Location	**Area (Hectare)**	**Remarks**
RSP Plant Area	15.4	
RSP Township Area	1.62	
Mandira Dam Area	2185.20	Water Reservoir of RSP
Adjacent Land Parcel toward South of the RSP Plant Area	1.62	
Total	**2203.84**	

- Total developed Greenbelt within RSP plant Boundary is 518.76 Hectare out of 1592.73 Hectare which is about 32.6% of the plant area.
- In RSP Township area, sparse and dense vegetation developed in 1277.15 Hectare out of 3360.93 Hectare land.
- Mandira dam area of RSP is mainly water reservoir of 2185.20 hectare along with some sparse as well as dense vegetation of 1052.19 hectare.

Table 4 – 3 : Greenbelt Area in SAIL-RSP Land, Township & Mandira Dam Area

Sl. No.	Name of The Area	Area in Ha	Greenery in Ha	%
1	Rourkela Steel Plant	1714.73	559.33	32.62
2	Rourkela Steel Township	3360.93	1277.15	38
3	Mandira Dam area	5001.3	1052.19	21

4.3.3 Ground Truth Observation at RSP Owned Land Area:

During ground truth verification the status of greenery inside the RSP plant boundary were observed to quantify the diversity of planted species as well as visited to observe the available vacant spaces inside the plant facilities including the slag dumping area and area nearby lagoon at Tarkera site. To observe the status of land under ownership of SAIL-RSP, outside the existing plant boundary also visited for better assessment of greenery development opportunities in future.

- Almost half of a portion of Tarkera lagoon has been covered by water hyacinth, and its surrounding area covered by scattered trees and shrubs. Patches of plantation were observed near Tarakera lagoon with species like Cassia, Copper pod, Sissoo, Neem, Bamboo etc.

FIG 4-8 : Tarkera Lagoon Hyacinth & Surrounding Area

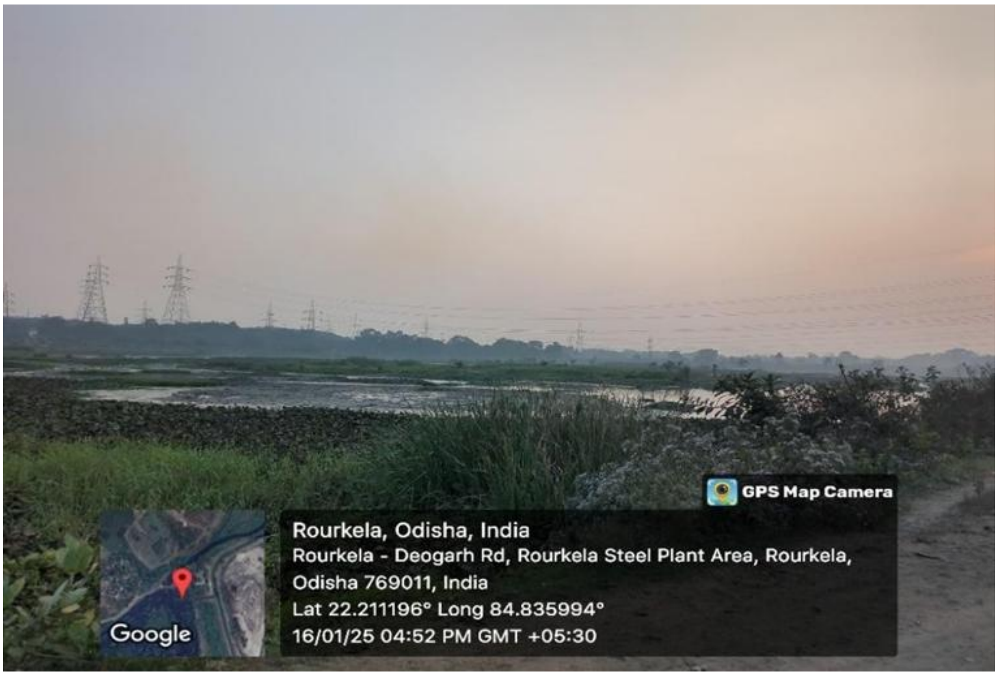


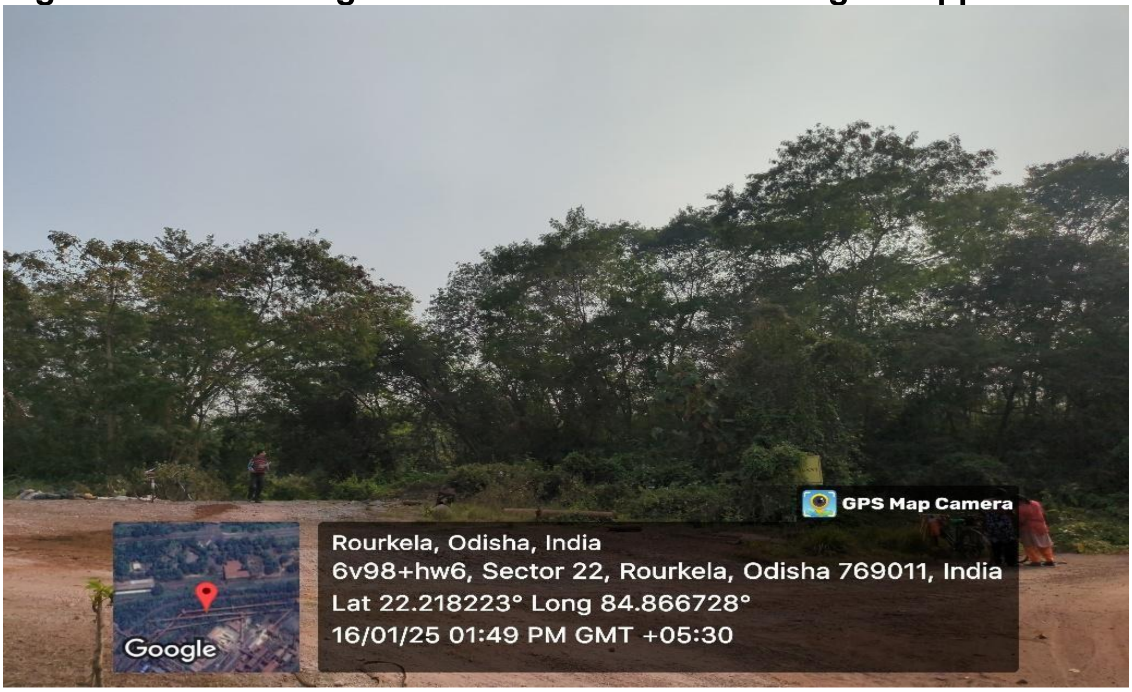
Fig. 4-9: Greenery Development at Tarkera Lagoon Site

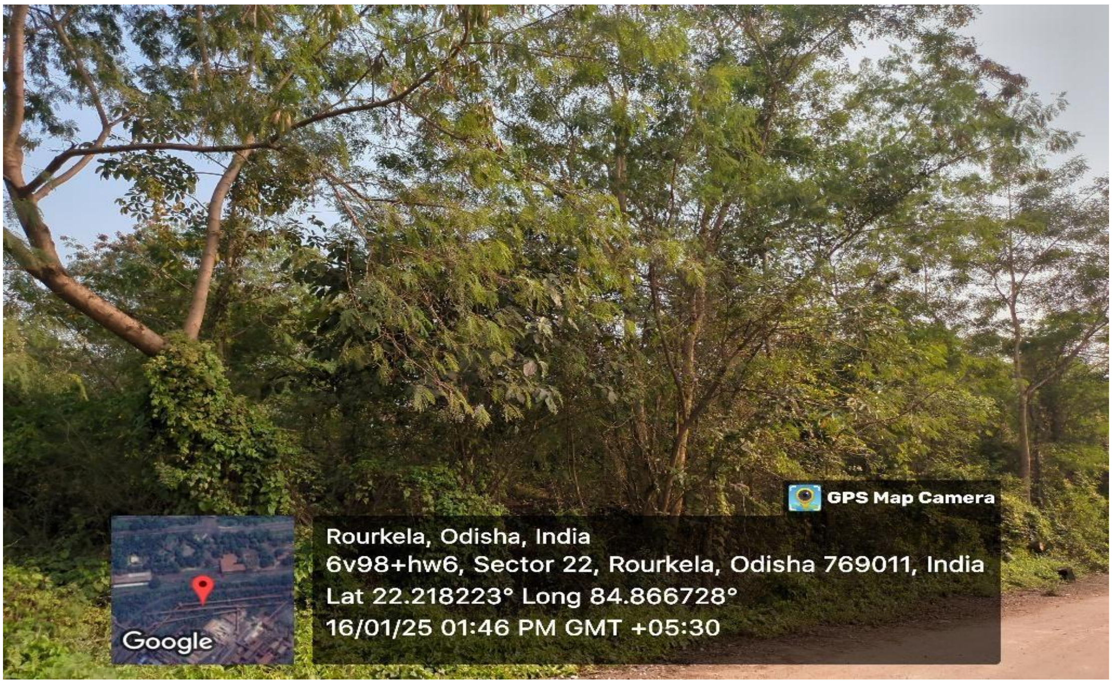
- Slag dumping sites near Hot Strip mill - 2 and Plate Mill are also a huge/ potential spaces of greenery development if gets vacant in near future.

Fig 4-10 : Slag Dumping Ground near HSM -2

- The dense vegetation covered been observed near New Wagon Tippler of Raw Material Handling Yard side. The area is mainly covered with tree spices like Cassia, Subabool, Semal, Siris and Sisoo.

Fig. 4-11: Dense Vegetation Cover Near New Wagon Tippler





- The other green cover (shrubs or big trees) in several section of the plant section like Silicon steel mill, Blast Furnace area and beside plant roads been observed. Mainly tree species like Cassia, Chatim, Mango, Neem, Peepal, Sisoo, and Teak were observed.

Fig. 4-12: Dense Vegetation Cover Near Silicon Steel Mill

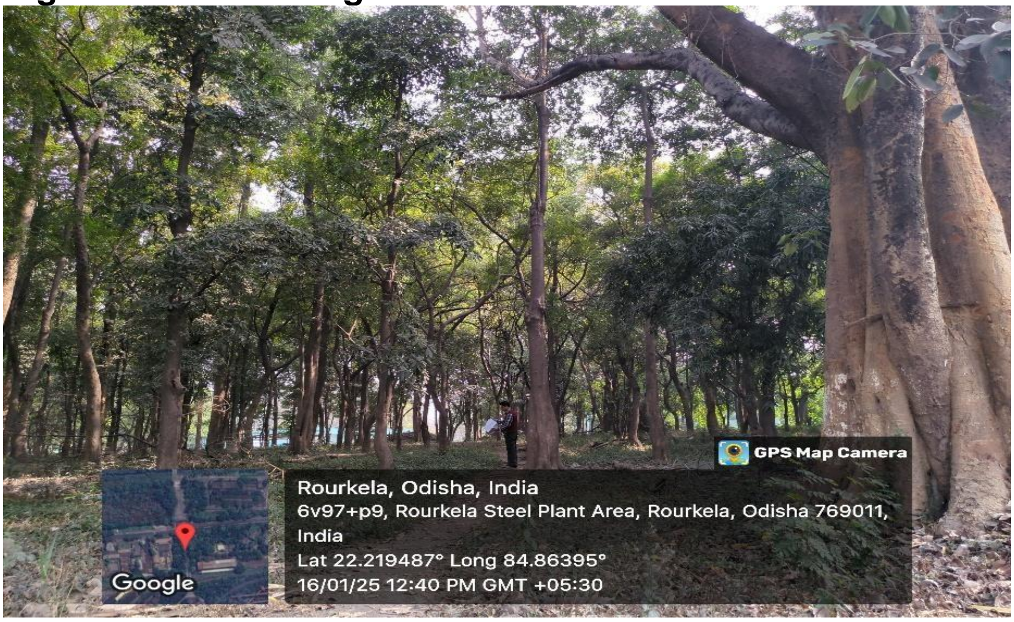
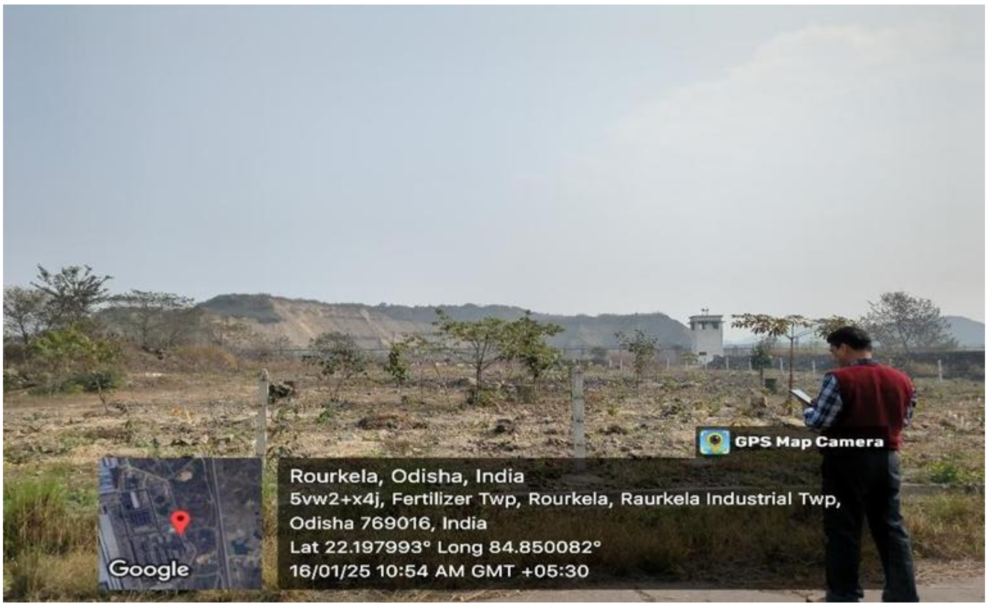


Fig. 4-13: New Plantation in Different Plant Sections of SAIL-RSP

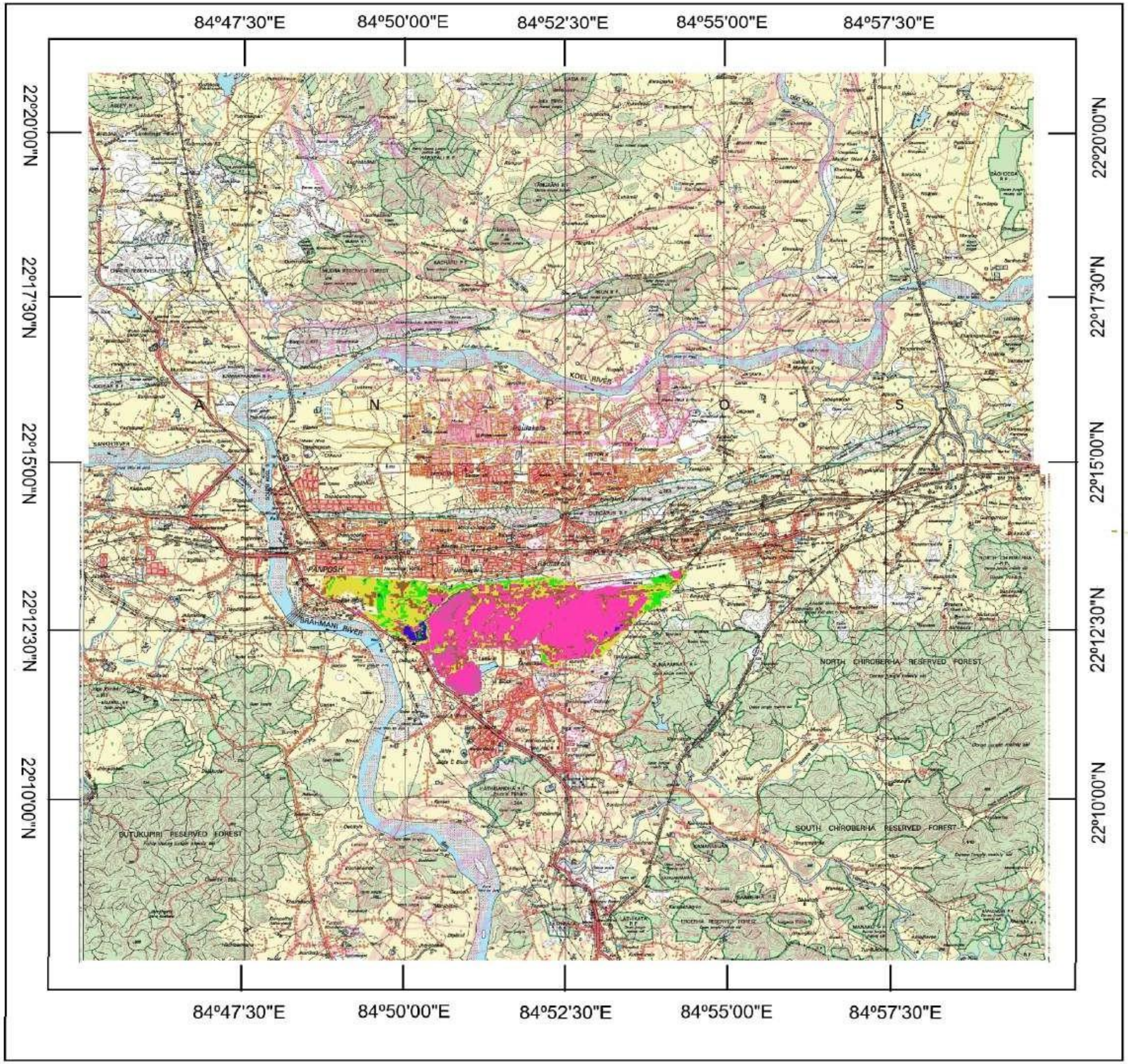


- There are some lands under the ownership of **SAIL-RSP** (Steel Authority of India Limited - Rourkela Steel Plant) that are located to the south of the existing plant boundary. This area sparsely covered by trees, shrubs and bushes. Mainly tree species like Palash, Neem and Khajur were observed.

Fig. 4-14 : Sparse Vegetation Near Fertilizer Plant (Outside RSP Plant Boundary)

4.4. Conclusion:

The present status of the land under ownership of RSP is presented in the above Tables-4.4. The objective of this study is to identify the areas where a healthy or dense vegetation cover can be developed primarily. Accordingly, the identified best prospective land parcels where sufficient land available to develop more greenery are the area categorised as Barren Land and Shrub & Grasslands within Plant Area, Township Area, Mandira Dam Area and adjacent land parcels towards southern side of plant boundary under ownership of RSP. All the slag dumping site within plant can also be converted into green cover. Although, satisfactory amount of tree plantation program near Tarkera nali and other site as well already been initiated by RSP and strengthening all these trees will help to achieve the decarbonisation target of RSP in future.



LEGEND

- Waterbody (-0.28 - 0.0)
- Built-up Area (0.0 - 0.14)
- Barren Land (0.14 - 0.18)
- Shrub & Grassland (0.18-0.27)
- Sparse Vegetation (0.27 - 0.36)
- Dense Vegetation (0.36 - 0.74)

CONVENTIONAL SIGNS OF TOPOMAP

- Express highway: with toll; with bridge; with distance stone
- Roads, metalled: according to importance
- Roads, double carriageway: according to importance
- Unmetalled road. Cart-track. Pack-track with pass. Foot-path
- Streams: with track in bed; undefined. Canal
- Dams: masonry or rock-filled; earthwork. Weir
- River: dry with water channel; with island & rocks. Tidal river
- Submerged rocks. Shoal. Swamp. Reeds
- Wells: lined; unlined. Tube-well. Spring. Tanks: perennial; dry
- Embankments: road or rail; tank. Broken ground
- Railways, broad gauge: double; single with station; under constrn
- Railways, other gauges: double; single with distance stone; do
- Mineral line or tramway. Kiln. Cutting with tunnel
- Contours with sub-features. Rocky slopes. Cliffs
- Sand features: (1) flat. (2) sand-hills (permanent). (3) dunes (shifting)
- Towns or Villages: inhabited; deserted. Fort
- Huts: permanent; temporary. Tower. Antiquities
- Temple. Chhatri. Church. Mosque. Idgah. Tomb. Graves
- Lighthouse. Lightship. Buoys: lighted; unlighted. Anchorage
- Mine. Vine on trellis. Grass. Scrub
- Palms: palmyra; other. Plantain. Conifer. Bamboo. Other trees
- Areas: cultivated; wooded. Surveyed tree
- Boundary, international
- " state: demarcated; undemarcated
- " district; subdivision, tahsil or taluk; forest
- Boundary pillars: surveyed; unlocated.
- Heights triangulated: station; point; approximate. 200 . 200 .200
- Bench-mark: geodetic; tertiary; canal. BM 63·3 .BM 63·3 .63
- Post office. Telegraph office. Overhead tank.
- Rest house or inspection bungalow. Circuit house. Police station
- Camping ground. Forest: reserved; protected. CG RF PF
- Spaced names: administrative; locality or tribal. KIKRI NĀGA
- Hospital. Dispensary. Veterinary: hospital / dispensary
- Aerodrome. Helipad. Tourist site
- Power line: with pylons surveyed; with poles unsurveyed

DASTUR

M. N. DASTUR & COMPANY (P) LTD
CONSULTING ENGINEERS, KOLKATA

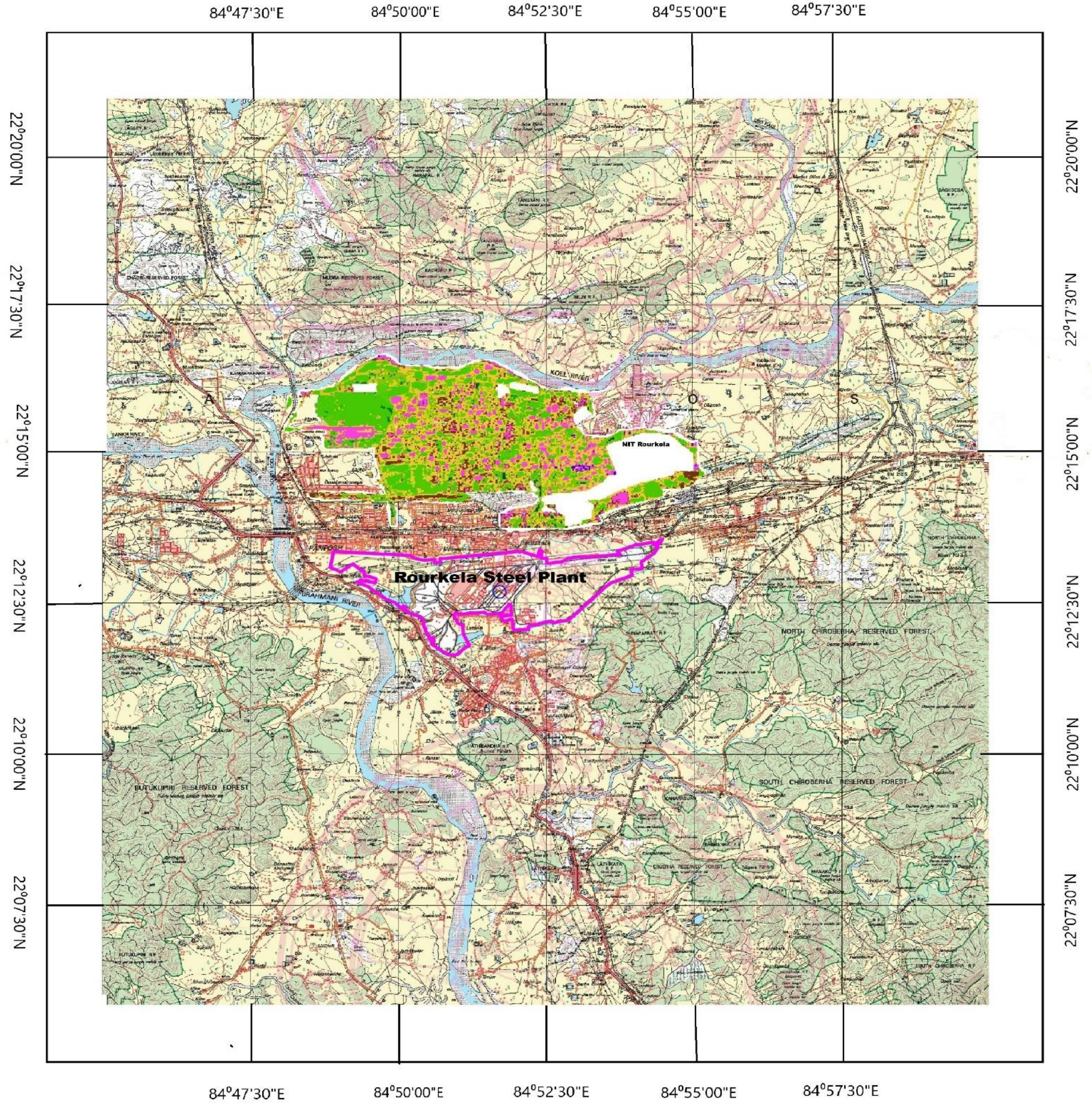
FOR :

SAIL - ROURKELA STEEL PLANT
ODISHA

GREENERY ASSESSMENT FOR ROURKELA STEEL PLANT DECARBONISATION PROJECT

NDVI MAP OF RSP PLANT

DRAWN	ATBH	27.03.2025	DRG. No.	REV.
APPROVED	SM	27.03.2025	11704-97A-000-ENV-0001	0



LEGEND

- Waterbody
- Built - up Area
- Barren land
- Grass / Shrubland
- Sparse vegetation
- Dense vegetation

CONVENTIONAL SYMBOLS OF TOPOMAP

Express highway: with toll; with bridge; with distance stone
Roads, metalled: according to importance
Roads, double carriageway: according to importance
Unmetalled road. Cart-track. Pack-track with pass. Foot-path
Streams: with track in bed; undefined. Canal
Dams: masonry or rock-filled; earthwork. Weir
River: dry with water channel; with island & rocks. Tidal river
Submerged rocks. Shoal. Swamp. Reeds
Wells: lined; unlined. Tube-well. Spring. Tanks: perennial; dry
Embankments: road or rail; tank. Broken ground
Railways, broad gauge: double; single with station; under constrn
Railways, other gauges: double; single with distance stone; do
Mineral line or tramway. Kiln. Cutting with tunnel
Contours with sub-features. Rocky slopes. Cliffs
Sand features: (1) flat. (2) sand-hills (permanent). (3) dunes (shifting)
Towns or Villages: inhabited; deserted. Fort
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Lighthouse. Lightship. Buoys: lighted; unlighted. Anchorage
Mine. Vine on trellis. Grass. Scrub
Palms: palmyra; other. Plantain. Conifer. Bamboo. Other trees
Areas: cultivated; wooded. Surveyed tree
Boundary, international
" state: demarcated; undemarcated
" district; subdivision, tahsil or tāluk; forest
Boundary pillars: surveyed; unlocated.
Heights triangulated: station; point; approximate. △ 200 . 200 . 200
Bench-mark: geodetic; tertiary; canal BM 63·3 . BM 63·3 . 63
Post office. Telegraph office. Overhead tank.
Rest house or Inspection bungalow. Circuit house. Police station
Camping ground. Forest: reserved; protected CG RF PF
Spaced names: administrative; locality or tribal KIKRI NĀGA
Hospital. Dispensary. Veterinary: hospital / dispensary
Aerodrome. Helipad. Tourist site
Power line: with pylons surveyed; with poles unsurveyed

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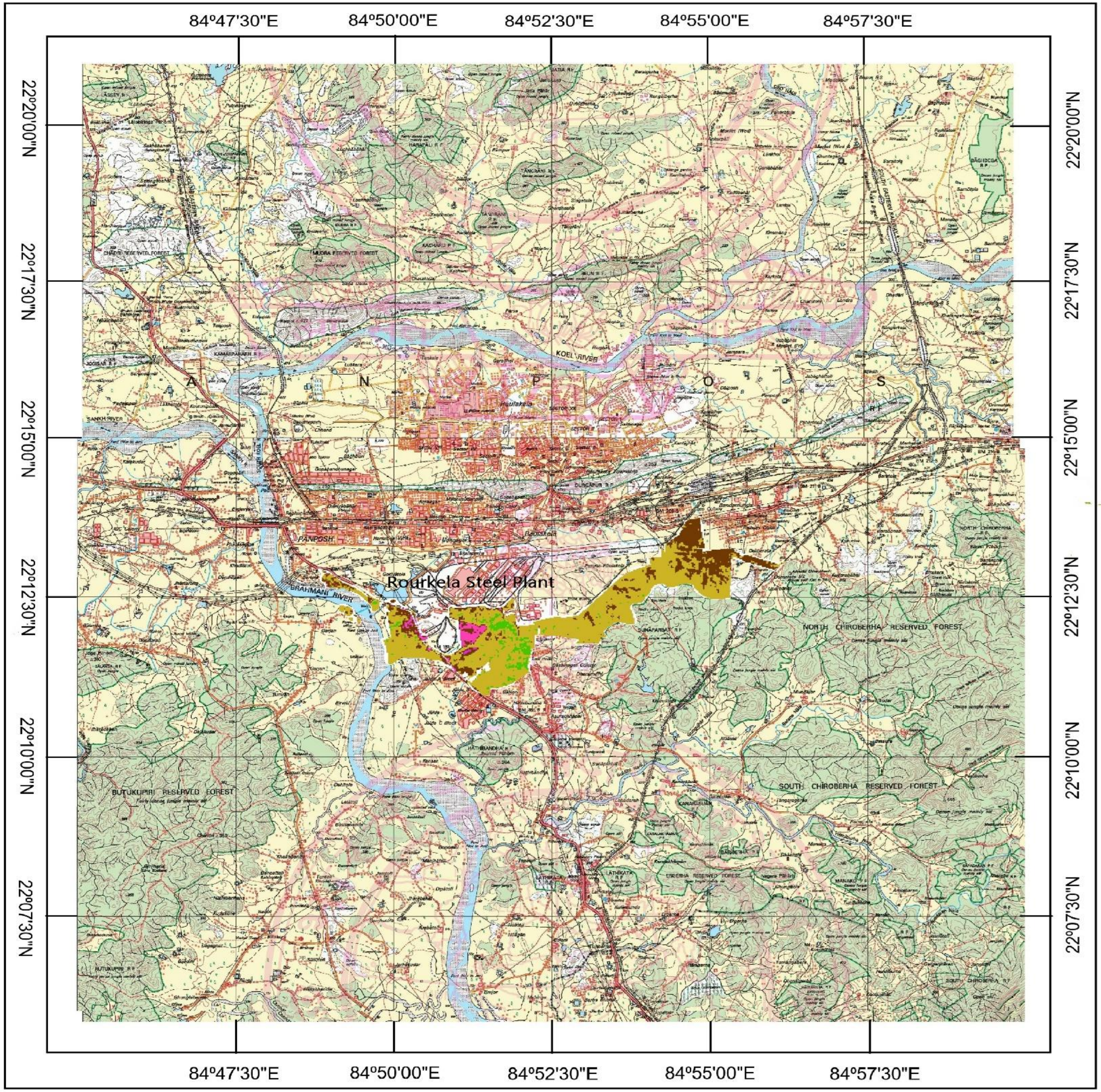
FOR :

SAIL - ROURKELA STEEL PLANT
ODISHA

GREENERY ASSESSMENT FOR ROURKELA STEEL PLANT DECARBONISATION PROJECT
NDVI MAP OF RSP TOWNSHIP IN TOPOSHEET

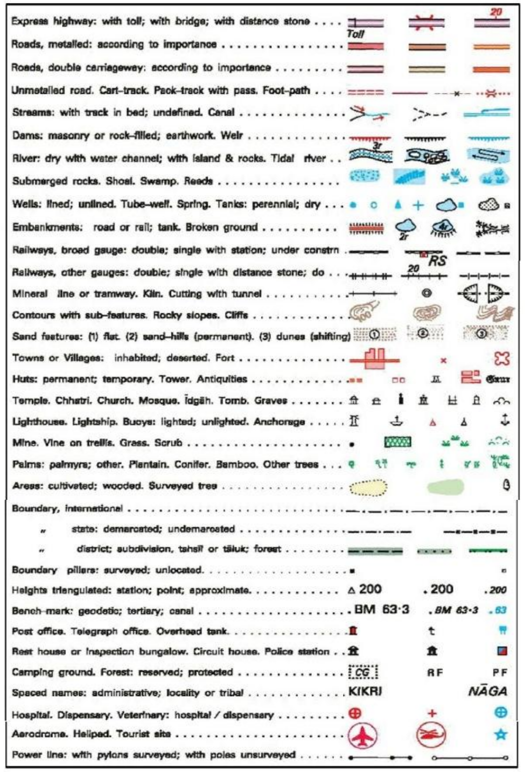
DRAWN	ATBH	27.03.2025	DRG. No.	REV.
APPROVED	SM	27.03.2025	11704-97A-000-ENV-0002	0



LEGEND

- Waterbody (-0.28 - 0.0)
- Built-up Area (0.0 - 0.14)
- Barren Land (0.14 - 0.18)
- Shrub & Grassland (0.18-0.27)
- Sparse Vegetation (0.27 - 0.36)
- Dense Vegetation (0.36 - 0.74)

CONVENTIONAL SIGNS OF TOPOMAP



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FOR :

SAIL - ROURKELA STEEL PLANT
ODISHA

GREENERY ASSESSMENT FOR ROURKELA STEEL PLANT DECARBONISATION PROJECT

NDVI MAP OF RSP SOUTH SIDE LAND BEYOND PLANT BOUNDARY

DRAWN	ATBH	27.03.2025	DRG. No.	REV.
APPROVED	SM	27.03.2025	11704-97A-000-ENV-0003	0

Milestone - 5 Report

on

Determination of Implementation Plan

to

SAIL - Rourkela Steel Limited

Submitted by

M. N. Dastur & Company (P) Ltd.

August 2025

5. Determination of Implementation Plan

The Rourkela Steel Plant (RSP), a unit of Steel Authority of India Limited (SAIL), has made significant efforts toward the development of greenery around plant boundary walls, plantation inside & outside plant premises, adjacent Township & Mandira dam area and land parcels towards southern side of plant boundary.

5.1 Gap Identification based on Present & Target Baselines:

Out of 1714.73 Hectare of Rourkela Steel Plant land, the green cover found from satellite imagery processing (Milestone – 4) and site survey (Ground truth verification) in RSP is about 32.62% i.e. 559.33 Hectare. Among this 559.33 Hectare, thick vegetation exists in 5.14 Hectare area which is located eastern side (Raw material Handling Yards) of RSP plant mainly. Sparsely populated trees are quite common in RSP and also the grass and shrubs which needs time to grow. The detail location of all type of greenery in RSP has been enlisted in Table 5-1.

Table 5-1: Details of Green Cover in SAIL-RSP with Respective Locations

Green Cover	Area (in Ha)	Location	Remarks	Estimated Target
Shrub & Grass Land	421.45	Mainly at Tarkera Nali side and also demarcated at NDVI diagram (Fig 4-4; Milestone 4)	This area can be converted into a lushy greenery through more sapling's plantation in future. As it is a huge area having a great potential to be dense jungle.	Target is to increase tree density by 1500-2000 tress/hectare in these areas.
Sparse Vegetation	132.74	• The area surrounding New Wagon Tippler of RMHS yards of RSP. • Tarkera Nali surrounded area	Tree density is quite lesser than the 2500 tress/hectare (standard of MOEFCC), hence horticulture department of RSP	Horticulture department of Rourkela Steel Plant should take necessary action to strengthen these areas and increase

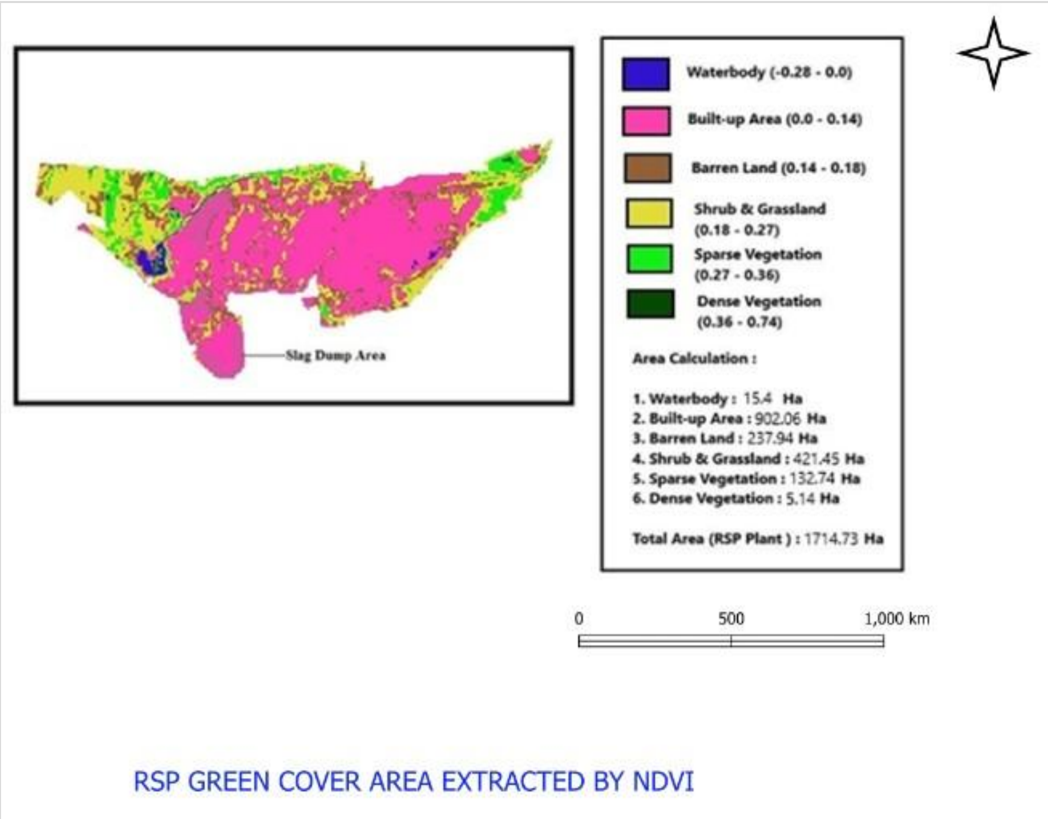
Green Cover	Area (in Ha)	Location	Remarks	Estimated Target
			should plant take care of the trees already planted and increase the saplings no. yearly.	tree density by 500-700 trees /hectare rate.
Dense Vegetation	5.14	A few areas found near Wagon Tippler (Raw material unloading sections)	Dense jungle/a healthy vegetation is present in few part of RSP land.	Tree density is this region is about 1500-2000 tress/hectare. Towering, vigorous trees with broad trunks are found in this region at the time of field survey. Hence, no need for further plantation in this area.
Total	**559.33**			

Target Greenery: Green belt is plantation of trees for reducing the pollution as they absorb both gaseous and particulate pollutant, thus removing them from atmosphere. Green plants form a surface capable of absorbing air pollutants and forming sinks for pollutants, improves the aesthetic value of local environment. Green belts are planned open spaces, provide safeguarded from developmental activities such as construction of buildings, factories, any other infrastructural activities also. Development of green belt consisting of 3 tier along the periphery of the project with native species is most important guideline for any type of industry. Green vegetation cover is beneficial in many ways leading to conservation of biodiversity, retention of soil moisture, recharge of ground water and maintaining pleasant climate of the area, providing possible habitats for birds and animals. Green belt minimizes the build-up of pollution levels in urban / industrial areas by acting as pollution sinks. The 3 tier green belt will absorb pollutants released from the industrial activity into atmosphere and helps in effective pollution control.

The Ministry of Environment, Forest and Climate change (MoEFCC) insisted to develop green belt for new and existing projects proposing expansion and modernisation in their respective Environmental Clearance (EC), to minimize the impacts due to air pollution and noise pollution in the environment. According to MoEFCC, Metallurgical industries (ferrous and non-ferrous) must have a action plan for the green belt development plan in 33% area land with not less than 1500-2500 trees per hectare (tree density), providing details of species, width of plantation, planning schedule etc. The green belt shall be around the project boundary and a scheme for greening of the roads used for the project shall also be incorporated.

In Rourkela Steel Plant green cover (including shrubs, grasses and all small & big trees) found is about 32.6 % (559.33 Ha out of 1714.73 ha) of the total area. Hence, 6.86 hectare of more area needs to be prepare for greenbelt development (gap identified as per rules of MoEFCC) by horticulture department of RSP. There are many slag dump sites which is located near HSM-2 (Hot Strip Mill) , New Plate Mill, Silicon Steel Mill of RSP, where plantation can be carried out in near future. Also, 237.94 ha of barren land (located mainly Tarkera Nali side) is identified within Rourkela Steel Plant boundary, where future afforestation program can also be planned.

Fig 5-1: Greenery Area Distribution of Rourkela Steel Plant



5.2 Species of Trees Suggested for Greenery Development

The tropical climatic conditions in the Rourkela Steel Plant region create a supportive environment for the natural regeneration and growth of several native and economically significant plant species. Intense sunlight promotes more efficient photosynthesis in this tropical region and also Wind facilitates the process of evapotranspiration. List of trees which are suggested to be planted based on carbon sequestration target are enlisted in Table 5-2.

Table 5-2: List of selected tree species for future greenery development

Plant species	Carbon Sequestration Potential CO_2 eq./tree Sp./yr. (Kg)	Characteristics
Acacia auriculiformis (Akashmoni)	29.5	Fast growing, Dust tolerant
Acacia leucophloea (Safed Babul)	64.1	Fast growing, Evergreen, Dust Tolerant, Drought Tolerant
Albizzia lebbek (Siris)	77	Fast growing, wide-spreading dense canopy, resilient to drought.
Cassia siamea (Kassod/Chakundi)	34.7	Fast growing, dense canopy, resilient to drought. Avenue Plantation.
Eucalyptus citriodora (Nilgari)	64.1	Fast growing, resilient to drought.
Ficus religiosa (Peepal)	141.2	Evergreen, wide-spreading canopies, long lifespan.
Ficus variegate (Fig)	24.3	Moderate to fast growing, dense canopy, Evergreen, Dust tolerant
Gmelina arborea (Gamhar)	23.7	Evergreen, fast growing, dense canopy, dust, SO2 & NOx tolerant,
Syzygium cumini (Jamun)	21.3	Fast growing, Evergreen, Dust tolerant
Peltophorum pterocarpum (Radhachura)	65.3	Fast growing, dense canopy, resilient to drought. Avenue Plantation.
Mangifera indica (Aam/Mango)	33.8	Evergreen, wide-spreading canopies, long lifespan.

Plant species	Carbon Sequestration Potential CO_2 eq./tree Sp./yr. (Kg)	Characteristics
Azadirachta indica (Neem)	32.7	Moderate growing, dense canopy, resilient to drought.
Madhuca longifolia (Mahua)	43.7	Moderate growing, dense canopy, resilient to drought.
Artocarpus heterophylla (Kanthal)	42.7	Moderate growing, dense canopy, resilient to drought.
Pongamina pinnata (Karanja)	30.7	Moderate growing, dense canopy, resilient to drought.

Mainly fast growing and having higher CO_2 sequestration potential are suggested to be planted in project site. The survival rate of these above trees must be verified as per past record maintained by horticulture department of SAIL-RSP.

Survival Rate of several Species of trees within Rourkela Steel Plant must be calculated based on previous year wise survival data by horticulture department of SAIL-RSP. Rourkela Steel Plant is located at Sundargarh district of Odisha. Approximately 44% area of Sundargarh district covered by forest including dense & open mixed jungle. (Data Source : India State Forest Report 2019).

A survival rate plant calculator is a tool used to estimate the likelihood of a plant surviving in a given environment or under specific growing conditions. Life tables are used to calculate survival rates, which are used to quantify patterns of death within a community, estimate life expectancy, and assess the effects of population dynamics. A life table is a record of survival and reproductive rates in a population, broken out by age, size, or developmental stage. The general procedure is to link year-to-year variation in ecological factors like temperature, rainfall, or population density with individual factors like sex. For population projections, 5-year survival rates are computed, while 10-year survival rates are calculated for estimates of net migration.

Techniques to Enhance Survival Rate of a Sapling/Tree

Survival of Trees is as important as planting one. The key to increasing the survival rate of trees after planting is to provide the right conditions and care to support the tree's growth and development.

Here are some ways to increase the survival rate of trees after planting:

1. **Choose the right tree for the location:** Before planting, it is important to choose a tree species that is well-suited to the location, considering factors such as soil type, climate, and the tree's eventual mature size. This will increase the chances of the tree surviving and thriving in its new environment. Soil of Rourkela is quite rich in nutrients having nitrogen in the range of 890 mg/kg to 1285 mg/kg, phosphate in the range of 680 mg/kg to 1235 mg/kg & potassium in the range of 850 mg/kg to 1290 mg/kg, promotes suitable growth of vegetations and promoted species richness. Also, the soil is neutral to very slightly alkaline in nature with pH value ranging from 7.16 to 7.42 which favours nutrient availability for vegetation growth.
2. **Plant trees at the right time of year:** The best time to plant trees varies depending on the climate and the tree species, but in general, it is best to plant trees when they are dormant, which is typically in the fall or early spring. This allows the tree to establish its root system before the growing season begins.
3. **Use proper planting techniques:** When planting trees, it is important to follow proper planting techniques to ensure that the tree has the best chance of surviving. This includes digging a hole that is the appropriate size and depth for the tree, using the right mix of soil and compost, and properly staking and watering the tree.
4. **Provide adequate care and maintenance:** After planting, it is important to provide ongoing care and maintenance to ensure that the tree stays healthy and continues to grow. This includes watering the tree regularly, pruning and shaping as needed, and protecting the tree from pests and diseases.
5. **Consider using tree guards:** Tree guards can help to protect young trees from pests, animals, and other threats. Tree guards can be made from a variety of materials, such as plastic, metal, or mesh, and can be used to prevent damage to the tree's trunk, branches, and leaves.

By following these tips, you can help to ensure that the trees thrive and provide benefits to the environment and the associated community for many years to come.

5.3 Key Safeguard Measures for Greenery

- **Wire Fencing and Boundary Wall:** To ensure the physical protection of developed green areas, wire fencing and/or boundary wall construction is essential. These structures act as a barrier against encroachment, grazing by cattle, illegal dumping, and other anthropogenic pressures. Properly installed fencing and boundary walls help preserve the integrity of green belts, plantations, and ecological zones, especially those located near industrial operations or human settlements.
- **Display of awareness signage** to discourage unauthorized entry or damage.
- **Engagement of local communities, employees, and school children** for protection and plantation through free distribution of saplings and greening rewards as a part of CSR.

Maintenance Protocol

- **Regular Watering:** Especially during summer and dry months using treated water or rainwater harvesting.
- **Weeding and Mulching:** To reduce competition and retain soil moisture.
- **Pest and Disease Management:** Use of organic pesticides and regular inspection.
- **Pruning and Thinning:** For healthy plant growth and aesthetics.
- **Soil Enrichment:** Using compost, organic matter, and bio-fertilizers.
- **Monitoring:** Periodic survival rate assessment and replantation if required.

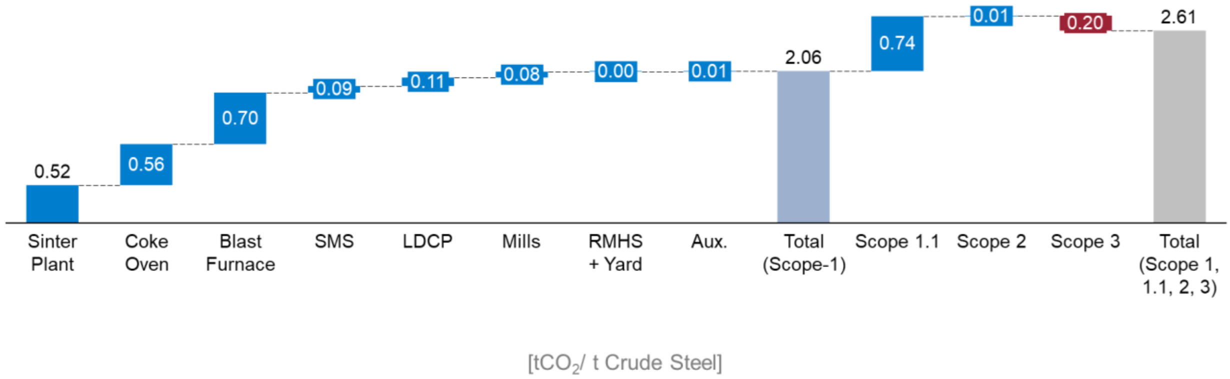
5.4 Summary of Net Zero Roadmap

Based on the SAIL RSP's target to bring down CO_2 emissions to 2.0 T_{CO2}/T_{CS} by 2030 and eventually achieve India's net zero target by 2070, GHG inventory was prepared for the existing plant for FY 22-23 (refer Milestone 1 report), the absolute CO_2 emission for 4

MTPA crude steel production is 10.52 MTPA and the resulting total CO_2 emission intensity came out to be 2.61 T_{CO2}/T_{CS}.

The unit-wise distribution of CO_2 emission intensity has been illustrated in Fig 5-2 (as estimated in the Milestone 1 report).

Fig. 5-2: CO_2 emission intensity for FY 22-23.



Based on the data received from RSP, the CO_2 emission intensity for FY 23-24 for 4.16 MTPA crude steel production was about 2.61 T_{CO2}/T_{CS}. The CO_2 mitigation strategies have been studied with FY 23-24 as the baseline year.

The net-zero strategy has been bifurcated into a short-term plan and a long-term plan based on the targets of decarbonization for 2030 and net zero in 2070 (refer Milestone 2 report). The summary of net-zero roadmap has been given in this section.

5.5 GHG Emission Reduction Plan for SAIL RSP (up to FY31)

5.5.1 Decarbonization strategies

By 2030, SAIL has a target to reach CO_2 emissions intensity to 2 T_{CO2}/T_{CS}. In order to bring down the emission intensity of crude steel production certain initiatives have been suggested based on preliminary evaluation done in the milestone 2 report. These initiatives can be categorized as follows:

1. **Energy Efficiency**
2. **Renewable energy transition**
3. **Material Efficiency**
4. **Green hydrogen**
5. **Alternate Iron & Steel Making Route**

5.5.2 Decarbonization Strategies for RSP

In line with the decarbonization target of SAIL RSP, a few measures have been finalized in discussion with the plant in-charges of various units to ensure their feasibility and alignment with the overall operational objectives of RSP.

The details of each initiative have been mentioned in Milestone 2 report. A summary table with respect to change in key performance indicators (KPI) and the resultant reduction in CO_2 emission intensity has been given in Table 5-3.

Table 5-3: Summary of Initiatives planned for FY24 - FY31

Plant Unit / Initiative	Implementation Year	Initiative	Parameter	Unit	Original value	Final value	Change in Coke rate of BF-1	Change in Coke rate of BF-5	Wt. avg. coke rate (BF-1+BF-5)	Coke Sale (tpa)	CO2 reduction, tpa	Intensity reduction, tCO2/tCS
Sinter Plant-3	FY 25-26	Hot water mixing in mixing drum of SP-3	Coke breeze	kg/tSinter	52	49	-	-	-	11,160	-74,036	-0.02
BF & COBP	FY 25-26	BF-5 4th stove addition to reach blast temp above 1200 °C	Coke rate	kg/thm	416	410	458	390	410	25,913	-1,71,905	-0.04
SMS-2	FY 25-26	5 kg additional scrap addition to BOF of SMS-2	Pig iron sale	tpa	1,33,831	1,52,876					-83,240	-0.02
BF & COBP	FY 25-26	Pellet increase to 30% in BFs replacing lump ore	Coke rate	kg/thm	410	404	452	384	404	27,652	-1,83,441	-0.04
BF & COBP	FY 26-27	BF-1 top pressure increase	Coke rate	kg/thm	416	416	458*	398	416	1,885	-12,503	-0.01
BF & COBP	FY 26-27	Coal quality improvement - COB 1-6 (Coal Blend: 10% from Tasra Mines (17% ash) instead of present indigenous coal (27% ash), 63% HCC (12% ash) and 27% SCC (7% ash) - Resultant coke ash - 14.9% from 16.2%	Coke rate	kg/thm	404	396	443	376	396	37,285	-2,47,898	-0.06
BF & COBP	FY 26-27	Partial replacement of PCI with 17 kg/thm NG	PCI (NG)	kg/thm (kg/thm)	123(0)	99 (17)	-	-	-	-	-82,172	-0.02
HBI/Scrap Addition in BF-5	FY 30-31	About 300 ton HBI /Scrap per ton of HM charge in BF-5 to reduce coke rate	Coke rate	kg/thm	396	315	0	299	379	9,76,612	-7,82,753	-0.19
Renewable Power	FY 26-27	100 MW solar installation and 10 MW Hydroelectric power by RSP	Scope 2 reduction	MW	0	22	-	-	-	-	-1,23,621	-0.03
Renewable Power	FY 26-27	660 Million Units of RE Power by Purchase Power Agreement	Scope 2 reduction	Mill KWh	0	660	-	-	-	-	-3,32,960	-0.08

Total reduction by FY 26-27	**-20,94,529**	**-0.51**
tCO2 /tCS at FY 26-27		**2.10**

Plant Unit / Initiative	Implementation Year	Initiative	Parameter	Unit	Original value	Final value	Change in Coke rate of BF-1	Change in Coke rate of BF-5	Wt. avg. coke rate (BF-1+BF-5)	Coke Sale (tpa)	CO2 reduction, tpa	Intensity reduction, tCO2/tCS
BF & COBP	FY 29-30	Stamp charge COB-7 addition and coal quality improvement in COB 7 with HCC-30%, SCC-70% - Resultant avg. Coke ash - 14.2% from 14.9%	Coke rate	kg/thm	379	378	443	297	378	9,248	-49,313	-0.01
Renewable Power	FY 26-27	330 MW Solar PV installation (rooftop + barren land + water body) in 155 Hactre. Final power drawl 66 MW.	Scope 2 reduction	MW	0	66	-	-	-	-	-2,69,643	-0.06

Reduction from FY 27-28 to FY 30-31	**-3,18,956**	**-0.08**
tCO2 /tCS at FY 30-31		**2.03**

***Insignificant Change in Coke rate**

5.5.3 Cost Analysis for Suggested GHG Mitigation Strategies

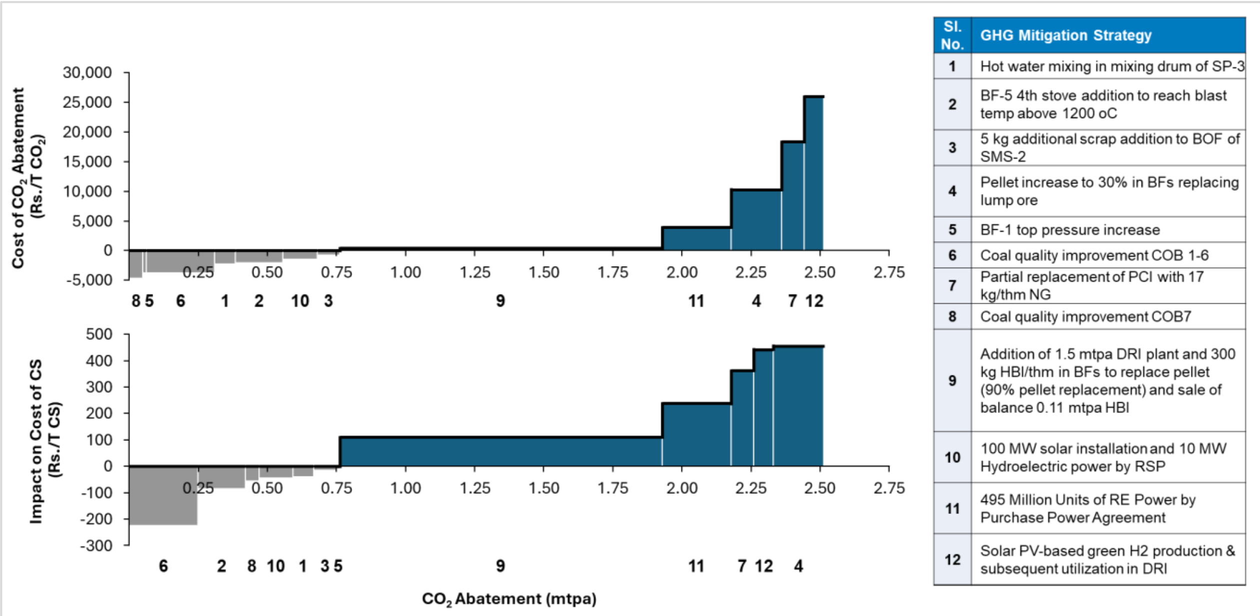
Based on these assumptions made in Table 2-17 in Milestone 2 Report, the cost impact for the selected near-term decarbonization strategies has been given in Table 5-4.

Table 5-4: Cost of CO_2 Abatement and Impact on cost of Crude Steel Production

Sl. No.	Initiative	CO_2 abated (MTPA)	Impact on cost of CS (Rs. /T CS)	Cost of CO2 abatement (Rs. /T CO_2)
1	Hot water mixing in the mixing drum of SP-3	0.07	-40	-2,261
2	BF-5 4th stove addition to reach blast temp above 1200 °C	0.17	-86	-2,076
3	5 kg additional scrap addition to BOF of SMS-2	0.08	-16	-792
4	Pellet increase to 30% in BFs replacing lump ore	0.18	455	10,329
5	BF-1 top pressure increase	0.01	-11	-3,768
6	Coal quality improvement COB 1-6	0.25	-224	-3,760
7	Partial replacement of PCI with 17 kg/thm NG	0.08	363	18,367
8	Coal quality improvement COB7	0.05	-56	-4,688
9	Addition of 1.5 mtpa DRI plant and 300 kg HBI/thm in BFs to replace pellet (90% pellet replacement) and sale of balance 0.11 mtpa HBI	1.17	111	395
10	100 MW solar installation and 10 MW Hydroelectric power by RSP	0.12	-44	-1,483
11	495 million Units of RE Power by Purchase Power Agreement	0.25	238	3,964
12	Solar PV based green H2 production & subsequent utilization in DRI	0.07	442	25,988

The marginal abatement cost curve (MACC) and the impact on the cost of crude steel production for the suggested strategies has been given in Figure 5-3.

Fig. 5-3: MACC for Suggested Strategies up to FY 31



5.6 Net Zero Roadmap for SAIL RSP (Up to FY70)

In line with the RSP's target of achieving net zero, a pathway has been formulated. The strategies and the respective timelines are given in Table 5-5.

Table 5-5: Net zero roadmap of SAIL RSP

Years	Strategies	Hot Metal& DRI (MTPA)	Crude Steel (MTPA)	CO_2 Intensity
FY 31-40	**Facilities added** COB-6 NG based DRI (1X 2.5 MTPA) New SMS-1 (2.8 MTPA EAF Based) **Facilities de-functionalized** COB-4 COB-5 Old SMS -1	HM-4.7 DRI-4	6.4	1.94
FY 41-50	**Facilities added** H_2 based DRI (2x 2.5 MTPA)	HM-0 DRI-9	7.3	1.0

Years	Strategies	Hot Metal& DRI (MTPA)	Crude Steel (MTPA)	CO_2 Intensity
	SMS-3 (4.5 MTPA EAF based)			
	Facilities de-functionalized SP-1,2 & 3 BF-1 BF-5 COB-1,2,3,6,7 SMS -2			
FY 51-60	**Facilities added** Replacing NG based to H_2 based DRI in (1x 2.5 MTPA & 1X1.5 MTPA) DRI Modules and using hydrogen as fuel in reheating furnace & H_2 preheater in DRI	DRI-9	7.3	0.6
FY 61-70	Green power replacing coal-based electricity Addition of biochar in SMS instead of pet coke	DRI-9	7.3	0.0

Decarbonization Strategies: FY 31-40

In the period 2031 – 2040, the addition of an NG–based DRI module of 2.5 MTPA capacity must be targeted. Old SMS-1 of 0.5 MTPA capacity has been envisaged to be replaced by a new EAF-based SMS-1 with a capacity of 2.8 MTPA.

Capital repair of COB-6 (0.8 MTPA) is expected to be completed by FY 33-34, COB-4 (0.4 MTPA) and COB-5(0.4 MTPA) shall be de-functionalized accordingly as production of COB-6 restarts.

The Crude Steel production capacity shall increase to 6.4 MTPA and the net CO_2 emission intensity shall be reduced to 1.94 T_{CO2}/T_{CS} by 2040.

Decarbonization Strategies: FY 41 – 50

In the period 2041 – 2050, the addition of another 2 modules of H_2-based DRI of 2.5 MTPA capacity each and 4.5 MTPA EAF-based SMS-3 must be targeted. Accordingly, sinter plants need to be de-functionalized. The remaining 2 BFs (BF-1 and BF-5) and remaining coke ovens (1,2,3,6,7) shall also be de-functionalized. The crude steel capacity increases to 7.3 MTPA. Post 2050, the crude steel capacity shall remain constant at 7.3 MTPA. The net CO_2 emission intensity shall be reduced to 1.0 T_{CO2}/T_{CS} by 2050.

Decarbonization Strategies: FY 51 - 60

Post 2050, it has been assumed that green hydrogen shall be readily available for commercial utilisation. According to TERI projection, under conservative scenario the national grid emission intensity shall be 0.22 T CO_2/ MWh. All the DRI units shall be operated with 100% green hydrogen and the fuel for reheating furnace and other areas shall be replaced with green hydrogen. In line with these projections and assumptions, the net CO_2 emission intensity of RSP shall be reduced to 0.6 T_{CO2}/T_{CS} by 2060.

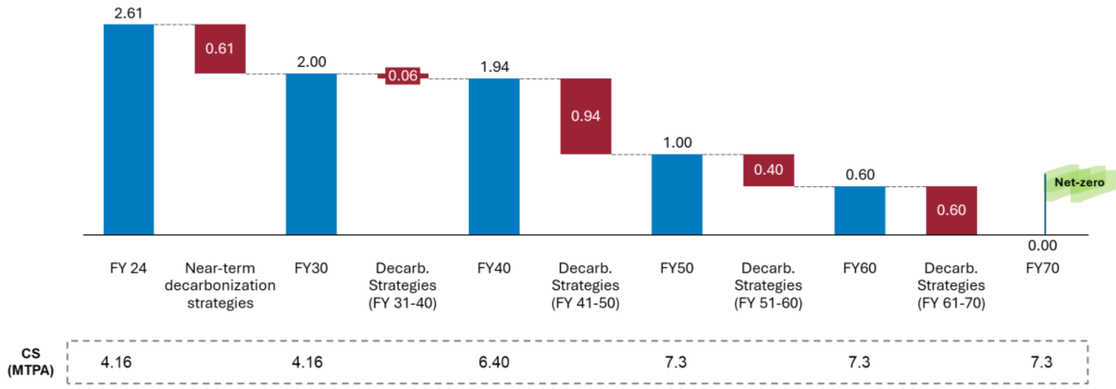
Decarbonization Strategies: FY 61 - 70

In line with the net-zero target of India by 2070, it has been assumed that the power available from the grid shall be 100% green power post 2060. This would eliminate the remaining scope-2 emissions, and the emission intensity shall be reduced to 0.2 T_{CO2}/T_{CS} by 2070.

With the availability of carbon-neutral fuels like bio-char carbonaceous material in EAF operation will slowly be replaced. This would lead to a reduction of residual emissions from the plant and thus bring down the CO_2 emission intensity to near zero. As the bio-char shall be derived from biomass, it is considered to be a net-neutral fuel thus there is no additional emission for combustion of bio-char.

The overall CO_2 emissions intensity reduction to achieve SAIL's target of net zero by 2070 has been illustrated in Figure 5-4.

Fig 5-4: CO_2 Emission Intensity Reduction to achieve net-zero for SAIL RSP



5.7 Proposed Monitoring Plan

It is suggested that a monitoring group be formed by RSP, which will review the CO_2 emission and implementation plan quarterly. The group will measure the CO_2 emission of the overall plant quarterly based on the WSA framework to check the quarterly emission level. To implement the suggested strategy, the group needs to work with the applicable departments to get approval for and implement individual strategies. Post approval of any intervention, the monitoring group will make an elaborate micro-schedule till implementation, which will be reviewed with actual progress quarterly and reported to the appropriate authority.

This group shall also be responsible for planning the long term decarbonisation projects mentioned in section 5.6. They shall conduct the FEL 3 level study to generate actionable data which should aid the relevant authorities to make the go/no-go investment decisions.

Annexure - 4

Scanned copy of Corporate Environment Policy

स्टील अथॉरिटी ऑफ इण्डिया लिमिटेड

STEEL AUTHORITY OF INDIA LIMITED

Corporate Environmental Policy

Steel Authority of India Limited, one of the leading steel producers of India, in its endeavour to strengthen environment management and maintain clean and sustainable environment in and around its plants, mines & other units is committed to:

i. Protect the environment by integrating sound environmental practices for control and prevention of pollution from all its activities.

ii. Comply with legal and other requirements pertaining to the environment, forests and wildlife and to go beyond.

iii. Systematic approach of environment management by accreditation with Environment Management System.

iv. Contribute towards mitigation of climate change through adoption of measures to reduce emission of greenhouse gases, enhancing green coverage, adopting energy efficient technologies, enhancing use of green energy.

v. Promoting innovative environment-friendly processes and products.

vi. Ecological restoration of degraded mined out landscapes.

vii. Integrate principle of "reduce, recover, recycle and reuse" in its operations for conservation of natural resources, including water, to ensure sustainable future.

viii. Continual improvement of environmental performance by setting challenging targets, transparent reporting system and robust review mechanism.

ix. Continuously monitor emissions, discharges and ambient air quality and uplink with SPCB and CPCB portals for self-regulation of environmental deviations, if any.

x. Communicate environmental performance to all stakeholders through annual report, Board report, Corporate Sustainability Report and all such means from time-to-time.

xi. Engaging employee for commitment and responsibility towards environment protection through capacity building.

xii. Promoting environmentally responsible behaviour amongst all stakeholders.

Annexure-5

RSP's Deviation Report for the period July – September, 2025

Annexure-1(a)

सेल SAIL

Rourkela Steel Plant

Deviation from Environmental Clearance Conditions

1. Name of the Plant/Unit : Rourkela Steel Plant
2. Name of the Project for which EC was granted : Modernisation Cum Expansion of Sail - Rourkela Steel Plant for Enhancing Hot Metal Production from 4.500 MTPA to 4.855 MTPA, Crude Steel Production from 4.200 MTPA to 4.850 MTPA and Saleable Steel Production from 3.880 MTPA to 4.325 MTPA by Installing Coke Oven Battery#7, Steel Melting Shop#3, New Normalizing Furnace in New Plate Mill, New Oxygen Plant and Natural Gas Pipe Line Network Inside the Existing Plant Premises and Adopting Technological Measures in Existing Blast Furnaces for Enhancing Hot Metal Production viz, Stove No.4 in BF#5, Granshot, Micro Pelletisation Plant, within the premises of Rourkela Steel Plant
3. Environmental Clearance no., & date and Issuing authority : EC22A008OR110441, dated 30/03/2022 Director, MoEF&CC
4. Validity of Environment Clearance : 30^{th} March, 2029
5. Period (Quarter) of the report : July - Sept., 2025
6. Deviation from Env. Clearance Conditions :

SN.	Environment Clearance Condition	Compliance Status	Deviation	Corrective Action Proposed
NIL				

Director I/c
Rourkela Steel Plant, SAIL

Annexure-1(b)

सेल SAIL

Rourkela Steel Plant

Deviation from Environmental Policy

Name of the Plant/Unit : **Rourkela Steel Plant**

Period (Quarter) of the report : **July - Sept., 2025**

a) Deviation from Corporate Environment Policy (SAIL) :

SN.	Policy Commitment	Deviation	Corrective Action Proposed
NIL			

b) Deviation from RSP's Integrated Management System Policy :

SN.	IMS Policy Commitment	Deviation	Corrective Action Proposed
NIL			

Director I/c
Rourkela Steel Plant, SAIL

Annexure-2

Rourkela Steel Plant

Compliance Report in respect of various Environmental Acts / Directions

Name of the Plant/Unit : **Rourkela Steel Plant**
Period (Quarter) of the report : **July-Sept., 2025**

<table>
<tr><th>SN.</th><th>Show-cause Notice(s) / Directions issued by SPCB/CPCB/State Government/Central government/Court of Law under Air (PCP) Act, Water (PCP) Act, Environmental (Protection) Act & Wildlife (Protection) Act, during the quarter or Pending as on date</th><th>Present status and Action taken for compliance of the notices/directions</th><th>Bank Guarantee(BG) submitted, if any, with amount of BG and validity</th></tr>
<tr><td>1)</td><td>SPCB issued a direction, vide ref. no. 17660/IND-I-CON-01, dated 25.09.2025.</td><td>
a) Total number of points given in the direction = 31
b) Number of points complied already = 23
c) Number of points for which actions initiated = 8
<table>
<tr><th>SN.</th><th>Ongoing Point</th><th>Present Status</th></tr>
<tr><td>1.</td><td>Improvement of Lagoon Efficiency</td><td rowspan="3">Budget sanctioned and tendering actions initiated.</td></tr>
<tr><td>2.</td><td>Desilting of Lagoon</td></tr>
<tr><td>3.</td><td>Use of Aeration systems in Lagoon</td></tr>
<tr><td>4.</td><td>Installation of HD-IP cameras at Lagoon</td><td>Note initiated for financial sanction for procurement.</td></tr>
<tr><td>5.</td><td>Third party audit of Water Pollution Control Systems</td><td>Carried out last year. PR raised for this year.</td></tr>
<tr><td>6.</td><td>TCLP test for CCD sludges</td><td>BOs received. Note initiated for approval.</td></tr>
<tr><td>7.</td><td>Establishment of Treatment System#2 & Treatment System#3 for achieving ZLD.</td><td>Order placed for TS#2 and is under execution. TS#3 will be taken up after completion of TS#2.</td></tr>
<tr><td>8.</td><td>Submission of BG.</td><td>Appeal for exemption submitted.</td></tr>
</table>
</td><td>Nil.</td></tr>
</table>

Director I/c
Rourkela Steel Plant, SAIL

Annexure-6
Scanned Copies of News Paper Advertisements
(Published on 12/04/2022)

1. **Sambad (Odia News Paper), dated 12/04/2022 :**

ଭାରତୀୟ ଇସ୍ପାତ ପ୍ରାଧିକରଣ ସଂସ୍ଥା
ରାଉରକେଲା ଇସ୍ପାତ କାରଖାନା
ରାଉରକେଲା-୭୬୯୦୧୧, ଓଡ଼ିଶା, ଭାରତ

ସେଲ୍ ରାଉରକେଲା ଇସ୍ପାତ କାରଖାନା ଆଧୁନିକୀକରଣ ଓ ସମ୍ପ୍ରସାରଣ
ସାଧାରଣ ବିଜ୍ଞପ୍ତି

ଭାରତ ସରକାରଙ୍କ ଜଙ୍ଗଲ ଓ ପରିବେଶ ମନ୍ତ୍ରଣାଳୟ ୨୦୨୨ ମାର୍ଚ୍ଚ ୩୦ ତାରିଖରେ ସେଲ୍ ରାଉରକେଲା ଇସ୍ପାତ କାରଖାନାର ଉତ୍ତପ୍ତ ଧାତୁ ଉତ୍ପାଦନ ବାର୍ଷିକ ୪.୫୦୦ ନିୟୁତ ଟନ୍‌ରୁ ୪.୮୫୫ ନିୟୁତ ଟନ୍, ଅଶୋଧିତ ଇସ୍ପାତ ଉତ୍ପାଦନ ବାର୍ଷିକ ୪.୨ ନିୟୁତ ଟନ୍‌ରୁ ୪.୮୫୦ ନିୟୁତ ଟନ୍ ଏବଂ ବିକ୍ରିଯୋଗ୍ୟ ଇସ୍ପାତ ୩.୮୮୦ ନିୟୁତ ଟନ୍‌ରୁ ୪.୩୨୫ ନିୟୁତ ଟନ୍‌କୁ ବୃଦ୍ଧି କରିବା ନିମନ୍ତେ କାରଖାନା ପରିସର ମଧ୍ୟରେ କୋକ୍ ଓଭେନ ବ୍ୟାଟେରି-୭, ଷ୍ଟିଲ ମେଲ୍ଟିଂ ସପ-୩, ନୂତନ ପ୍ଲେଟ ମିଲରେ ନୂତନ ନର୍ମାଲାଇଜିଙ୍ଗ ଫର୍ଣ୍ଣେସ, ନୂତନ ଅକ୍ସିଜେନ ପ୍ଲାଣ୍ଟ ଏବଂ ପ୍ରାକୃତିକ ଗ୍ୟାସ ପାଇପ୍ ଲାଇନ ଶୃଙ୍ଖଳ ତଥା ଉତ୍ତପ୍ତ ଧାତୁ ଉତ୍ପାଦନରେ ବୃଦ୍ଧି ଆଣିବା ପାଇଁ ବିଦ୍ୟମାନ ବ୍ଲାଷ୍ଟ ଫର୍ଣ୍ଣେସ ଗୁଡିକରେ ବୈଷୟିକ ପଦକ୍ଷେପ ଗୁଡିକର ସ୍ଥାପନା ନିମନ୍ତେ ପରିବେଶ ମଞ୍ଜୁରୀ ପ୍ରଦାନ କରିଛି। ପରିବେଶ ଅନୁମତି ପତ୍ର ସେଲ୍ ଏବଂ ଜଙ୍ଗଲ ଓ ପରିବେଶ ମନ୍ତ୍ରଣାଳୟର ୱେବସାଇଟରେ ଉପଲବ୍ଧ ରହିଛି।

ତାରିଖ: ୦୫.୦୪.୨୦୨୨ — ରାଉରକେଲା ଇସ୍ପାତ କାରଖାନା ପକ୍ଷରୁ
ସ୍ଥାନ: ରାଉରକେଲା — ସ୍ୱା/- ଭାରପ୍ରାପ୍ତ ମହାପ୍ରବନ୍ଧକ
(ପରିବେଶ ଇଞ୍ଜିନିୟରିଂ)

ପଞ୍ଜୀକୃତ କାର୍ଯ୍ୟାଳୟ: ଇସ୍ପାତ ଭବନ, ଲୋଦି ରୋଡ, ନୂଆ ଦିଲ୍ଲୀ-110003
Corporate Identity Number: L27109DL1973GOI006454, Website: www.sail.co.in
ପ୍ରତ୍ୟେକଙ୍କ ଜୀବନ ସହ ଯୋଡି ହୋଇ ରହିଛି ସେଲ

2. **Dainik Jagaran (Hindi News Paper), dated 12/04/2022 :**

स्टील अथॉरिटी ऑफ इंडिया लिमिटेड
राउरकेला इस्पात संयंत्र
राउरकेला–769011 (ओडिशा), भारत

सेल – राउरकेला इस्पात संयंत्र का आधुनिकीकरण–सह–विस्तारण
सार्वजनिक सूचना

पर्यावरण, वन एव जलवायु परिवर्तन मंत्रालय (एम.ओ.ई.एफ.सी.सी.), भारत सरकार ने 30 मार्च, 2022 को सेल–राउरकेला इस्पात संयंत्र के आधुनिकीकरण–सह–विस्तारण के लिए हॉट मेटल उत्पादन 4.500 एमटीपीए से 4.855 एमटीपीए, क्रूड स्टील उत्पादन 4.200 एमटीपीए से 4.850 एमटीपीए और सेलेबल स्टील उत्पादन 3.880 एमटीपीए से 4.325 एमटीपीए तक बढ़ाने के लिए कोक ओवन बैटरी # 7, स्टील मेल्टिंग शॉप # 3, नई प्लेट मिल में नई नॉर्मलाइजिंग फर्नेस, मौजूदा प्लांट परिसर के अंदर नया ऑक्सीजन प्लांट और प्राकृतिक गैस पाइप लाइन नेटवर्क स्थापित करके और मौजूदा ब्लास्ट फर्नेस में तकनीकी उपायों को अपनाकर सेल, राउरकेला इस्पात संयंत्र, राउरकेला के परिसर के भीतर मौजूदा ब्लास्ट फर्नेस से हॉट मेटल उत्पादन बढ़ाने के लिए पर्यावरण मंजूरी प्रदान की है। पर्यावरण मंजूरी पत्र की प्रति सेल और एम.ओ.ई.एफ.सी.सी. की वेबसाइटों पर देखी जा सकती है।

दिनांक : 05/04/2022 — राउरकेला इस्पात संयंत्र के लिए
स्थान : राउरकेला — हस्ता./– महा प्रबंधक प्रभारी (पर्यावरण इंजीनियरी)

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There's a little bit of SAIL in everybody's life

3. **The Indian Express (English News Paper) dated 12/04/2022 :**

STEEL AUTHORITY OF INDIA LIMITED
Rourkela Steel Plant
Rourkela - 769 011, Odisha, India

Modernization cum Expansion of SAIL – Rourkela Steel Plant
Public Notice

Ministry of Environment Forests and Climate Change (MoEFCC), Govt. of India has accorded Environment Clearance on 30th March, 2022 for Modernisation cum Expansion of SAIL – Rourkela Steel Plant for Enhancing Hot Metal production from 4.500 MTPA to 4.855 MTPA, Crude Steel Production from 4.200 MTPA to 4.850 MTPA and Saleable Steel Production from 3.880 MTPA to 4.325 MTPA by installing Coke Oven Battery#7, Steel Melting Shop#3, New Normalising Furnace in New Plate Mill, New Oxygen Plant and Natural Gas Pipe Line Network inside existing Plant premises and adopting technological measures in Existing Blast Furnace for Enhancing Hot Metal Production from the existing Blast Furnaces, within the premises of Rourkela Steel Plant, SAIL, Rourkela. Copy of the Environment Clearance letter can be viewed at SAIL & MoEFCC's websites.

Date : 05/04/2022 — for Rourkela Steel Plant,
Place : Rourkela — Sd/- General Manager I/c (Env. Engg.)

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